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Stress Along the Medieval Anglo-Scottish Border? Skeletal Indicators of Conflict-Zone Health

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Stress Along The

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Abstract

Title: Stress along the Medieval Anglo-Scottish Border? Skeletal indicators of conflict-zone health.
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Health changes experienced by populations living in regions of conflict have come to the forefront of research in light of recent increases in socio-political instability in modern populations. Political and ethnic unrest in modern populations have been shown to instigate a decline in the health of people living within the region of unrest. Population displacement and sabotage of resources associated with violent conflict has lead to increased prevalence rates of malnutrition and infectious diseases in addition to increased mortality. The aim of this study was to bridge the gap in literature between modern medical anthropology population studies of the health consequences of living in a conflict-zone and bioarchaeological population studies of demographic and palaeopathological indicators of stress. To achieve the aim, a bioarchaeological survey of four medieval (ca. 900 – 1600 AD) British cemetery populations along the Anglo-Scottish border, described as a conflict-zone in contemporary historical documents, was conducted to calculate rates of mortality and morbidity in a socio-politically 'stressed' population. This conflict-zone population was hypothesised to have demonstrated higher rates of mortality, stunting, wasting, non-specific indicators of stress, and metabolic bone diseases when compared to four 'unstressed' contemporary skeletal populations from neighbouring cemeteries. Direct comparison of the two regions did not indicate a difference in overall mortality or morbidity between the two populations. However, the conflict-zone population demonstrated higher prevalence rates of cribra orbitalia, periosteal bone lesions, and vitamin C deficiencies in the few available non-adults along with higher rates of enamel hypoplasia in the young adults. These contradictory results call into question both the documentary evidence regarding the longevity and severity of medieval border warfare and the sensitivity of osteological data to health changes associated with a conflict-zone lifestyle. The focus of future bioarchaeological research on conflict-zones in past populations must focus on refining the relationship between causal factors and skeletal indicators of stress.

for my parents

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1   Introduction

Conflict has been present in human society for thousands of years, and remains a constant in populations today. Its causes can be rooted in the aftermaths of great environmental, climatic, or social change or it can be attributed to political ambitions of more powerful groups of people to dominate other societies. Regardless of its cause, the effects of conflict on human populations have been the focus of living population research studies describing the physical and psychological stress caused by life in a region of conflict. Studies conducted in modern regions of conflict have described decreases in the overall health of populations exposed to these stresses for an extended period of time (e.g. Elbedour, 1998; Horton, 1999; Jones, 2000; Benyamini and Solomon, 2005). These population surveys have highlighted an association between the nutritional and psychological stresses caused by political and military struggles with increases in rates of nutritional deficiencies and infectious diseases in the local populations (Green, 1994; Panter-Brick, 1998; Kinfu, 1999).

Biological anthropological studies conducted on living populations have provided anthropomorphic and biomedical data summarising the dramatic increases in mortality and morbidity rates in populations affected by war, specifically chronic malnutrition affecting the growth of children, and increases in epidemic infectious diseases associated with increased mortality across the population (Hansluwka, 1985; Panter-Brick, 1998; Pedersen, 2002; Panter-Brick, 2010). Furthermore, recent historical studies have successfully applied modern anthropological investigation techniques to documented accounts of population health during periods of war (Dean, 1997; Pizarro et al., 2006). Public health surveys of populations from conflicts in the recent past have also described similar increases in mortality, malnutrition, and higher rates of chronic infectious diseases within groups both directly and indirectly involved in war (Zellner et al., 1996; Ali and Ohtsuki, 2000; Kemkes, 2006; Pizarro et al., 2006; Bramsen et al., 2007). Given these recent advances in anthropological and historical descriptions of conflict-zone population health changes in general health and physical appearance of individuals exposed to the chronic stresses of living in a conflict-zone should also be recognizable in skeletons in the archaeological record. How these trends are demonstrable in an archaeological assemblage of human skeletal remains recovered from burial contexts remains largely unexplored.

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Bioarchaeological studies of health and disease in human populations rely on generating data on normal and abnormal variation from human skeletal remains to interpret health and disease patterns in past populations. Bioarchaeologists have described multiple indicators for identifying 'stress', called 'indicators of stress', in human populations through the observation of pathological lesions (Goodman et al., 1988; Larsen, 1997). These indicators are a set of dental and skeletal changes that are frequently observed in archaeological human skeletal remains and are of largely unknown aetiology. They are often connected with chronic malnutrition and infectious diseases, but have also been associated with evidence of trauma, congenital disorders, or cancer (Larsen, 1997; Lewis and Roberts, 1997; Ortner, 2003; Roberts and Manchester, 2005; Brickley and Ives, 2008; Weston, 2008). Palaeopathologists have often used these indicators to identify populations who were 'stressed', by quantifying these pathological lesions in prehistoric skeletal collections (Pietrusewsky et al., 1997; Buzon, 2006; Hutchinson and Norr, 2006; Klaus and Tam, 2009; Ubelaker and Pap, 2009). Previous bioarchaeological studies using skeletal populations from historical contexts have shown different prevalence rates for non-specific indicators of stress between portions of the population that were stressed and those who were not stressed (Rathbun, 1987; Visser, 1998; Slaus, 2000; Bennike et al., 2005; Brickley et al., 2005). Furthermore, bioarchaeological studies of health in both historic and prehistoric populations have identified human groups who experienced 'stress' as a result of environmental and climate change, increases in population density, economic changes, and migration (Rathbun, 1987; Goodman and Armelagos, 1989; Grauer, 1991; Cohen et al., 1994; Stodder, 1994; Ribot and Roberts, 1996; Manzi et al., 1999; Eshed et al., 2004; Brickley et al., 2007). Previous studies of the impact of war on the health of local populations have described nutritional insecurities and increased exposure to infectious diseases. However, no studies to date have attempted to link skeletal 'indicators of stress' directly to a historic population that experienced multi-generational social and political conflict.

1.1 Aim and Objectives

The aim of this study was to bridge the gap in the literature between biological anthropological population studies of the health consequences of living in a conflict-zone and bioarchaeological population studies of demographic and palaeopathological indicators of stress. Palaeopathological research has associated specific nutritional

deficiencies and infectious disease processes to observable bone changes in the human skeleton (Aufderheide and Rodríguez-Martín, 1998; Ortner, 2003). To achieve this aim, a bioarchaeological survey of people living in a Medieval British conflict-zone was conducted to describe rates of non-specific skeletal indicators of stress and metabolic bone diseases in a known socio-politically 'stressed' population.

Victory through attrition has been a vital strategy in human conflicts, both in present and past wars, with fighting forces and local populations both relying on the same natural resources to feed, clothe, and shelter themselves. Local populations residing in a region of conflict often experience a severe decrease in access to these resources through the confiscation of food by occupying armies, or through the destruction of property and food, so called 'scorched earth' campaigns, to deny these resources to the opposing force. Consequently, the most common health consequence of war today in local populations is chronic malnutrition and epidemic infections (Agadjanian and Prata, 2003; Guha-Sapir and van Panhuis, 2003; Ghobarah et al., 2004). However, the effect of these common health challenges in conflict-zone populations remains unconnected directly in bioarchaeological studies to socio-political violence. Brickley and Ives (2008: 96), however, have described the potential observations of palaeopathologists exploring disease patterns in a conflict-zone: "Pathological conditions are likely to occur from food shortages, including many of the metabolic bone diseases, in similar pathways as those affecting peoples displaced from natural disasters." Similarly, Ortner (2003: 405) has described the bone changes expected in a starved population to be:

> "a complete arrest of growth in young individuals that can only partially be made up later, resulting in stunted stature. In the adult, severe dietary restrictions can result in "hunger osteopathies" ... Such changes consist of severe osteoporosis with some overlay of osteomalacia. In archeological human skeletal remains dramatic differences in bone mass may be encountered. This will be particularly apparent in the axial skeleton, In archeological skeletons, differentiating starvation from the many other causes of reduced bone density may not be possible: However, if this condition occurs in skeletons of individuals less than 40 years of age at the time of death, the probability of starvation increases as a diagnostic option."

1.1.1 Primary Objective

The primary objective of this study was to demonstrate that bioarchaeological research can contribute to contemporary discussions of the effects of conflict on

health and disease patterns in human populations. Socio-political issues of border warfare, ethnic conflict, and struggles over available resources have clearly affected human populations in the past (see examples in Otto et al., 2006). These past societies did not have the benefit of currently available medical treatments for malnutrition, epidemic disease, and mental illness associated with conflict-zone lifestyles. Therefore, by studying populations in the past who had similar experiences, present researchers can broaden their knowledge of the long-term impact of conflict on human health. Bioarchaeological evidence for the long-term adverse mortality and morbidity effects of conflict on public health would allow governments and aid organisations today to conduct more informed discussions about methods of improving public health in modern conflict-zone populations. By examining the long-term effects of conflict on mortality and morbidity in past human populations, doctors, aid workers and relief organizations would have a more comprehensive knowledge of the long-term health needs of their current patients (Spiegel et al., 2010).

1.1.2 Secondary Objective

The secondary objective of this study was to link historical and bioarchaeological evidence of a conflict-zone lifestyle, which included socio-political instability. To achieve this objective, cemetery populations were analysed from the Medieval Anglo-Scottish border. The Anglo-Scottish border region of northern England and southern Scotland was described in historical documents as a region exposed to violent raids by English and Scottish armies and mercenaries from the 10th through the 16th centuries AD. This was because both countries were fighting to gain control over local populations, and the economic potential of the region's agriculture, wool production and trade, and coal mining industry (Mason, 1987; Goodman and Tuck, 1992; Summerson, 1993; Lomas, 1996a; MacIvor, 2001; Morgan, 2001). Historical records from Medieval Britain describe the counties of northern England and southern Scotland as, "a society hardened to the horrors of war" (Prestwich, 2006), suggesting higher physical and psychological stress levels in the general populations living within this border region (Mackie, 1978; MacIvor, 2001; Savage, 2002; South, 2002). Climate change, epidemic disease, and socio-economic shifts in use of the environment occurred in Britain throughout the medieval period (Platt, 1978; Dyer, 1989; McNeill, 1998; Dyer, 2002; Goldberg, 2004; Dyer, 2006; Woolgar, 2006).

However, those changes were described as consistently experience by all medieval British populations throughout the time period (Dyer, 1989; Keen, 1990; McCord and Thompson, 1998; McNeill, 1998; Barrell, 2000; Goldberg, 2004; Dyer, 2006). Therefore, this study aimed to control for these alternative causes of 'stress', such as differences in environment, climate, and activity (Goodman et al., 1988; Larsen, 1997), as much as possible in an archaeological context. Furthermore, medieval cemeteries from this region have been excavated in the recent past during programs of urban redevelopment and archaeological recovery and the resulting human remains were available for study (Roberts and Cox, 2003; Petts and Gerrard, 2006). This region's history and material culture offered both the historical evidence and the bioarchaeological materials to explore the relationship between conflict and potential chronic changes in public health patterns in a bioarchaeological framework.

1.2 Hypothesis

The medieval British populations living along the Anglo-Scottish border from the 10th through the 16th century were hypothesised to have significantly higher mortality and morbidity rates than contemporary populations living in other regions of Britain that were not exposed to chronic border warfare. Documentary evidence describes the consistent use of 'scorched earth' tactics by both the English and Scottish aristocracy, punctuated by occasional battles and castle sieges by their armies, as a subversive strategy to conquer their opponents through starvation. This strategy exposed the local border populations to a chronic state of food shortages and introduced new waves of infectious diseases from the passing troops. Local historical records allude to starvation and loss of property as the direct effects of a conflict-zone lifestyle on the border populations; however, these documents have been written by and for the wealthy and the land-owning aristocracy. They do not provide first-hand accounts of the war experiences from the perspective of the local agricultural populations. The health changes experienced by these local populations during the creation of the contested socio-political border along the modern Anglo-Scottish border was hypothesised to have been chronic and severe enough to alter population mortality rates, and to have ultimately have affected the skeletons of those individuals who experienced malnutrition and infections. Four recently excavated Anglo-Scottish border cemeteries were selected from the conflict-zone region, along with four English and Scottish cemetery populations from regions adjacent to the conflict-zone.

All eight skeletal collections were sampled and the skeletons were analysed using currently accepted bioarchaeological methods. The border population was directly compared to the non-border population in an effort to find bioarchaeological evidence for the health and disease consequences of life in a conflict-zone. The changes expected to be observed in the data from the Anglo-Scottish border conflict-zone cemetery populations were:

Demographic and body shape indicators

1. The conflict-zone population was hypothesised to have mortality profiles similar to non-combatant population mortality curves when compared to their neighbours. This trend was expected to be illustrated in high overall mortality in the conflict-zone, specifically high mortality in the younger adults, when compared to the mortality rates in neighbouring contemporary populations.

2. The conflict-zone population was hypothesised to have been stunted, wasted, and more gracile than their contemporary neighbours due to nutritional depravation experienced during the border conflicts.

3. The conflict-zone population was hypothesised to have significantly lower mean platymeric and platycnemic indices, in association with malnutrition, than their contemporary neighbours.

Palaeopathological indicators

1. The conflict-zone population was hypothesised to have higher prevalence rates of general skeletal indicators of stress, specifically cribra orbitalia and enamel hypoplasia, when compared to their contemporary neighbours.

2. Non-specific infection rates were hypothesised to be higher in the Anglo-Scottish border population, both in overall observed periosteal lesion rates and in the rates observed on the maxillary sinuses, the ribs, and the endocranial surface of the skull. This was hypothesised to be a reflection of higher rates of chronic, but not lethal, low-level infections found in modern conflict-zone populations.

3. The conflict-zone population was expected to have higher rates of metabolic bone diseases, specifically indications of vitamin C and D deficiencies and osteoporosis, associated with their experiences of chronic malnutrition.

4. The Anglo-Scottish border population was expected to have similar diets to their contemporary neighbours despite their restricted access to those

resources. Therefore, regional differences in diets were not expected to be indicated by similarities in the prevalence rates for dental caries.

1.3 Significance of Research

This is the first study to assess bioarchaeological differences between two regionally focused populations that differ only in their exposure to chronic socio-political violence. The study attempted to test the robusticity of bioarchaeological descriptions of stressed populations when applied to populations living in the same environments, relying on the same resources, and experiencing the same long-term shifts in climate and culture.

This study is also the first regional survey of morbidity and mortality in medieval northern England and southern Scotland that describes the region as one unique population, and records skeletal data using the same methods. The skeletons compared in this study have been previously analysed (Daniels, 1986; Henderson, 1990; Boulter and Rega, 1993; Anderson, 1994; Cardy, 1997; Holst, 2005; Melikian, 2005, 2009), but, these studies were conducted using various methods of recording and analysis. Therefore, previously generated demographic and palaeopathological skeletal data from these populations was not comparable. Previous comparisons of regional health and disease patterns in Scotland and England have used the modern Anglo-Scottish border as a boundary between medieval populations (Cross and Bruce, 1989; Grove, 1995; Boylston et al., 1998; Boylston et al., 2000; King and Noble, 2002; Roberts and Cox, 2003; Anderson et al., 2005). However, the historical and cultural evidence available from the medieval period has described more similarities between general populations living within both the Scottish and English border regions, than with English populations living south of the Pennines or the Scottish highland populations (Fraser, 1971; Mackie, 1978; Lomas, 1996a; Winchester, 2000; MacIvor, 2001).

1.4 Structure of Thesis

This thesis is organised into six chapters exploring the issues of changes in public health associated with conflict, socio-political instability in medieval Britain, and how that instability was reflected in health as observed in the bioarchaeological record from Anglo-Scottish border cemeteries.

Chapter 2 describes changes in mortality and morbidity observed in modern regions of conflict from the perspective of living populations, and how those changes might be observed in archaeological skeletal populations. The medieval documentary and archaeological evidence from England and Scotland that describes social, political, and economic changes in the Anglo-Scottish border region from approximately 900 to 1600 AD are also summarised. The changes, from a cohesive community of Northumbrians to a volatile and contested international border between the two countries, are outlined. Chapter 3 describes the skeletal materials chosen, and the analytical methods applied to a random sample of eight cemetery populations. Chapter 4 documents the results of these analyses, followed by a statistical comparison of data between the 'conflict-zone' and 'neighbours' regional populations. Chapter 5 summarises the results of the analysis and provides an interpretation of the impact of a conflict-zone lifestyle on the evidence for mortality and morbidity, with Chapter 6 providing conclusions and suggestions for future work.

1.5 Definitions

Many of the terms used in bioarchaeological research are words with broad applications throughout the research community. The following definitions attempt to clarify the author's specific intent when using these words in the following thesis.

1.5.1 Conflict-Zone

A conflict-zone in the context of this study is a geographic region whose native inhabitants are directly affected by socio-political instability, which has degenerated into armed conflict on one or more occasions. A border has also been described as a geographic region where socio-political instability is indicated in cultural, political, economical, and linguistic differences between the populations living in the region. However, the distinction between a border and a conflict-zone lies in the source of socio-political instability. A border region is created by political differences and instability between centralised political states or nations. A conflict-zone's existence, however, is not dependent on international politics. A conflict-zone could also exist within a state or nation, and be defined as a social division between ethnic groups, social classes, or be a by-product of immigration. In the context of this study, the conflict-zone examined is also a modern national border. However, that border was

created in the medieval period and was drawn through populations that previously coexisted in the socio-political context of a cohesive kingdom.

1.5.2 Population

A population in the context of bioarchaeological research is a collection of human skeletal remains (Chamberlain, 2006). The populations compared in this study, the conflict-zone and contemporary neighbours populations, were composed of skeletal remains from various parish church and monastic cemetery excavation sites as discussed in Chapter 3. The skeletons included in this study were assumed to have been representative of the individual medieval men, women, and children who lived, worked, and died in the local areas around the cemeteries where they were buried.

1.5.3 Stress

Stress in the context of bioarchaeological studies can be a vague description of any adverse change experienced by a population. However, in the context of this study, stress refers to the specific biological systemic response that the human body experiences to 'noxious stimuli' (Goodman et al., 1988: 173).

> "…principally the pituitary-adrenal cortical and the sympathetic-adrenal medullary, led to the release of 17-hydroxycorticosteroids and catecholamines, respectively. Hydroxycorticosteroids and catecholamines (epinephrine and norepinephrine) act throughout the body in initiation of alarm and increased resistance. Under conditions of real threat, the response is generally adaptive if both the threat and response are short-lived. However, chronic or repeated activations of the stress response may lead to a variety of functional disorders, including cardiovascular disease, ulcers, hypertension, and immune suppression. Conditions which provoke chronic or repeated activations include perceived stressors as well as conditions, such as sociopolitical events, for which individuals perceive little control." (Goodman et al., 1988: 173)

The noxious stimulus explored in this study is specifically socio-political violence. In the medieval Anglo-Scottish border context, stress from socio-political violence was described as chronic fear, war, and malnutrition.

2 Descriptions of Conflict-zone Health

The focus of recent military aggression has changed from engaging enemy troops on a battlefield to directly affecting civilians through 'scorched earth' campaigns of property destruction, disruption of socio-economic infrastructure, and guerrilla warfare strategies (Gibson, 1989; Goldson, 1996; Pedersen, 2002; Panter-Brick, 2010). This change has had detrimental consequences on the health of local populations, with children often characterised as the worst sufferers of these effects (Goldson, 1996; Ghobarah et al., 2004; Annan and Brier, 2010; Pike et al., 2010). The direct effects of political violence are, "mortality and morbidity associated with armed conflict, and indirect effects which include what occur as a consequence of the physical conflict; the disruption of health care and education with resulting infection, malnutrition and the displacement of families" (Goldson, 1996: 810). Violence and socio-political instability in modern border regions in particular have been shown to instigate a decline in the health of populations living within the region of unrest (Gibson, 1989; Horton, 1999; Cardozo et al., 2004; Brajša-Žganec, 2005). The definition of a border, however, has been justifiably vague. In modern contexts, borders between humans have been created along political divisions between nations and states, separations between peoples of difference ethnic or religious identities, and between individuals of different socio-economic lifestyles (Horton, 1999; de Jong et al., 2008; Pike et al., 2010; Varley, 2010). Pedersen (2002: 176) described the change in contemporary wars as, "less of a problem of relations *between* states than a problem *within* states."

2.1 Conflict-zone Health in Living Populations

Prior to the 1980s, socio-cultural anthropology studies in regions of political instability largely focused on collecting ethnographic descriptions of non-western cultures, while experiences of violence or chaos associated with political or socio-economic changes have been tangential anecdotes noted by researchers as interfering with or distracting from their primary research goals (Avruch, 2001: 638 - 41). "Although some of the dominant theoretical paradigms utilized in anthropological inquiry over the last century – evolutionism, structural functionalism, acculturation

studies, and marxism – have examined societal manifestations of violence, the lived experiences of their research subjects have often been muted" (Green, 1994: 228). However, the focus of anthropological publications shifted towards describing conflict experiences and the expression of violence in cultural contexts during the 1980s and 1990s (Avruch, 2001; Panter-Brick, 2010; Pike et al., 2010).

Since this change in anthropological studies, qualitative studies of the impact of conflict have described chronic malnutrition and infectious diseases, delayed growth in children leading to a decrease in maximum height (stunting) and weight (wasting), higher mortality rates in infants and children, and mental health symptoms associated with post-traumatic stress in the local populations residing in regions of conflict (Green, 1994; Panter-Brick, 1998; Jones, 2002; Pedersen, 2002; Nepal, 2007; Pike et al., 2010). Furthermore, medical anthropologists have attempted to quantify the health changes experienced by local populations in conflict-zones and described in previous anthropological surveys (Miller and Rasmussen, 2010; Panter-Brick, 2010; Spiegel et al., 2010). The results of this research are summarised in the following sections describing the health changes observed in regions of socio-political instability.

2.1.1 Current Public Health Trends

Current research in modern war zones has documented increases in metabolic and infectious disease prevalence rates associated with political and social instability. "Infectious diseases and neonatal disorders remain the largest cause of excess mortality in conflict settings" (Spiegel et al., 2010: 342). Conflict-zone populations suffer from high rates of pneumonia, endemic diarrhoea, cholera, and increased mortality from exacerbation of existing non-infectious diseases, such as diabetes and cancer due to the changes in standards of living, medical care, and exposure to new pathogens when a stable, modern population is transformed by war (Cardozo et al., 2004; Spiegel et al., 2010).

Similar trends have been observed in the currently on-going conflict in Iraq (Salvage, 2007). Increased mortality has been recorded in infants, children under the age of five, and in adult males associated with increased violent deaths not directly related to war trauma, but as a result of increased tension in a living environment (Salvage, 2007: 10). Increased prevalence rates of diarrhoeal diseases, acute respiratory infections, and typhoid, particularly in children, have also been

documented in Iraqi populations where the conflict has removed access to clean water and basic levels of sanitation (Salvage, 2007: 10).

Increased mortality rates, specifically deaths associated with diarrhoea-related diseases, also correlated with surges in the number of migrants into the Darfur region of Sudan following a government supported agenda of ethnic cleansing and genocide, which began in 2004 and continues today (Degomme and Guha-Sapir, 2010). Since the instigation of violence, large refugee camps have been established in Darfur with humanitarian aid agencies attempting to mitigate the mortality and morbidity crisis in these camp populations. Degomme and Guha-Sapir's (2010) analysis of mortality data from 63 surveys in Darfur refugee camps attempted to introduce more nuanced mortality figures by separating the rates by causal factors. This reassessment showed a decrease in violence-caused mortality in the Darfur populations between 2004 and 2008 (Degomme and Guha-Sapir, 2010). However, there was a dramatic rise in diarrhoea-related mortality during the same period with marked peaks in mortality during events when humanitarian aid workers were ejected from Darfur due to political instability (Degomme and Guha-Sapir, 2010).

A recent and on-going ethnic conflict in modern northern Pakistan has shown the negative effect conflict can have on the populations that choose to remain in a region of tension, violence, and fear. Ethnic prejudice and violence between Sunni, Shia, and Ismaili muslim populations in the town of Gilgit has led to differential access to obstetric care and increases in maternal and infant mortality for Sunni women where violence and prejudice have excluded Sunni populations from safe access to modern medical care (Varley, 2010). "With Gilgit's obstetrical health facilities located in exclusively or predominantly Shia enclaves, and staffed largely by Ismailis and Shias, Sunni physicians and patients were profoundly impacted. The town's primary government hospital saw an approximately 90% decrease in Sunni maternity patients following the onset of conflict" (Varley, 2010: 64). The conflict specifically experienced by Gilgit's population occurred in 2005, following a build-up of ethnic division and tension in the area since the 1970s over land ownership, and was characterised by curfews, mortar attacks, bombings, and police surveillance (Varley, 2010). The infrastructure of Sunni socio-economic systems were also directly affected by the escalation of violence in 2005 with school closures, media and telecommunications blackouts, Sunni business strikes, and Sunni officials, including physicians, were frequently targets of attacks by Shia and Ismaili individuals (Varley,

2010). Prior to the 2005 conflict, maternal morbidity and mortality were estimated at 8.9/1000 live births and was largely attributed to severe iron deficiency anaemia, in-utero foetal death, preeclampsia, ruptured uterus, post-partum haemorrhage, and sepsis resulting from home-births, hospital deliveries, and illegal abortions (Varley, 2010: 62). Qualitative data collected by Varley (2010) described Sunni women unable to travel to doctor appointments because they could not or would not endanger male family members who must accompany them in public, the inability of Sunnis to arrange taxi travel to hospitals and clinics outside of their ethnic neighbourhoods, and the absence of Sunni medical personnel in obstetric units during periods of increased tensions. She also spoke with doctors whose Sunni patients were rushed out of hospitals shortly after giving birth by their apprehensive male relatives, given incorrect diagnoses by stressed doctors and untrained nursing staff, and refused treatment by Shia or Ismaili staff (Varley, 2010). A quantitative assessment of this hostile environment on maternal and infant mortality is still on-going, but Varley (2010) estimated that they would mirror higher levels commonly seen in rural Pakistani populations that do not have regular access to modern medical treatment.

2.1.1.1 The aftermath of conflict

Recent anthropological studies among modern populations have also described health changes observed in regions where war violence has recently ended. Although violent events have ceased to directly affect local populations in these particular examples, these current studies have shown that chronic health problems remain part of the post-war experience of local populations.

The Guatemalan army subjected the local populations within the Mayan regions of the country to scorched earth campaigns of property destruction, the involuntary imprisonment of community members, and clandestine executions following a political coup in the 1970s (Green, 1994: 243 - 4). Green (1994) listened in 1989 to first-hand accounts from Mayan women and children of violent raids, involuntary detention, and executions of family members in Guatemala and the detrimental mental and physical health changes they experienced during the 1970s. The widows and orphans who lost family members during the subsequent military occupation in the 1980s described symptoms of chronic headaches, gastritis, ulcers, diarrhea, sleeplessness, loss of appetite, and depression during the anthropologist's research visit (Green, 1994: 246 - 9). Green also described the local children as

displaying overt signs of stunting, malnutrition, and chronic respiratory infections (Green, 1994: 248 - 9).

Similarly, Cliff and Noormahomed (1993) described high rates of infant and child mortality, malnutrition, and infectious diseases in Mozambique in association with that country's post-colonial civil war, which began in 1977 and ended in 1992. One year after the end of the multi-generational conflict, epidemics of measles, cholera, scabies, diarrhoea, respiratory infections, and malaria were recorded both in populations living in areas directly affected by conflict and among populations who fled the conflict-zones (Cliff and Noormahomed, 1993: 845). The estimated annual infant mortality was 200 deaths per 1000 live births and the annual mortality rates in children under five-years-old was estimated at 350 deaths per 1000 children (Cliff and Noormahomed, 1993: 845). Malnutrition was described as the leading cause of infant and child mortality (Cliff and Noormahomed, 1993: 845). Of the children who did survive, a survey of 275 individuals found that 53% were stunted and 7% were wasted (Cliff and Noormahomed, 1993: 845).

2.1.1.2 Health in the former Yugoslavia: A regional survey

In 1991, ethnic conflict between the Serbs, Croatians, Bosnians, and Kosovo Albanians in Yugoslavia erupted into war which created new nations and reiterated to the western world the health consequences of life in a region of violent conflict (Weinberg and Simmonds, 1995; Brajša-Žganec, 2005; Wang et al., 2010). The negative affects of this conflict on public health were monitored by humanitarian aid workers and research communities in an effort to mitigate both the immediate and long term mortality and morbidity consequences of a conflict-zone lifestyle. The results of this research indicated rates of mortality and infectious diseases increased dramatically in the immediate aftermath. The long-term consequences of the conflict on population health and quality of life described high rates of child mortality, delayed puberty in adolescents, and chronic pain in adults.

Throughout the conflict, the World Health Organisation (WHO) aimed to record the rates of communicable disease in Bosnia with varying degrees of success (Weinberg and Simmonds, 1995). Weinberg and Simmonds' (1995) analysis of the available epidemiological data from WHO during the war demonstrated a significant increase in infectious diseases, specifically water-related disease such as enterocolitis, hepatitis A, and scabies. These trends were particularly high in the displaced refugee

groups that moved out of the regions directly affected by the conflict (Weinberg and Simmonds, 1995). A significant delay in the onset of puberty was documented in the females in the Croatian city of Šibenik when comparing onset ages from before the conflict in 1985 to those after the conflict in 1996 (Prebeg and Bralic, 2000). Prebeg and Bralic's (2000) study showed this trend of delayed menarcheal age in girls was in contrast to the overall trend of the earlier onset of puberty observed in six other populations in Croatia that were not directly affected by war. This study described the potential for long-term consequences in the health and development of children in the aftermath of a conflict.

In 1995, four years after the war began, Brajša-Žganec (2005) surveyed 583 Zagreb school children between the ages of 12 and 15 years for depression symptoms associated with their personal experiences during 1991. This study found that girls displayed more symptoms of depression overall; however, boys suffered from higher rates of depression symptoms associated specifically with their direct experiences of war (Brajša-Žganec, 2005: 40). Of these children, 283 were refugees who moved to the city in 1991 from areas of conflict in Croatia and 300 were born and raised in Zagreb (Brajša-Žganec, 2005). The author, however, did not present the differences in depression rates between the children who were refugees in comparison to those who were permanent residents of Zagreb. Therefore, it was impossible to assess whether the difference in depression rates between the sexes was affected by their initial residence in a conflict-zone, their experiences as migrants, or other causal factors.

To assess the more long-term affects of war on public health, Babiae-Banaszak et al (2002) surveyed 1297 individuals between 1997 and 1999 to quantify physical and mental health in a Croatian population in the years following the war. Within the population surveyed, respondents were divided into two groups; one group that lived in locations directly affected by the war and a second group which was indirectly affected. Significantly higher rates of depression symptoms and perceptions of physical and emotional ill health were reported in those populations that directly experienced the war (Babiae-Banaszak et al., 2002: 397 - 8). Younger respondents in the conflict regions, those between 18 and 24 years old, also reported significantly higher rates of bodily pain (Babiae-Banaszak et al., 2002). Although these results suggested that populations residing in the regions directly affected by conflict within Croatia were overall in poorer health, particularly the younger individuals with lower

levels of education and lower incomes, this study specifically focused on the individual's perceptions of health rather than the actual rates of morbidity in the populations (Babiae-Banaszak et al., 2002).

Horton's (1999) summary of health problems in the Croatian town of Vukovar, on the newly formed border with Bosnia, described twice the level of heart disease, hypertension, ischaemic heart disease, and cerebrovascular disease among refugees who had moved into the city and away from conflict-zones in the surrounding rural landscape. He also noted a reported 50% increase in tuberculosis and a general increase in hepatitis A in Bosnian populations (Horton, 1999: 2141). Reported rates of post-traumatic stress disorder (PTSD) also increased from five to six percent in the population of Vukovar before the war to 27% in 1999 (Horton, 1999: 2142).

The effect of war experiences on the health of older adults is another area of research that could be conducted in this living population. Horton (1999) described how the breakdown of social services and infrastructure in a rural region of Croatia, which passed between Serbian and Croatian control in 1995, resulted in the temporary isolation of the elderly in local villages. Out of 524 villages directly affected, more than 75% of the total population that remained in 1995 were over 60 years old, of which half did not have electricity, a third had no income, and six percent needed emergency medical care (Horton, 1999: 2143-4). "Older people were badly affected and frequently less able to cope with their experiences than their younger counterparts" (Horton, 1999: 2143). However, the extent of the war's affect on overall mortality and morbidity rates, or the long-term impact on health, in the elderly of Croatia have not been reported.

The populations of northern Kosovo were also involved in ethnic conflict between the ethnic Albanians and the Serbs between 1991 and 1999. The residents of the Mitrovicë region today are socially divided between the two ethnic groups and they have been geographically separated, with the majority of Albanians living in the southern portion of the district and the Serbs in the northern portion (Wang et al., 2010). Low level violence still exists between these two ethnic groups in northern Kosovo despite the official end of the war. In an effort to describe the long-term consequences of the war and its continuing violence in this region, Wang et al (2010) surveyed 1115 households in 2008 to quantify rates of war injuries and persistent pain. The results of their study indicated an overall higher population mortality rate,

with a reported child mortality rate that was double the rate in Serbia in 2007 (Wang et al., 2010: Table 1). There were also higher levels of pain in the individuals older than 15 that directly experienced injury or torture related to the ethnic violence (Wang et al., 2010).

These recent studies of mortality and morbidity trends over two decades of war, social and political instability, and low-level violence have describe the continuing detrimental affects of stress, malnutrition, and infectious diseases on local populations directly impacted. Particularly at-risk were the children and young adults who were growing and developing socially when the conflict began. Higher mortality rates, delayed maturation, and high rates of depression and anti-social behaviour were specifically observed in the children of Bosnia, Croatia, and Kosovo Albanians.

2.1.1.3 Infant and Child Health

Recent studies in other conflict-zone populations have described similar trends of increased infant and child mortality and morbidity rates in children exposed to violence throughout the world (Gibson, 1989; Goldson, 1996; Panter-Brick, 1998; Pedersen, 2002). Previous research has shown that the developing body and immune system of a child is more vulnerable to the illness and mortality associated with a conflict-zone lifestyle because a growing child has not had the opportunity to fully develop immunity to diseases which are more prevalent during disruptions in normal social and political infrastructures and is more in need of nutritional stability to sustain their biological maturation (Johnston, 2002; Lejarraga, 2002; Norgan, 2002; Mulholland and Adegbola, 2005; Bellos et al., 2010). Anthropological studies of living children in the context of recent conflicts have found consistently higher rates of child mortality, malnutrition, and morbidity in populations from around the world. Direct experience of political violence has also significantly increased the rates of domestic violence and rape in local women (Barthauer and Leventhal, 1999; Cottingham et al., 2008; Clark et al., 2010). These episodes can lead to unwanted or unplanned pregnancies, putting both the health of the abused woman and the child at risk (Cottingham et al., 2008).

In 1990, two months following the Iraqi army's invasion of Kuwait and the evacuation of refugees to Saudi Arabia, 106 Kuwait children between seven and 14 years old were surveyed for health and emotional problems associated with the violence and terror they had experienced during the invasion of their country (Al-

Eissa, 1995). This study reported significantly higher rates of anorexia, constipation, weight loss, difficulty sleeping, and nightmares in the Kuwaiti children when compared to the rates observed in 120 Saudi children of the same age who were unaffected by conflict (Table 2.1).

Table 2.1: Frequency of affective symptoms in Kuwaiti and Saudi Arabian children following the onset of the Iraq invasion of Kuwait (Al-Eissa, 1995: 1034).

Symptom	Kuwaiti Children Cases/No.	%	Saudi Arabian Children Cases/No.	%	Difference (p)
Headache	25/106	24	17/120	14	0.069
Anorexia	37/106	35	16/120	13	<0.001
Vomiting	8/106	8	6/120	5	0.428
Diarrhoea	13/106	12	8/120	7	0.148
Abdominal Pain	19/106	18	16/120	13	0.341
Constipation	22/106	21	11/120	9	0.020
Weight loss	31/106	29	10/120	8	<0.001
Difficulty sleeping	37/106	35	8/120	7	<0.001

In contrast to the relatively brief experiences of war in Kuwait, Angola has been politically unstable and in a general state of civil war since 1975, when it declared independence from Portuguese colonial rule. "Although war has been part of Angolan reality for decades, it has not affected the country evenly. Some parts of the country - both rural and urban - have suffered direct and generalized devastation, especially during the 1992 – 1994 fighting, whereas other parts have been largely spared direct fighting and have been affected indirectly" (Agadjanian and Prata, 2003: 2516). A 1996 survey of 4440 households, conducted by Agadjanian and Prata (2003), aimed to explore the relationship between conflict and malnutrition within the context of modern civil war, health care, and ethnicity. This study described the nutritional health of children born during intense fighting, between 1991 and 1994, in contrast to the health of children born after the end of the violence, between 1995 and 1996 (Agadjanian and Prata, 2003). Their description of malnutrition was defined by smaller height and weight measurements taken from living children throughout the country, rather than physical symptoms of nutritional deficiencies. The authors found malnutrition rates in the Angolan population were higher than the rates observed in other sub-Saharan African countries (Agadjanian and Prata, 2003).

Additionally, Agadjanian and Prata (2003) compared the malnutrition prevalence rates in living children between two regions in Angola that were differently affected by conflict, specifically during the 1992-1994 period of fiercest fighting. One region was directly exposed to violent conflict and economic disruption caused by the war and was essentially removed from access to modern services such

as electricity, running water, and access to health care. In contrast, the other region was indirectly exposed to the conflict and only experienced long periods of disrupted access to modern services and reduced economic activities. The results of this analysis found higher levels of both stunting and wasting in the regions more directly affected by war (Agadjanian and Prata, 2003: 2522). The higher rates of wasting were overall found in younger children. Stunting, however, showed a more dramatic relationship with other socio-economic factors and malnutrition rates in Angola. This study ultimately concluded that, "children living in the parts of the country where fighting had been particularly ferocious and generalized, and the devastation most profound, exhibited significantly higher levels of malnutrition, especially of stunting, than did children living in the country's less affected parts" (Agadjanian and Prata, 2003: 2525).

Civil war in Angola erupted again following Agadjanian and Prata's 1996 survey, but finally concluded in 2002. Avogo and Agadjanian (2010) conducted another survey in 2004 of families in Luanda, the capital city of Angola, and attempted to identify long-term patterns of child morbidity and mortality associated with that country's 25-year civil war. The interviewed population was divided into three groups: those who migrated to Luanda because of war-related violence in other regions of Angola, those who migrated to Luanda for reasons other than war (such as economic opportunity), and permanent residents of the city who did not migrate. The results of this survey identified significantly higher mortality in children younger than five within the war-related migrants in comparison to the non-war migrants and the long-term residents (Avogo and Agadjanian, 2010). The authors noted these increased rates were specifically observed in the first year following family migration and related these deaths to malnourishment and physical injuries experienced in conflict-zones compounded by the psychological stress and health consequences of forced migration to an unfamiliar environment (Avogo and Agadjanian, 2010: 58).

Anthropomorphic descriptions of stunting and wasting have been shown to have a synergistic relationship with chronic disease in children (Panter-Brick, 1998; Bejon et al., 2008). Disease can initially cause growth disruption in children, but malnutrition can maintain the disease state and contribute to the early death of the child (Johnston, 2002; Norgan, 2002). Bejon et al's (2008) survey of Kenyan children younger than five years old admitted to hospital found severe wasting was more strongly linked with acute disease and mortality than stunting. Severe malnutrition,

described by anthropomorphic measurements for stunting and wasting, was observed in over half of the cases of severe malaria, gastroenteritis, lower respiratory infections, HIV, and invasive bacterial disease in this Kenyan population (Bejon et al., 2008).

A similar analysis of growth data from African children took in a wider geographical area when describing the effects of conflict on wasting in children (O'Hare and Southall, 2007). O'Hare and Southall's (2007) analysis of United Nations Children's Fund's (UNICEF) 2004 demographic data on health in sub-Saharan Africa showed significantly more children under five years-of-age were underweight in 21 countries that had recently experienced conflict, between 1990 and 2004, when compared to 21 other African countries that were politically stable during the same period of time. They also found that infant and maternal mortality was significantly higher in the countries that experienced conflict (O'Hare and Southall, 2007).

Recent medical research into the long-term effects of stunting and wasting in childhood has found a link to heart disease later in life (Barker et al., 2005; Head et al., 2008). Barker et al's (2005) study of 8760 Helsinki residents demonstrated that children who had below average body mass during the first two years of life, and later 'caught-up' with their peers by reaching their age-appropriate average body mass by 11 years old, were significantly more likely to develop coronary heart disease in adulthood. Although both the males and females in the study demonstrated a significant association between low-weight in childhood and heart disease in adulthood, stunting between birth and two years was also associated with heart disease in males (Barker et al., 2005: 1805).

For the individuals who developed heart disease later in life, the mean weight of both boys and girls between birth and two years of age was between one and three standard deviations below the average population mean (Barker et al., 2005: 1805). For the males, the mean height for age was also between one and two standard deviations below the population mean between birth and ten years of age for those who developed heart disease in adulthood. Height in the females with heart disease had a less significant difference from the population mean, but remained at least one standard deviation below the population mean between the ages of four and ten years (Barker et al., 2005: 1805). "These observations demonstrate that coronary events are independently associated with both prenatal and postnatal growth. We found that the effects of body size at these three ages [i.e. birth, two years, and eleven years old]

were independent of the effects of socioeconomic status in adulthood" (Barker et al., 2005: 1808). The authors related these trends of undernutrition in pre- and post-natal development to a resistance of muscle tissue to insulin which led to a disproportionate high fat mass and coronary heart disease in adulthood when these individuals experienced "catch-up growth" as a relatively rapid increase in body mass during later childhood (Barker et al., 2005: 1808). Although these individuals had not been directly exposed to the adverse health effects of birth and early childhood in a region of conflict, low birth weight and underdevelopment in infancy due to malnutrition had an adverse effect on their body mass indexes and the health of their hearts in adulthood. These trends could be expected to hold for a population whose low birth weights and underdevelopment in childhood was caused by malnutrition and stress in both their birth mothers and themselves in a conflict-zone.

Head et al (2008) found similar trends of heart disease associated with starvation and malnutrition experienced by the youths of Guernsey Island during the German occupation of the island from 1940 to 1945. This study compared the rates of cardiovascular disease in 873 adults, of which 225 had been exposed to food deprivation and German occupation, and 648 who were evacuated from the island before the occupation (Head et al., 2008). In contrast to Barker et al's results, Head et al (2008) found no association between low birth weight and heart disease in the Guernsey adult population. However, those individuals who experienced food depravation and the German occupation were significantly more likely to have cardiovascular disease in later life (Head et al., 2008). Those children who were born in urban parishes, where food shortages were more severe during the occupation, were also at significantly greater risk for heart disease than those children who were born in rural parishes (Head et al., 2008).

Caballero (2005) observed an association between undernourished children and overweight mothers in developed or developing countries. This association was specifically noted in Kyrgyzstan, Indonesia, and Russia, where poor socio-economic conditions have contributed to slower rates of child development in past generations (Caballero, 2005: 1514). The observed increase in body mass in these mothers could be the biological response of a body that developed in a state of undernutrition when restricted access to food is removed later in life. Similar to the trends in the Icelandic population, these women are at greater risk of developing heart disease and their

undernourished children are at greater risk of developing a body mass classified as medically obese in adulthood.

These previous studies of the overt health and mortality changes observed in children living in conflict-zones have described the detrimental effects of war on the nutritional status and development of local children, which can lead ultimately to higher mortality rates in the most vulnerable children within the population. For those children who survived to adulthood, their experiences of poor health during development put them at greater risk of developing cardiac, gastro-intestinal, and metabolic health problems later in life.

2.1.1.4 Mental Health

Conflict experiences have been strongly correlated with symptoms of mental illness associated with PTSD in living populations who both directly and indirectly experience violence (Dean, 1997; Cardozo et al., 2000; Jones, 2000; Friedman, 2005; Nepal, 2007; Pols and Oak, 2007). Numerous recent studies have described a synergistic relationship between war experiences, mental illness, and physical illness. These recent studies of the effects of war on mental health in living populations have shown how psychological stress can adversely affect health with increased experiences of pain, depression, and the potential for long-term poor health.

Tol et al's (2010) survey of the published literature on mental illness in Nepal associated with the ongoing conflict between Maoist rebels and the royalist government found the highest rates of mental illness in those individuals who personally perpetrated or survived physical violence (Table 2.2).

Table 2.2: Mental illness prevalence in modern Nepalese population samples (Tol et al., 2010: 41).

Mental Illness	Population Assessed	Prevalence Rate
PTSD	Refugees	3 % / 4 %
	Tortured Refugees	14 % / 43 %
	Internally displaced populations	53 %
	Torture survivors seeking help	60 %
	Former child soldiers	55 %
	Children never conscripted	20 %
Depression	Refugees	14 %
	Tortured Refugees	25 %
	General population	30 %
	Internally displaced populations	80 %
	Torture survivors seeking help	81 %
	Former child soldiers	53 %
	Children never conscripted	24 %
Persistent Pain Disorder	Refugees	28 %
	Tortured Refugees	51 %
Functional impairment	Former child soldiers	62 %
	Children never conscripted	45 %

Gibson's (1989) review of previous research on the reactions of children to the stress of political violence, described as the involuntary detention of family and community members and the children themselves witnessing violent acts, discussed personality changes and mental health issues in adolescents who have grown up experiencing political violence. Acute reactions included normal responses of weeping, shaking, and intense nervous energy, sleep disturbance, loss of weight and appetite (Gibson, 1989: 659, 62). Chronic reactions were described as the same, but they continued to occur well after the crisis with the purpose of conveying distress and "serving a defensive function by altering the child's contact with reality" (Gibson, 1989: 661). Children responded most severely to events which interfered directly with the organisations of their family or community groups via detentions, or when they directly witnessed physical violence which resulted in feelings of 'survivors' guilt' (Gibson, 1989: 663 - 4). The reactions of children differed by sex, in that boys are more sensitive to stress than girls, and by age, with infants and toddlers responding more severely to dentition of an immediate family member, young school children to the loss of possessions or absence of community members, and adolescents to the threat of physical violence they or their family might experience (Gibson, 1989).

Northern Kenya is currently experiencing endemic warfare on a chronic, low-intensity scale between three ethnic groups of African pastoralists, the Samburu, Pokot, and Turkana (Pike et al., 2010). Interethnic violence among these populations is characterized as violent encounters between individuals self-identifying as belonging to enemy communities (Pike et al., 2010: 45). The violence consists specifically of raids where members of one ethnic community attack a village consisting of individuals subscribing to another ethnic identity with the aim of stealing livestock, meanwhile also causing traumatic injuries and occasionally death (Pike et al., 2010: 46). This low-intensity fighting has taken place in this region for at least several decades and has contributed to an attitude within Kenya that the northern regions of the country are, "backward and warlike, contributing to easy population and elite dismissal of northern conflicts as 'timelessly tribal'" (Pike et al., 2010: 49). Pike et al (2010) have collected descriptions of health changes associated with this on-going conflict and the changes in socio-economic status caused by theft of household wealth (cattle) in all three ethnic groups. They list disrupted sleep, nightmares, and

heart palpitations in adults as lingering physical complaints in addition to the traumatic injuries sustained in raids. These populations rely on livestock production as the only viable source of income in this marginal environment and they derive the majority of their diet from the meat, milk, and blood of cattle, camels, donkeys, goats, and sheep (Pike et al., 2010: 49). Therefore, the loss of a family's livelihood through theft of livestock can be detrimental to the long-term health and survival of the family. "All three communities cite loss of livestock as a known cause of men's suicides" (Pike et al., 2010: 48).

Akello and colleagues (2010) described a synergistic relationship between psychological stress and physical symptoms of pain and illness in their analysis of children raised in a conflict-zone and directly involved in perpetuating the instability. The communities of Northern Uganda have been systematically prayed upon and exposed to violent village raids by the Lord's Resistance Army (LRA), a guerrilla militia force composed of ethnic Acholi and supported by the Sudanese government, since its formation in 1988 (Annan and Brier, 2010). These raids, to provide the LRA with supplies, captured youths to serve as fighters, and captured women to serve as "wives" and servants, attacked Acholi villages among the 'bush' regions of Northern Uganda which provided cover for the LRA (Annan and Brier, 2010). Akello et al's (2010) research into health and disease patterns in northern Ugandan children explored the relationships between decades of armed conflict, mental health trauma, physical symptoms of illness, and social coping mechanisms in children between the ages of nine and 16 years old. These children described non-specific chronic pain, such as headaches and chest aches, which were not resolved with medical treatment. One girl who had been raped complained, "I am feeling pain all over me and also stomach ache. I am not sick but because of bodily pain I need prayers" (Akello et al., 2010: 215).

Annan and Brier (2010) interviewed 36 women in 2009 who had escaped from their LRA captors and returned to their families, in some cases with children born of LRA fathers. These women described, "going without food, walking long distances, as well as witnessing, experiencing, and some even being forced to perpetrate violence against strangers and peers. Nearly everyone in the region experienced some war violence, but abducted females experienced significantly higher levels: 13 types of violence were reported in the full survey compared to eight by non-abducted females" (Annan and Brier, 2010: 155). Upon returning to their families, some of

these women described experiencing nightmares, anger, emotional sensitivity, and violent outbursts (Annan and Brier, 2010: 155 - 7). The traumatised populations of northern Uganda were also subjected to forced displacement in 2002 when the government established camps and depopulating the countryside. "In 2006, when our first interviews took place, there were 1.7 million people, nearly 90% of the Acholi population, in displaced camps. Most fell far below emergency standards for hygiene and availability of water" (Annan and Brier, 2010: 153).

The majority of current anthropological studies of population health changes associated with a conflict-zone lifestyle have relied on researchers asking study participants to complete surveys describing symptoms experienced. Jones and Kafetsios (2002) have called into question the reliability of self-assessing surveys for mental illness. The authors argue that self-reporting checklists are helpful for assessing psychosocial distress symptoms in a population; however, they are not useful for assessing actual prevalence rates of diagnosed mental illness in conflict-zone populations (Jones and Kafetsios, 2002). Similarly, the self-perception of illness and diminished functioning in individuals who experienced war could be psychosomatic and should not be taken as synonymous with a medical diagnosis.

2.1.2 Conflict-zone Health in Historical Populations

Recent historical studies have analysed contemporary documentary sources, such as military medical records, parish church records, and census data, to assess the life-long health of military and local populations along the frontlines of past wars (Kemkes, 2006; Pizarro et al., 2006). These studies offer additional detail regarding the long-term impact of conflict on health and found high rates of chronic nutritional deficiencies, malnutrition, and infections as well as decreases in life expectancy in population records dating from as early as the 17th century (Antonov, 1947; Field, 1995; Outram, 2001; Robson et al., 2009). The studies summarised below indicate that conflict negatively effected health in past populations in ways similar to the observations made by anthropologists in living populations.

2.1.2.1 High Mortality

The destabilisation of the Soviet Union's political and economic systems following the Cold War (1947 – 1991) exacerbated the dramatic decrease in Russian population health during that long-term conflict during which the state diverted resources from

supporting the general population to develop industrialisation and defence programs (Field, 1995). Field described a, "dramatic decrease in life expectancy of men," and a general increase in illness throughout the population caused by chronic malnutrition and vitamin deficiencies (1995: 1472 - 3). This research highlighted the long-term increase in population mortality and morbidity patterns when violence, fear, and food depravation even at a low-intensity, becomes chronic.

High levels of infant mortality were reported in a German village occupied by French troops during the French Revolution (1787 – 1802 AD) (Kemkes, 2006). Kemkes' (2006) analysis of the historical demographic data from four German villages in the Rhineland showed an increase in male infant mortality during the French Revolutionary War and a significant shift in the ratio of male to female live births (Kemkes, 2006: 814). The German Rhineland was invaded and occupied by the French army from 1792 to 1802 as part of a campaign of conquest during the French Revolutionary Wars (Kemkes, 2006). German rule was superseded by a French republican government and the local population was conscripted into the French army, charged with economically supporting the occupying French army, and subjected to systematic raids involving torture, rape, and occasional fatalities (Kemkes, 2006: 809 - 10). During and immediately after the war, the number of live male births decreased significantly in comparison to the total number of live female births (Kemkes, 2006). The author associates this shift in restricted access to food and other economic resources by the local populations with the damages inflicted during war (Kemkes, 2006: 820).

Significant decreases in population were also experienced in Germany during the Thirty Years War (1618 – 1648 AD). Population mortality increased with the onset of war and battle-related mortality decreased when hostilities ceased; however, the overall population mortality remained high from starvation and disease in the post-war era (Outram, 2001). Outram's (2001) reassessment of the historical evidence available from Germany suggested reductions in fertility and permanent net migration, associated with chronic malnutrition in the conflict-zones, also contributed to the observed decrease in the German population at the time.

Chronic mental health issues have also been noted in past populations which has had a long-term detrimental affect on the mortality rates of local populations (Sawchuk et al., 2004; Pizarro et al., 2006; Robson et al., 2009). In historical contexts, mental illness is discussed as a co-morbidity that may or may not influence

the overall morbidity or mortality rates recorded in a conflict-zone. For example, Sawchuck et al's (2004) analysis of suicide rates in colonial Gibraltar from 1878 to 1945 described a nuance within the causal relationship between depression associated with social suppression under British colonial rule, which had been present since 1704, and increased mortality in the local residents. Pizarro et al (2006) discuss the co-morbidity of long-term mental illness in former soldiers from the US Civil War (1861 – 1865) as a contributing factor to their premature deaths after the end of the conflict. Similarly, Robson et al (2009) described PTSD as one of many of the debilitating illnesses affecting the long-term recovery of British prisoners of war (POWs) from nutritional depravation, infectious disease, and traumatic injuries sustained in World War II (WWII) prison camps in south-east Asia. Even among those who survived to older age, individuals who experienced war directly, particularly those who were injured and suffered from PTSD symptoms, were more likely to die at a younger age than their contemporary counterparts (Bramsen et al., 2007).

2.1.2.2 Malnutrition

Chronic nutritional deficiencies and starvation are central elements in historic descriptions of illness and mortality in regions of socio-political instability. Between 1918 and 1940, populations in Spain experienced similar episodes of malnutrition, nutritional deficiencies, and wasting associated with political unrest (Barona, 2008). Barona (2008) described how nutritional science developed in the inter-war period out of the observations of wasting and nutritional deficiencies observed in Spanish adults. "Surveys developed by nutritionists at the end of the war indicate that the average loss of weight of the population in Madrid as a result of deficiency diseases represented approximately 30 per cent of their weight before the start of the war" (Barona, 2008: 101). Barona's (2008: 101) own analysis of 1938 to 1939 health data from Madrid showed, in addition to general wasting and mortality, the main deficiency illnesses were pellagra, deficiency neuropathies, optic and acoustic neuritis, simple glossitis, and hunger oedema associated with diets poor in vitamins and protein.

Records from World War II (WWII) have chronicled the visible stunting and wasting caused by food deprivation and malnutrition in children during and following the war (Zellner et al., 1996; Ali and Ohtsuki, 2000; Ali et al., 2000; Ellison and Kelly, 2005). Ellison and Kelly's (2005) analysis of growth rates in British

schoolchildren from 1940 to 1945, directly compared height and weight measurements of children between six and 15 years old from Jersey, London, and rural 'camp' schools. Jersey was under German occupation during this period of the war; the population was exposed to severe food shortages and the constant threat of violence from the occupying force (Ellison and Kelly, 2005). The children who lived in Jersey during the German occupation gained significantly less weight and grew significantly fewer inches in height than their same age cohorts in both London and the 'camp' schools (Ellison and Kelly, 2005: 767). The authors associated the observable changes in growth rates within the Jersey sample with differences in food rationing practices between Britain and Germany, where British rations gave more access to protein, fats, sugar, and dairy products and Germany provided bare minimum caloric rations which were deficient in fats and protein to children between six and 18 years old (Ellison and Kelly, 2005: 770).

Similarly, long-term trends of stunting and wasting were observed in Japanese children following the end of WWII in 1945 (Ali and Ohtsuki, 2000; Ali et al., 2000). Ali and Ohtsuki's (2000) analyses of the Japanese Ministry of Education's annual data on the height and weight of school children found that between 1932 and 1951 the overall population trend of earlier maturation throughout the 20th century was reversed for both boys and girls; boys' growth was more significantly delayed than that of the girls (Ali and Ohtsuki, 2000: 366). This trend was observed in both the decreased stature and body weight of children between the ages of six and 17 years during the WWII and post-war years (Ali et al., 2000). These results indicated that Japanese boys were more sensitive "to poor conditions during and after the war," but that all children were adversely affected by the famines and economic crises of the mid-20th century in Japan (Ali and Ohtsuki, 2000: 367 - 9).

Zellner et al's (1996) study of non-adult growth in German school children identified similar trends of delayed maturation, stunting, and wasting between the late 1930s and early 1940s, caused by the traumatic events of World War II (Zellner et al., 1996). Nine surveys of stature and weight were conducted between 1880 and 1985 on 'healthy' children between the ages of seven and 14 years in the German town of Jena (Zellner et al., 1996: 372). The overall trends of increased stature and body weight through time were demonstrable in both boys and girls. The author associated these trends with improved nutrition, the introduction of antibiotic treatments for infectious diseases, and an increase in protein consumption during the century examined

(Zellner et al., 1996: 379). However, the average stature recorded for girls decreased by 0.6 cm between 1932 and 1944 (Zellner et al., 1996: 376). This study indicated that girls in particular were susceptible to interrupted development during periods of conflict.

2.1.2.3 Increase in chronic disease

More frequent and chronic illness throughout life and a decreased life-expectancy was observed in American Civil War veterans who survived their war experiences (Dean, 1997; Pizarro et al., 2006: 372). Pizarro *et al* (2006) examined the life-long affects of war on the health of soldiers who fought in and survived the American Civil War (1861 – 1865). By analysing the recruitment and post-war medical records of 15,027 Union army soldiers who survived past 1890, the authors were able to identify events of morbidity and mortality associated with soldiers' individual levels of war experiences (Pizarro et al., 2006: 194). Those experiences may have included fighting in multiple battles, killing many enemy soldiers in close hand-to-hand combat, witnessing the deaths of friends, and episodes as a prisoner of war (Pizarro et al., 2006: 194). The results of this analysis described a greater risk of mortality at a younger adult age for those soldiers who were recruited into the military at an age younger than 18 years (Pizarro et al., 2006). Similarly, those men who enlisted at a younger age were later diagnosed with more cardiac, gastro-intestinal, and nervous diseases (Table 2.3) across their adult life than those who were older enlistees (Pizarro et al., 2006: 197). Additionally, those soldiers in companies that experienced more soldiers deaths throughout the war were diagnosed with significantly more illnesses in these three disease categories over their later adult life than those soldiers who were less directly involved in combat (Pizarro et al., 2006: 198).

Table 2.3: Ailments by disease category as diagnosed in American Civil War Veterans by military surgeons in the 19th century (Pizarro et al., 2006: 195).

Disease Category	Symptoms
Cardiac	irregular pulse, regurgitant or stenotic murmurs, heart enlargement, arteriosclerosis, edema, cyanosis, dyspnea, impaired circulation.
Gastro-intestinal	diarrhea, dyspepsia, pain, ulcer, vomiting food or blood, abdominal tenderness, dysphagia, malassimilation.
Nervous	paranoia, psychosis, hallucinations/illusions, insomnia, confusion, hysteria, memory problems, anxiety, depression, antisocial behaviour, trouble with balance, aphasia, paralysis, tremor, vertigo, headaches, epilepsy.

High rates of infection and chronic health problems associated with malnutrition have been recorded in military populations that survived WWII. Robson et al's (2009) study of British WWII prisoners of war (POWs) held in Japanese prisons in south-east Asia describes the long-term health consequences of untreated malnutrition and infectious diseases in an adult population. In 1941-42, the Japanese advanced throughout Asia and captured Singapore from the British, which maintained a military presence of approximately 100,000 troops (Robson et al., 2009: 88). These troops were assembled as prisoners of war, transported to various camps throughout south-east Asia, and used as a forced labour (Robson et al., 2009: 88). During captivity, these prisoners of war were severely malnourished on a diet primarily of poor-quality rice, experiencing extreme weight loss and nutritional deficiency diseases, and were exposed to infectious diseases, such as malaria, tuberculosis, and chronic dysentery, for which they received little or no medical treatment (Robson et al., 2009: 89). After returning to the UK, veterans of this POW experience experienced higher rates of mortality at younger ages from tuberculosis, chronic liver disease, and cirrhosis (Robson et al., 2009: 90). High rates of chronic tropical infectious diseases and parasites were also recorded in this population (Robson et al., 2009). Nutritional neuropathy, or permanent damage to the nervous system associated with chronic malnutrition which included optic atrophy, deafness, sensory loss, loss of tendon and muscle control, and wasting, was described in British, Australian, and American veteran populations from these POW camps (Robson et al., 2009: 92). Medical studies conducted 30 years after the war reported the overall infection rate in this population remained at 15% (Robson et al., 2009: 87). One case of an infectious complication associated with a traumatic grenade injury affected the trauma victim than 60 years after the initial injury (Surov et al., 2006).

2.2 Recognising the bioarchaeology of conflict zone health: overview of the literature

The increases in mortality, malnutrition, and rates of disease observed in living and past populations through previous surveys and analyses of historical records have been described in various cultures, environments, and time periods. These changes in population health in association with socio-political instability seemed consistent across human populations. If a conflict-zone lifestyle is indeed a causal factor for

high mortality and morbidity in human populations, then bioarchaeological evidence of these trends should be observable in past populations associated with documented episodes of socio-political instability. Bioarchaeological indicators of conflict-zone health, specifically demographic evidence of increased mortality, palaeopathological indicators of non-specific stress, and metabolic bone diseases, have not been described in previous studies of human skeletal remains from historically verified war zones to date. Skeletal evidence of stress associated with violent conflict has only been introduced as a hypothetical interpretation of skeletal changes observed in prehistoric cemetery populations (Larsen, 1997; Klaus and Tam, 2009). This is the first study to search for skeletal evidence of nutritional stress in an historic population from a known war zone. A review of the hypothesised skeletal indicators of conflict-zone health is summarised in the following section.

2.2.1 Skeletal Stress

The skeleton is a living tissue, similar to other organs in the body, which supports and protects the vital organs (Hall, 2005). Bone goes through a continuous recycling process throughout life; new bone is deposited by bone-forming cells (osteoblasts) and dead or diseased bone cells are consumed by bone resorbing cells (osteoclasts) (Hall, 2005). This gradual resorption and formation of bone occurs on a consistent basis in an environment of biological homeostasis (Hall, 2005). Bone can respond to stress, or disruption to its normal function, in only two ways; it can either be formed or resorbed (Goodman et al., 1988; Larsen, 1997; Ortner, 2003). "Conditions which provoke chronic or repeated activations [of systemic biological responses] include conditions, such as socio-political events, for which individuals perceive little control" (Goodman et al., 1988: 173).

As seen in the previously summarised medical, anthropological, and historical studies, physical and psychological stress from experiences in a conflict-zone can reduce the ability of the human body to function at its peak through food deprivation, malnutrition, increased exposure to infectious disease, and reduced social functioning (Goldson, 1996; Pedersen, 2002; Tol et al., 2010). In turn, the decreased health and productive potential of a conflict-zone population may reduce their ability to recover food resources, thus perpetuating the negative affects of conflict-zone malnutrition (Norgan, 2002; Roberts and Manchester, 2005: 222). When the body is unable to recover from disease, nutritional deficiencies, or systemic biological stress, an

individual remains chronically ill and might develop bone changes associated with poor health. Chronic forms of stress have been described in human skeletal remains in previous bioarchaeological studies as a suite of demographic and palaeopathological trends labelled, 'indicators of stress' (Table 2.4).

Table 2.4: Demographic and pathological indicators of skeletal stress (Goodman et al., 1988: 179).

Data Type	Stress Indicator	Ages at Risk	Severity	Possible Causes
Demographic	Mortality Profile / Life expectancy	All Ages	Severe and Chronic	Adaptive response to multiple types of stress.
	Adult Stature	Non-adults	Chronic	Chronic undernutrition during development.
	Growth Retardation	Non-adults	Chronic (one year)	Chronic undernutrition.
	Decreased sexual dimorphism	Non-adults	Chronic	Delayed puberty and malnutrition.
Pathological	Enamel Hypoplasia	6 mo. to 7 yrs	Acute	Malnutrition.
	Traumatic Lesions	All Ages	Acute	Interpersonal Violence.
	Periosteal Infections	All Ages	Chronic	Infections.
	Cribra Orbitalia / Porotic Hyperostosis	All	Acute or Chronic	Malnutrition and or infections.
	Osteoporosis	All	Acute or Chronic	Calcium or protein malnutrition in non-adults and women.

These demographic and palaeopathological descriptions appear to be accepted in the bioarchaeological literature as recognizable in skeletal remains and indicate 'stress' in past populations (Larsen, 1997; Buzon, 2006; Boldsen, 2007; Klaus and Tam, 2009). This bioarchaeological survey of medieval British populations from an historic region of conflict is the first study to search for the demographic and palaeopathological descriptions of skeletal stress in archaeological collections of human skeletal remains.

2.2.2 Demographic Changes

Bioarchaeological research defines a population as a group or collection of human skeletal remains (Chamberlain, 2006; Pinhasi and Bourbou, 2008). Furthermore, the quantitative analysis of a human skeletal population can be used to describe mortality patterns and changes in body shape associated with malnutrition and epidemic disease in populations from the past (Chamberlain, 2006), and "when examined together, a number of [pathological] lesions and growth indicators can provide clues to the pattern of nutritional deficiency" (Goodman and Armelagos, 1989: 228).

Previous archaeological studies of chronic malnutrition, infections, and high mortality have been specifically associated with demographic changes in life expectancy, decreased stature in children and adults, decreased sexual dimorphism,

and observable stunting in children (Clark et al., 1986; Goodman and Armelagos, 1989; Humphrey, 2000; Gunnell et al., 2001; Pinhasi et al., 2006; Saunders, 2008; Watts, 2010). To test for these demographic trends in medieval Anglo-Scottish border populations in comparison to their contemporary neighbours, determining the age and sex distributions, stature, and body mass for both the medieval 'stressed' and 'unstressed' populations was necessary to provide the contextual framework for interpreting health and disease patterns observed in the human skeletal remains (Hansluwka, 1985; Ortner, 1991; Mays, 1998; Roberts and Manchester, 2005; Chamberlain, 2006; Pinhasi and Bourbou, 2008). The general methods used to estimate palaeodemography and body shape are summarised in the following sections and the specific methods used are described in Chapter 3.

2.2.2.1 Palaeodemography

Demographic reconstruction depends on the ability to estimate both age-at-death and sex from the skeleton (Loth, 1995). The estimation of biological sex within skeletal populations is necessary to describe differential affects of mortality and morbidity between subgroups in the population as well as essential for some methods of age estimation (Iscan and Loth, 1986b, a; Suchey et al., 1986b, a; Mays and Cox, 2000). Age profiles allow researchers to test for indications of age related stunting and wasting, delayed skeletal maturation, and decreased life expectancy (Scheuer and Black, 2000a; Chamberlain, 2006; Saunders, 2008).

Sex in the context of bioarchaeological research is specifically defined as the biological sex, male or female, of a human being and is distinctly different from describing the gender or cultural experience associated with being male or female (Walker and Cook, 1998). Macroscopic sex estimation using skeletal remains is based on visually assessing morphological differences between males and females after the individual has reached sexual maturity (Stone et al., 1996; Mays and Cox, 2000; Scheuer and Black, 2000a; Hauspie, 2002). Sex cannot be macroscopically determined for non-adult skeletal remains (Mays and Cox, 2000; Scheuer and Black, 2000a), thus bioarchaeologists must interpret sex-based differences in health from data collected only from those individuals who survive to adulthood. Differences in the health status of boys and girls cannot be determined through this method of skeletal analysis.

Methods of age estimation rely on assessing skeletal markers of growth and degeneration experienced throughout life (Cox, 2000; Scheuer and Black, 2000a). However, skeletal age may or may not accurately reflect chronological age as the rates of aging in the skeleton can be positively or negatively affected by genetics, disease, and environment factors (Cox, 2000; Scheuer and Black, 2000a). The skeletal age of a non-adult, an individual who was in the pre-pubescent developmental phases of life at the time of their death, can be estimated through observing the development and eruption of teeth as well as the ossification, growth, and epiphyseal fusion state of the skeleton (Hillson, 1996; Scheuer and Black, 2000a). The skeletal age of an adult individual can be estimated by observing the final stages of maturation and the rates of degeneration and age-related morphological changes throughout the skeleton (Cox, 2000; Scheuer and Black, 2000a). The adult age estimation methods used in bioarchaeological research were developed on well-documented skeletal collections of individuals who died in the recent past and may not be an accurate comparative example for medieval British populations (Roberts and Manchester, 2005). Molleson and Cox's (1993) test of current age estimation methods on the post-medieval British skeletal collection from Christ Church, Spitalfields, London, found that the older adults in the London population were systematically under-aged.

These biases under-represent the older individuals in a population by systematically under-aging their skeletal remains (Meindl et al., 1985b; Walker et al., 1988; Meindl et al., 1990; Saunders et al., 1992). Mortality profiles and life expectancy estimates can be calculated from skeletal age-at-death estimations (Chamberlain, 2006). However, the inherent biases in skeletal age estimation, which forms the basis of the mathematical calculations of mortality, must be taken into account when interpreting the estimations of mortality and life expectancy for an archaeological population (Roberts and Manchester, 2005; Chamberlain, 2006).

Death rates in a stable historical population dependent on an agricultural economy are high in infants and young children under 5-years-old followed by a decrease in mortality rates in older children which again increase steadily through adulthood (Eshed et al., 2004). The highest rates of death in this 'attritional' mortality profile were in the adults older than 45 years at the time of their death (Gowland and Chamberlain, 2005: 152). Age-at-death rates in archaeological populations, however, typically indicate the highest rates occur in adults between the ages of 30 and 45 years old and gradually decrease through the adult age categories (Gowland and

Chamberlain, 2005: 152; Chamberlain, 2006: 90). These differences in mortality profiles between living and archaeological populations have been attributed to biases inherent in age-at-death methods applied to skeletons as previous described. Additionally, infant death rates in archaeological populations are lower than the rates expected in a living population, indicating that infant skeletal remains are under-represented in skeletal populations (Lewis, 2007).

Previous archaeological studies of mortality curves in cemetery populations have found high rates of mortality associated with epidemic disease (Gowland and Chamberlain, 2005; Sawchuk, 2009), delayed or retarded development in children (Kunitz, 1987; Saunders et al., 1993; Lewis and Gowland, 2007), and war (Boylston et al., 2000; Holst, 2004). Mortality profiles associated with civilian, or 'non-combatant,' populations in regions of former conflicts have been described as an, "approximate those of their source (i.e. living) populations, with the exception that the age category 20–30 years is slightly over-represented in both samples of deaths indicating greater exposure of younger adults to conflict-related death" (Chamberlain, 2006: 79). In comparison, populations that experience famine have been found to have a normal population mortality curve that is simply proportionally higher than baseline population mortality because deaths occur in all age ranges at proportionally higher rates (Chamberlain, 2006: 72). The Medieval Anglo-Scottish conflict-zone populations were hypothesised to have mortality profiles similar to non-combatant population mortality curves.

Non-combatant mortality trends are described as elevated mortality from famine and disease. Famine mortality has been described as higher in every age category, relative to the baseline population, because starvation causes similar death rates across an entire population at one time (Chamberlain, 2006: 72). Similarly, death rates from epidemic diseases, particularly acute infections that do not affect bone, have been shown to have the same trend of elevated death rates in the general population (Gowland and Chamberlain, 2005; Chamberlain, 2006; Sawchuk, 2009). For example, Gowland and Chamberlain (2005) demonstrated this catastrophic mortality rate in victims of the Black Death interred in 14th century mass graves at the Royal Mint, London. The highest death rates for that population were observed in the young adult ages, and they gradually decreased in a relatively straight line through old age, killing a consistent percentage of the entire living population (Gowland and Chamberlain, 2005: 153). Sawchuk (2009) demonstrated that influenza epidemics

dramatically reduced population life expectancy, specifically in women. Bishop and Knüsel's (2005) recent survey of eleven mass graves found high proportions of children, adolescents, and adult females with traumatic peri-mortem palaeopathological lesions. These populations were interpreted as a cross-section of the women and children in the region at a time of violent warfare and were non-combatants killed during the conflict (Bishop and Knüsel, 2005).

Combatant mortality, on the other hand, has a distinctively higher mortality rate in individuals between 20 and 24 years old and the sex distribution is dominated by males (Chamberlain, 2006: 80). This difference in age-at-death and sex distributions reflects the structure of military organisations, which in Medieval Britain were composed entirely of men (Prestwich, 1996, 2006). For example, a mass grave from the Battle of Towton, which occurred in 1461 AD in Yorkshire, demonstrated a combatant mortality profile in both its age-at-death trends and the sex distribution in the population (Boylston et al., 2000). The population consisted of adult individuals over the age of 15 years at the time of their death and all were estimated to have been male (Boylston et al., 2000; Holst, 2004).

It was hypothesised that the mortality profiles from the medieval Anglo-Scottish border cemeteries would be 'non-combatant' demographic profiles with all ages and both sexes equally represented.

2.2.2.2 Body Shape Estimations

Estimations of body shape and size in skeletal populations can be made using published regression equations and ratios associated with measurements of skeletal elements. Estimated stature, body mass, platymeric index, and platycnemic index are descriptions of body size and shape that can be assessed from skeletal remains and can be used to assess trends of stunting and wasting, and can provide indirect evidence of possible chronic malnutrition (Trotter, 1970; Brothwell, 1981; Ruff, 2000; Ruff et al., 2005; Ruff, 2007). "Intrinsic and extrinsic factors, such as genetic inheritance and nutrition respectively, can affect normal growth. However, infectious disease may also affect growth, and there is a strong relationship between infection and nutritional status" (Walrath et al., 2004: 133).

The maximum attainable height and weight of an individual is initially determined by genetics, but can be influenced by nutritional and environmental stress (Cameron, 2002a; Johnston, 2002; Roberts and Manchester, 2005; Pinhasi, 2008).

Modern populations living in regions of socio-political conflict have demonstrated a decrease in height (Zellner et al., 1996; Ali and Ohtsuki, 2000). Skeletal growth in children can be slowed or delayed by poor nutrition, although this trend can be reversed during periods of adequate nutrition (Ribot and Roberts, 1996; Cameron, 2002b; Norgan, 2002). "Growth can be intermittently affected if there are famines, crop failures or other crises in a population. The stature of an individual or population therefore is taken to reflect the level of childhood health, although a genetic predisposition to be short or tall can be present for some populations" (Roberts and Manchester, 2005: 222). The affect of chronic nutritional depravation on modern populations in conflict-zones has shown that children were stunted and wasted for their age (Panter-Brick, 1998); these trends were hypothesised to be demonstrable in archaeological populations from the Medieval Anglo-Scottish border.

Stature and body mass estimation is intended to describe the maximum height and weight attained by the individual at the time of their death for non-adults and at the time of skeletal maturity for adults (Trotter, 1970; Ruff et al., 1991; Auerbach and Ruff, 2004; Ruff et al., 2005; Ruff, 2007). In archaeological populations, stature estimation is possible by using maximum long bone length in previously published regression equations derived from reference populations of biological similarity (Trotter, 1970; Cole, 2002; Ruff, 2007). The most accurate method of body mass estimation for adult skeletal remains is the anatomical method developed by Ruff et al. (1997), which mathematically accounts for stature variability and body shape differences between males and females (Ruff, 2000; Auerbach and Ruff, 2004). However, this method, requires excellent skeletal preservation (Ruff et al., 1997). When preservation prevents the application of this method, estimates derived from femoral head breadth have been demonstrated to be an acceptable alternative (Auerbach and Ruff, 2004). Ruff (2007) has recently published body mass estimation equations for non-adult skeletal remains based on two measurements of the femur. Ruff (2007) also demonstrated the applicability of the anatomical adult body mass estimation method to non-adult individuals between the ages of 15 and 17 years. These methods of body mass estimation remain untested in skeletal populations, other than in the reference skeletal collection used, and need verification of their accuracy.

The platymeric index is a ratio used to describe the shape of the femoral shaft below the lesser trochanter (Brothwell, 1981). A smaller ratio describes a femur that is 'flattened' antero-posteriorly while a larger ratio describes a more rounded

proximal femur (Brothwell, 1981). The causes of shape differences in the femoral shaft remain unknown, but lower indices have been associated with poorer health observed in past populations (Brothwell, 1981). Previous researchers have suggested it could be linked to a mechanical adaptation to individual body mass (Townsley, 1948; Ruff et al., 2006), pathological conditions (Brothwell, 1981), or a calcium or vitamin deficiency (Buxton, 1938). Parsons (1915) reported high rates of playtmeria in Anglo-Saxon (ca. 400 – 1000 AD) British populations, particularly in female individuals. The conflict-zone population in this study was hypothesised to have a significantly lower mean platymeric index than their contemporary neighbours.

The platycnemic index is a ratio used to describe the shape of the proximal tibia shaft (Brothwell, 1981). Tibial shafts that have surfaces of approximately equal size are known as eurycnemic, whereas a medio-laterally flattened tibial shaft is known as platycnemic (Lovejoy et al., 1976; Bass, 1995). As with the shape of the femur, the causes of shape variations in the tibial diaphysis are unknown, but have been associated with muscular stresses caused by environmental factors (Lovejoy et al., 1976), pathological conditions (Brothwell, 1981), and has been suggested to be associated specifically with a vitamin deficiency (Buxton, 1938). Lovejoy et al. (1976) suggested that platycnemia made the bone more able to withstand antero-posterior bending and torsional strains, whereas eurycnemic tibiae were stronger in the medio-lateral plane, possibly illustrating an adaptive response of bone to changes in body mass and movement related to differences in climate, environments, or lifestyles. Differences in the indices have been recorded in different ethnic populations in previous studies suggesting there may be a genetic component to its expression (Brothwell, 1981). The mean platycnemic index in the conflict-zone population was hypothesised to have been significantly lower than in the neighbours population.

2.2.3 Palaeopathological Changes

Different disease processes stimulate the formation or resorption of bone at different rates, creating areas on the bone which can be deficient in bone structure, have an excess of bone, or be a combination of destruction and formation that is abnormal in appearance (Ortner, 2003). Identification of areas of abnormal bone destruction or formation, called pathological lesions, in a human skeleton can indicate the type of diseases experienced by an individual during their life (Ortner, 2003).

Palaeopathological research observes and describes lesions of bone destruction or bone formation in archaeological bone then compares the patterns observed in a skeleton to known bone changes in previously diagnosed medical cases of bone diseases (Aufderheide and Rodríguez-Martín, 1998; Ortner, 2003; Mann and Hunt, 2005).

Previous anthropological studies describe the most common changes in health in living populations residing in a conflict-zone as increased malnutrition, nutritional deficiencies, and epidemic infectious diseases. The palaeopathological lesions observed in bioarchaeological studies to indicate general poor health in a human skeletal population are non-specific stress indicators (Goodman et al., 1988). Similarly, palaeopathological lesions indicative of metabolic bone disease are more specific to experiences of nutritional deficiencies during an individual's life. Higher rates of both the non-specific stress indicators and metabolic bone disease were expected to be found in the population from the medieval Anglo-Scottish border. Dental caries lesions were also observed in this study, as an additional palaeopathological change, which could suggest of any differences observed in the metabolic bone disease prevalence rates were associated with possible dietary differences in the region. Medieval documents describing Anglo-Scottish border warfare do not describe high rates of violent deaths in the general population. Therefore, palaeopathological indicators of traumatic injuries were not examined in this study because the prevalence rates were not expected to indicate differences in the rates of violent attacks between the conflict-zone population and their contemporary neighbours. The palaeopathological lesions which were expected to reflect general poor health and malnutrition in the medieval Anglo-Scottish border population are described in the following sections.

2.2.3.1 Non-specific Stress Indicators

The general palaeopathological indicators of stress observed in this study include enamel hypoplasia, periosteal reactions, porotic hyperostosis and cribra orbitalia (Goodman et al., 1988: 179; Larsen, 1997). Previous bioarchaeological research has associated these pathological indicators of stress with chronic poor health in past populations (Grauer, 1993; Mittler and Van Gerven, 1994; Palubeckaite et al., 2002; Piontek and Kozlowski, 2002; Bennike et al., 2005; Boldsen, 2007; Obertova and

Thurzo, 2008; Van der Merwe et al., 2010). The exact aetiology of these pathological lesions, however, remain largely unknown (Ortner, 2003).

Cribra Orbitalia and Porotic Hyperostosis

Usually bilateral, cribra orbitalia and porotic hyperostosis lesions occur on the orbital surfaces of the frontal bone (cribra orbitalia) or on the ectocranial surfaces of the parietal bones (porotic hyperostosis) and are formed when marrow in the cranium is stimulated to produce more red blood cells (Stuart-Macadam, 1989a; Roberts and Manchester, 2005: 229). The diplöe expands, leading to a thinning of the outer table, and enlargement of the diploic space (Aufderheide and Rodríguez-Martín, 1998). The lesions can very in appearance and expression (Figure 2.1). Minimal expression has the appearance of "multiple discrete pinhead-sized perforations" and in the most severe form of expression the trabeculae of expanded cancellous bone are visible through the completely resorbed outer table (Aufderheide and Rodríguez-Martín, 1998: 348).
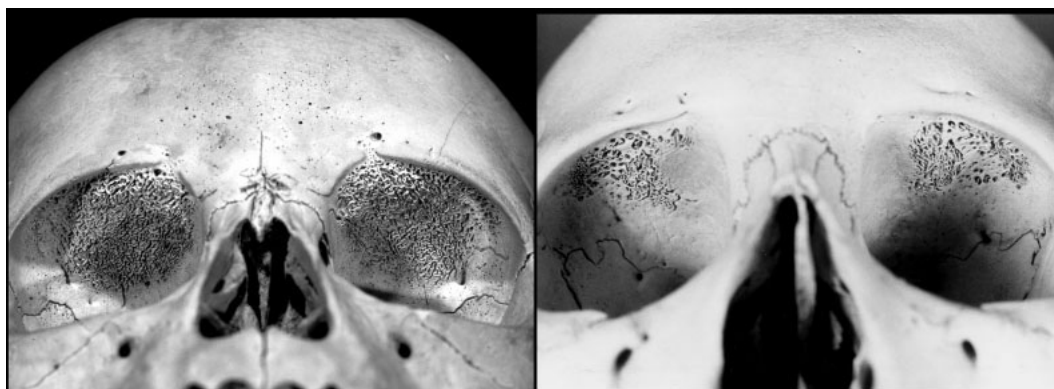
Figure 2.1: 'Active' (left) and 'healed' (right) cribra orbitalia lesions (Walker et al., 2009: 110).

Despite a long history of its recognition and description in the palaeopathological literature, the relationship between the formation of cribra orbitalia and porotic hyperostosis lesions and their causal factors is not understood (Aufderheide and Rodríguez-Martín, 1998). Previous research has associated these lesions with iron-deficiency anaemia (Stuart-Macadam, 1989a), thalassaemia and sickle-cell anaemia (Hershkovitz et al., 1997), infectious diseases (Grauer, 1993; Djuric et al., 2008), vitamin deficiencies (Ortner and Ericksen, 1997; Ortner and Mays, 1998; Walker et al., 2009), parasitic infections (Stuart-Macadam, 1991; Sullivan, 2005), and chronic blood loss (Sullivan, 2005). This variety of associations has led some researchers to suggest these lesions have different aetiological factors

attributable to differences in diet, economy, climate, and hygiene (Stuart-Macadam, 1991, 1992; Grauer, 1993; Molleson and Cox, 1993). The presence of cribra orbitalia in a human skeleton has been generally accepted to indicate the individual experienced at least one chronic form of nutritional stress or infection during their life (Larsen, 1997; Roberts and Manchester, 2005), as seen in previous bioarchaeological studies (Stuart-Macadam, 1989a; Mittler and Van Gerven, 1994; Piontek and Kozlowski, 2002; Wapler et al., 2004; Sullivan, 2005; Obertova and Thurzo, 2008; Walker et al., 2009). However, "in archaeological populations in Britain the vault lesions are rarely seen, with cribra orbitalia being much more common and an increase in porosity of the vault surface is often observed, sometimes with no attendant cribra orbitalia" (Roberts and Manchester, 2005: 230).

Enamel Hypoplasia

As a tooth crown forms in the maxilla and mandible during skeletal development, enamel is deposited on the exterior surfaces of the crown dentine as a layer of ameloblastic cells containing both organic and inorganic components (Hillson, 1996: 148). These cells undergo a maturation process following their deposition, which breaks down the organic components of the cells, leaving their mineral and crystallite components on the surface of the tooth crown as enamel (Hillson, 1996: 148-9). Enamel defects (Figure 2.2), or hypoplasias, occur when nutrients are diverted from tooth enamel formation to fortify the immune system and other biological systems essential for survival (Aufderheide and Rodríguez-Martín, 1998: 405). Linear furrows or grooves are created when the matrix secretion process is delayed or disrupted throughout the entire tooth and either no layer or a thinner layer of ameloblasts is deposited (Hillson, 1996: 167). The maturation process of the ameloblasts, however, is not delayed and the mature tooth crown forms with a region of enamel that is thinner than the biologically optimum. Pits are formed through the same process, yet occur in small regions of the tooth where the matrix secretion process is only locally disrupted (Hillson, 1996: 167). Enamel hypoplasia can occur on any tooth, but is most commonly reported in the incisors and canines (Aufderheide and Rodríguez-Martín, 1998: 406).

Figure 2.2: Enamel hypoplasia lines on the anterior teeth (Ortner, 2003: 595).

Enamel defects occur when children experience a nutritional deficiency or illness during the development of tooth crowns, between the ages of six months and seven years (Aufderheide and Rodríguez-Martín, 1998: 405; Reid and Dean, 2006). Enamel hypoplasia has been associated in previous studies with various causal factors including malnutrition, infectious diseases, chronic digestive disorders, and congenital defects that affect an individual during dental development (Goodman et al., 1987; Hillson, 1996; Reid and Dean, 2006; Lukacs, 2009). The presence of enamel hypoplasia in human skeletal remains indicates that the individual experienced an episode of nutritional deficiency during their childhood (Goodman et al., 1987; Goodman et al., 1988; Larsen, 1997; Boldsen, 2007; Halcrow and Tayles, 2008; Lukacs, 2009).

Periosteal Reactions

Infectious diseases can be inferred from observed changes to the skeleton by identifying patterns of bone deposition and resorption throughout the skeleton (Kelley, 1989; Rogers and Waldron, 1989; Ortner, 2003). Unique patterns of bone changes have been associated with specific infections in only a few instances, such as tuberculosis, leprosy, and treponemal diseases (Aufderheide and Rodríguez-Martín, 1998; Roberts et al., 2002; Ortner, 2003; Roberts and Buikstra, 2003). The general presence of infectious diseases in a population can be inferred from observing general indicators of infections in the skeleton, called non-specific infective lesions. Infectious diseases have been observed to change bone by both depositing new bone

and destroying pre-existing bone; however, the infectious disease must be present in the individual for an extended period of time to affect bone change. Describing infectious disease prevalence rates in skeletal populations is further confounded by the acute versus chronic nature of infections (Wood et al., 1992).

> "Skeletal paleopathology, particularly infections, tend to be viewed as evidence of high morbidity and, indeed, this may be the case. The converse, however, is also possible. Skeletal paleopathology may indicate a better host response to a disease because the host lived through the acute stage when other similarly afflicted individuals may have died. Thus, absence of skeletal disease may imply death due to acute conditions, whereas evidence of skeletal disease indicates a sufficiently adequate immune response to ensure survival to the chronic stage." (Ortner, 2003: 56)

Three types of bone changes have been described as responses to chronic diseases based on how bone is affected (periostitis, osteitis and osteomyelitis). All three types have been observed in British populations (Rogers and Waldron, 1989; Grauer, 1993; Roberts, 2000; Roberts and Cox, 2003).

Periostitis (Figure 2.3) is described as abnormal new bone deposits on the cortical surfaces and is associated with inflammation of the periosteum, of soft-tissue that encircles bone (Kelley, 1989; Ortner, 2003). Periosteal lesions have been commonly observed in populations and can be present on any bone in the skeleton; mild expressions of periosteal lesions are particularly common on the lower legs in Medieval British populations (Roberts and Cox, 2003; Roberts and Manchester, 2005). Periostitis can be associated with specific infections, but only in conjunction with other bone changes as described in the diagnostic criteria for those infections (Roberts, 2000; Ortner, 2003, 2008). Periostitis has also be associated with trauma, metabolic bone diseases, and bacterial infections (Roberts and Manchester, 2005: 173).
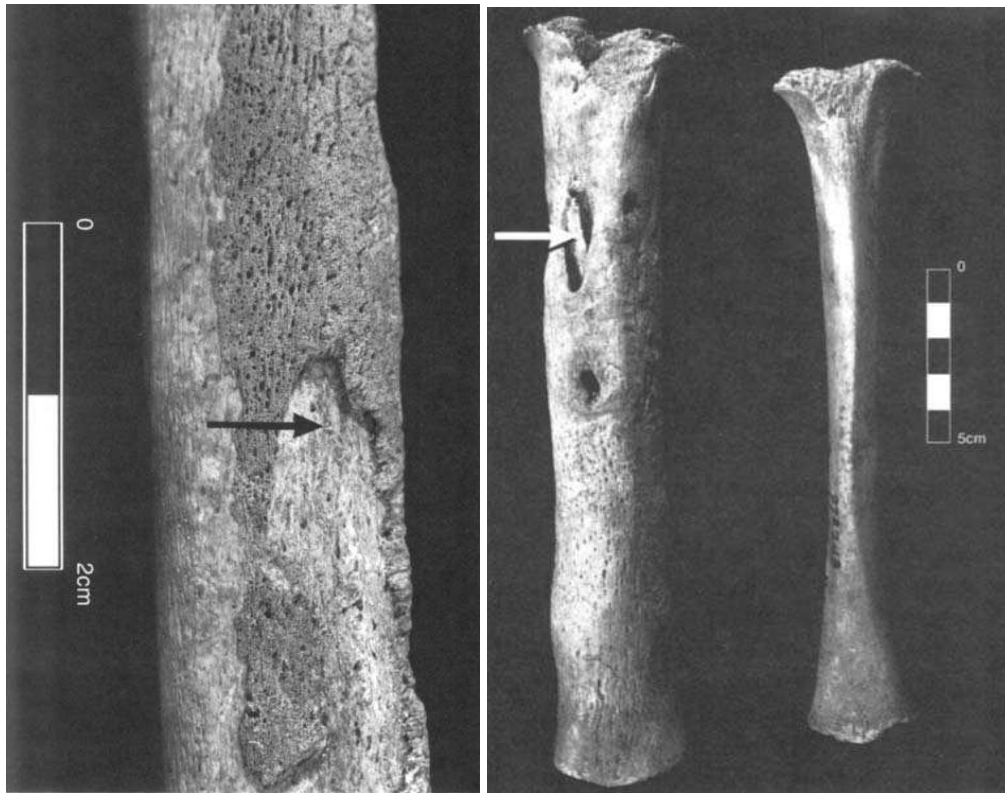
Figure 2.3: Periosteal new bone (left) and osteomyelitis, with cloacae, in a tibia (right) compared to a 'normal' tibia (Ortner, 2003: 201 - 10).

Osteitis describes changes to the internal cortex caused by infection (Kelley, 1989; Ortner, 2003). Deposits of abnormal new bone develop to increase the width of the cortex (Roberts and Manchester, 2005). These lesions, however, are difficult to observe without radiographs and can only be seen when post-mortem damage allows observation of a cross section of the bone (Ortner, 2003; Roberts and Manchester, 2005).

Osteomyelitis describes gross changes to the medullary cavity characterised by enlargement of the bone and the presence of a cloaca, or drain for pus (Kelley, 1989; Ortner, 2003; Roberts and Manchester, 2005). These bone changes can be caused by the spread of an infection from either the periosteum or cortex and can affect any bone in the skeleton (Kelley, 1989; Ortner, 2003).

The location of non-specific infectious lesions on certain bones in the skeleton can provide evidence of possible infections. For example, respiratory infections have been associated with non-specific infectious lesions in the maxillary sinuses and on the ribs (Roberts et al., 1998; Roberts, 2000, 2007). As infection rates were hypothesised to have been higher in the Anglo-Scottish border, the prevalence rates of non-specific infectious lesions were hypothesised to be higher both in the overall

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periostitis rates and in the rates observed on the maxillary sinuses, the ribs, and the endocranial surfaces of the skull.

2.2.3.2 Metabolic Bone Disease and Dental Caries

Increases in malnutrition and infectious disease are the two most consistent health changes experienced by populations exposed to long-term conflict which can directly affect the skeleton. Palaeopathological indicators of malnutrition can also suggest if stress experienced in a past population is related to nutritional deficiencies or differences in diet (Goodman et al., 1988; Larsen, 1997; Brickley and Ives, 2008). Previous population studies of metabolic bone and dental diseases that indicate dietary deprivation/excess have associated pathological changes in bone with starvation, vitamin deficiencies, and differences in the levels of carbohydrate consumption (Fildes, 1986; Stuart-Macadam, 1989a; Woodward and Walker, 1994; Ortner and Mays, 1998; Psoter et al., 2005; Walker et al., 2009).

Metabolic Bone Diseases

Metabolic bone diseases are nutritional deficiencies and metabolic disorders which have been shown in previous studies to affect bone, and can therefore be observed in the archaeological record (Brickley, 2000; Brickley and Ives, 2008; Mays, 2008). Previous research has noted bone changes in individuals with vitamin C deficiencies, vitamin D deficiencies, and osteoporosis (Fildes, 1986; Stuart-Macadam, 1989a; Ortner and Mays, 1998; Cox, 2000; Brickley, 2002; Mays, 2008). The body's access to vitamin and mineral rich foods and its ability to absorb the nutrients is essential to maintain health and a fully functioning immune system (Aufderheide and Rodríguez-Martín, 1998; Norgan, 2002; Ortner, 2003). Restricted access to these nutrients can specifically reduce the body's ability to fight infections and to maintain a healthy body (Norgan, 2002), and vitamin deficiency diseases have been described in the literature as linked to starvation and malnutrition associated with changes in diet, economy, social status, and infectious diseases (Ortner, 2003; Brickley et al., 2005; Schofield, 2006; Waldron, 2006; Wilbur et al., 2008).

Preservation issues can directly affect the diagnosis of metabolic bone disease; due to the degenerative affect of metabolic diseases on bone, diagenesis can disproportionately affect preservation of the skeletal elements of individuals chronically affected by these diseases (Ortner and Ericksen, 1997; Ortner and Mays,

1998; Brickley, 2000; Ortner, 2003). Additionally, Brickley et al's (2007) study of bones affected by disease shows that misinterpretations can occur due to the effects of diagnesis. Study of the skeletons from St. Martin's cemetery in Birmingham demonstrated that many of the individuals who were deliberately excluded from the overall skeletal analysis report, because they were described as poorly preserved, had lesions indicative of metabolic bone disease. Therefore, the reported prevalence rates for metabolic disease at St. Martin's were significantly lower than the actual rates observed in the population. This was because the environment of deposition of the burials and excavation practices had mistaken destructive bone changes for in-situ diagenesis (Brickley et al., 2007). Although preservation is anticipated to be relatively poor for some archaeological populations in comparison to modern skeletal reference populations, an assessment of palaeopathological indications of vitamin C and D deficiencies, and osteoporosis was necessary to test the hypothesis that the conflict-zone population experienced chronic malnutrition and nutritional deficiencies in the past.

Humans are one of the few mammals on earth that do not naturally synthesise vitamin C, or ascorbic acid, through a biochemical enzyme system in the liver (Aufderheide and Rodríguez-Martín, 1998; Ortner, 2003). Vitamin C is essential for the production of collagen, and therefore humans must acquire this resource from their environment through dietary metabolism (Ortner, 2003). Deficiencies in vitamin C, also known as scurvy, directly disrupt the formation of the organic matrix of bone, weakens connective soft tissues in the body, and increases the fragility of blood vessels, which can lead to bleeding (Ortner, 2003: 383). The symptoms of vitamin C deficiency include wasting, oedema, bruising, swollen and bleeding gums, vomiting blood, and loss of teeth (Ortner, 2003). This deficiency changes the appearance of the skeleton by depositing new bone along the limbs and in the skull, including in the orbits and on the jaws (Figure 2.4), with the premature loss of teeth (Ortner, 2003; Roberts and Manchester, 2005).
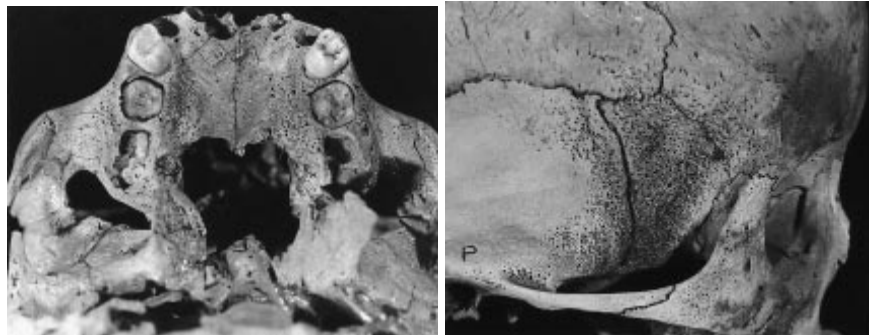
Figure 2.4: Porosity on the maxilla and palate (left) and the sphenoid (right) associated with scurvy (Ortner and Ericksen, 1997: 217 - 8).

Dietary sources of vitamin C include fresh fruits, vegetables, dairy products, meat, and fish (Brickley and Ives, 2008). A deficiency in vitamin C is most closely linked to dietary deficiencies in British populations, but has also been associated with premature birth and infections (Fildes, 1986; Stuart-Macadam, 1989a; Aufderheide and Rodríguez-Martín, 1998; Melikian and Waldron, 2003; Roberts and Cox, 2003; Maat, 2004). The populations along the Medieval Anglo-Scottish border were hypothesised to have higher prevalence rates of chronic vitamin C deficiency due to the destruction of their fresh food resources during periods of conflict.

Vitamin D deficiency disease, also known as rickets in children and osteomalacia in adults, causes mineralization failure in growing cartilage and bone yet it does not directly affect mortality (Ortner, 2003; Brickley and Ives, 2008). Although 90% of the vitamin D needed by the human body is provided by the skin's exposure to sunlight, dietary sources such as fish oils and dairy products provide supplemental vitamin D (Chaplin and Jablonski, 2009; Robins, 2009). As this deficiency directly impacts the normal growth of bones, skeletal changes generally affect children and adolescents during periods of rapid growth (Brickley et al., 2005). The most characteristic skeletal change associated with vitamin D deficiency is bending deformity of the weight-bearing long bones, such as the legs and arms (Figure 2.5).
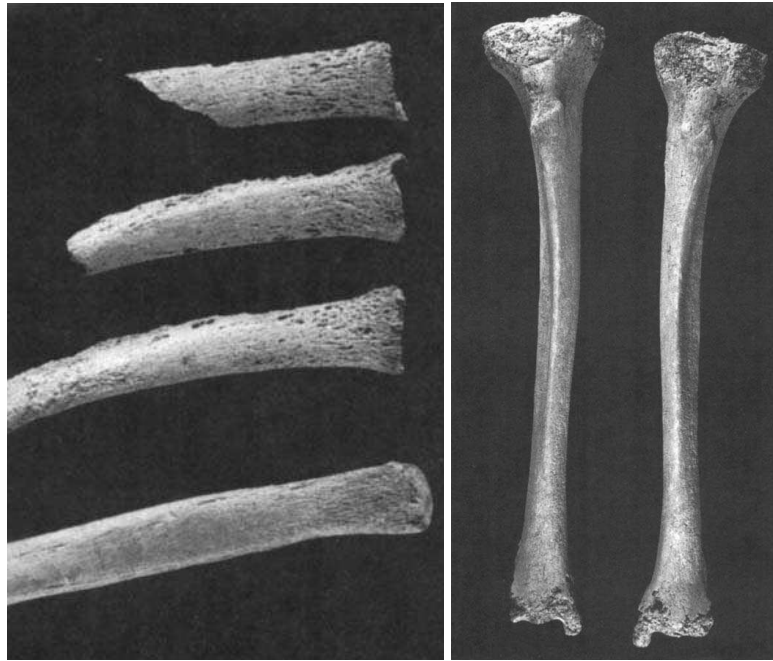
Figure 2.5: Porosity in infant ribs (left) associated with rickets and curved adult tibia (right) in 'healed' rickets (Ortner, 2003: 401 - 3).

Rickets and osteomalacia have been characterised as a disease of civilization due to their increased prevalence during the Industrial Revolution in urban populations with limited exposure to sunlight (Roberts and Manchester, 2005). Owen, in his 1889 survey for the British Medical Association, saw a link between the prevalence rate of rickets and population density (Stuart-Macadam, 1989a), and Stuart-Macadam's (1989a: 212) survey of prevalence rates in Europe described, "a very gradual increase in the occurrence of rickets during the European Middle Ages, at least in the cities." This vitamin deficiency has been observed in medieval British skeletons in previous palaeopathological research in association with a dietary shift away from fish and dairy products (Fildes, 1986; Ortner and Mays, 1998; Lewis, 2002a). The Medieval conflict-zone population was hypothesised to have higher rates of chronic vitamin D deficiencies associated with a scarcity of fresh meat, dairy, and fish in their diets as compared to their contemporary neighbours.

Osteoporosis, also called age-related loss of bone mass, is a condition of bone deterioration caused by a lack of mineralisation in the skeleton. A deficiency in calcium in the body reduces the productive potential of osteoblasts, which in turn produce poor quality bone structures. "The combination of abnormal thinning of compact bone, reduced cancellous bone, and enlarged haversian canals in compact bone is part of the pathological changes in osteopenia and osteoporosis" (Ortner,

2003: 22). Osteopenia is the calcium-deficiency state characterised by this change in balance between bone deposition and bone resorption (Ortner, 2003; Brickley and Ives, 2008). Osteoporosis is the clinical description of the bone when its mass has been reduced by more than 30% from osteopenia (Ortner, 2003; Brickley and Ives, 2008). Osteoporosis is more common in women and is often associated with age-related bone loss after menopause (Aufderheide and Rodríguez-Martín, 1998; Ortner, 2003; Roberts and Cox, 2003). The same trends have been described in British osteoporosis prevalance rates (Turner-Walker and Mays, 2001; Brickley, 2002; Roberts and Cox, 2003). However, a recent comparison conducted on medieval English and Norwegian cemetery populations described significantly higher rates of osteoporosis in women between 22 and 35 years old in the English population from Yorkshire (Turner-Walker and Mays, 2001). The authors associated the higher rates of bone loss with calcium deficiencies during pregnancy and breast-feeding (Turner-Walker and Mays, 2001). However, "the effects of starvation and malnutrition on the development of osteopenia remain almost completely un-investigated" (Brickley and Ives, 2008: 19). Higher rates of osteoporosis were hypothesised to have been present in the medieval Anglo-Scottish border in younger age categories than in neighbouring populations.

Dental Caries

Caries lesions are areas in the tooth crown that are affected by dental disease (Hillson, 1996). These areas of destruction appear as dark spots exposed by thinned enamel or as cavities (Figure 2.6) excavated out of the body of the tooth crown (Roberts and Manchester, 2005). Caries lesions are caused by the fermentation of sugars in the diet by bacteria in plaque (Hillson, 1996). These acids erode the tooth enamel and can also affect the dentine if the bacterial infection is not removed from the tooth surface (Hillson, 1996). Caries lesions are observed most often in the areas between teeth and on the cervical area between the crown and root (Hillson, 1996; Roberts and Manchester, 2005). These surfaces are most often affected by plaque deposits where the bacteria flourish (Roberts and Manchester, 2005).
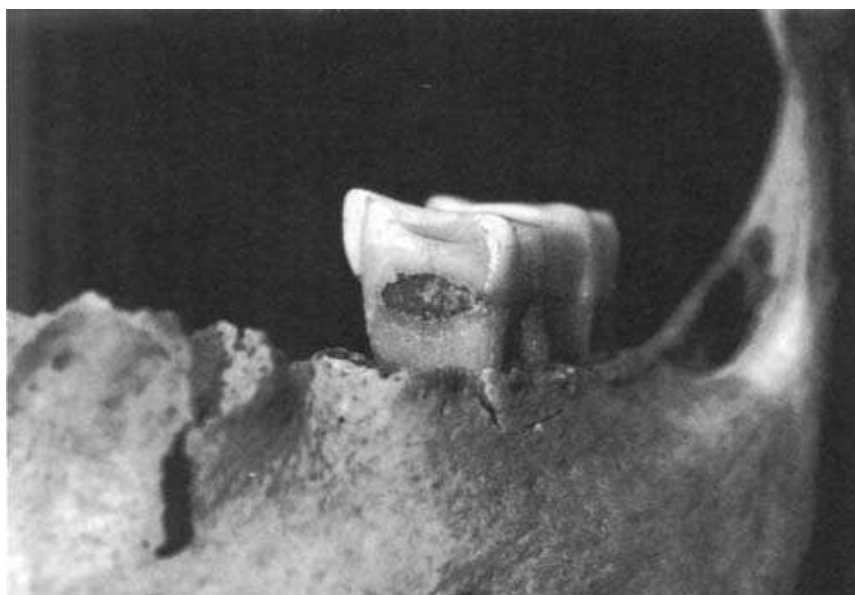
Figure 2.6: Dental caries lesion on the cervical area of a lower left first molar (Ortner, 2003: 592).

Previous studies of population-level dental caries prevalence rates have shown they can reflect changes in diet, environment, social status, oral hygiene, and lifestyle (Lukacs, 1989; Woodward and Walker, 1994; Freeth, 2000; Psoter et al., 2005; Roberts and Manchester, 2005; Keenleyside, 2008). A recent study conducted on modern prevalence rates found an overall association between increased counts of caries lesions and increased sugar consumption; however, this relationship did not apply specifically to industrialised Western countries (Woodward and Walker, 1994). "These results suggest that, in addition to sugar, other factors, such as other aspects of diet, exposure to fluoride and genetic effects, must be taken into account when seeking to explain variations in caries prevalence" (Woodward and Walker, 1994: 302). Caries lesions observed in children's teeth have been associated with malnutrition, specifically low-protein diets, in modern populations (Psoter et al., 2005). Documentary evidence of diets in Britain describes an increase in sugar consumption throughout the medieval period (Woodward and Walker, 1994; Schofield, 2006; Woolgar, 2006). Dental caries prevalence rates also increased from the early-Medieval through the post-Medieval Industrial Revolution in British populations (Roberts and Cox, 2003; Caffell, 2004; Roberts and Manchester, 2005). The diets were not expected to be different between the various populations in the Medieval Anglo-Scottish border cemetery populations. This is because diets throughout the peasant class have been described as consistent throughout Britain, and the cemeteries in this study were not described as burial locations for the aristocratic

or monastic communities. The prevalence rates of dental caries were hypothesised to be similar between the Medieval conflict-zone and neighbours populations in this study.

The skeleton can provide primary evidence of the presence of stress in past populations by providing demographic and palaeopathological indications of stress-induced factors. Medieval historical sources, discussed in the following section, described socio-political stress in the Medieval Anglo-Scottish border populations as directly associated with nutritional deprivation in the local region. Similar to modern populations living in regions of conflict, the skeletal populations along the Anglo-Scottish border should show a significantly higher level of malnutrition, along with associated stunting and wasting, higher rates of chronic infections, and shorter life-spans in the overall population. Age and sex distributions of the Medieval border populations should show higher mortality in the younger adults, particularly in the males. The palaeopathological profile of these same populations should show more general indicators of nutritional stress, higher prevalence rates of metabolic bone diseases and chronic non-specific infections.

2.3 A Medieval Conflict-zone

Descriptions of damage to communities and resources were recorded along both sides of the Anglo-Scottish border throughout the Medieval period (Fraser, 1971; Stevenson, 1991; Summerfield, 1995; Summerson and Harrison, 2000); this was similar to descriptions from modern regions of conflict along borders that have been violently created and continuously contested (Field, 1995; Horton, 1999; Pike et al., 2010). The following sections describe how the Anglo-Scottish border was created and how the populations living in the region were exposed to a conflict-zone lifestyle.

The modern political border between England and Scotland begins on the east coast of Britain at the city of Berwick-Upon-Tweed and runs south west to the Solway Firth, north of the English city of Carlisle (Figure 2.7). The border bisects the fertile Tweed River valley in the east, crosses the hills of the Cheviots, and continues through the western open moors and the Esk River valley to the Solway Firth. This border region experienced a prolonged and intense period of political instability, beginning with the fall of the Northumbrian kingdom in the 9th century, until the end of the 16th century. These border populations were hypothesised to have had higher rates of infant mortality, malnutrition, infections, and skeletal indicators of nutritional

stress than their contemporary English and Scottish neighbours due to their direct experiences of violent border wars, characterized by several types of conflict.

Initially political fighting was between the Northumbrian and Norman elite for nominal control over the region. Open war between the nobles existed periodically in the region as the border was established. The conflict continued and intensified during the 13th and 14th centuries with national campaigns of castle sieges and scorched earth battle tactics interspersed with low-intense fighting on a local scale. The Lanercost Chronicle recorded the devastation wrought by Edward de Brus's invasion into north-western England in 1314: "They burned many towns and two churches, taking men and women prisoners, and collected a great number of cattle in Inglewood forest and elsewhere, driving them off with them on the Friday; they killed few men except those who made determined resistance" (Sadler, 2006: 57).

Figure 2.7: Location of the modern Anglo-Scottish border in Britain.

Reiving, a local economic system of theft and hostilities, continued between local property owners with the approval of the March wardens, representatives of their respective crowns. These two later types of conflict directly affected the local border populations.

2.3.1 Anglo-Scottish Border History

A border was first created in the region by the Romans to divide their imperial possessions in the southern part of the island from the "unconquered tribes" to the north (Bede, 2008: i 5). The Romans constructed two walls both to defend their northern border. The first, the Antonine Wall, was constructed of earth around 80 AD between the Firth of Forth and the Clyde River in Scotland. The second wall, Hadrian's Wall, began construction in 121 AD between the modern cities of Newcastle-upon-Tyne and Carlisle and was a large stone and earth wall fortification with gatehouses and garrison stations positioned along the new fortified border (MacIvor, 2001). Rome dominated the region both with its military strength and, more influentially, with the structure of their society. The empire was able to bring large resources of manpower and material goods into Britain in an effort to build and maintain Roman infrastructure in regions so far away from its capital city (Lowe, 1999; Bede, 2008). Historical references to the locals suggest that the region was populated by dispersed communities of Celts, Britons, and Pict that did not have the military strength or social organisation to challenge the authority of Rome (Lowe, 1999; MacIvor, 2001). However, the expansion of Rome into Britain ended as the Empire declined and their military and political infrastructure withdrew from Hadrian's wall in the early 5th century, leaving a political vacuum in the region (Lowe, 1999). The political boundary established between 'Roman' Britons to the south of the wall and their neighbours to the north ceased to exist (MacIvor, 2001). However, the ideological association of the civilised populations in the Cumbrian and Northumbrian regions of northern England in contrast to the more disorganised and aggressive peoples to the north in Scotland lingered into the texts written centuries later (Lowe, 1999; Savage, 2002; Bede, 2008).

2.3.1.1 Northumbria

In the wake of the Roman retreat, local tribal leaders vied for power over the people that remained in the region. No local leader or cultural identity of 'native people' in the Anglo-Scottish border region was left in the area that could claim the helm in the political vacuum Rome created (Lowe, 1999). Regional leaders fought for control over the local residents, carving out smaller geographic areas over which they could exercise control (Savage, 2002). "It was a period of small entrepreneurial land

takings, of coalitions and new groupings, new names of peoples and the swift ebb and flow of power, when authority and control depended less on a state structure then the magnetism of individual potentates" (Cramp, 1994: 2).

Five early-Medieval Celtic and Anglo-Saxon kingdoms developed along the border region in the political vacuum left by the Romans (Lowe, 1999). The eastern half of the border region coalesced from the two kingdoms of Deria and Bernicia into the kingdom of Northumbria between 400 and 700 AD (Rollason, 2003). Carlisle was the administrative and religious centre of power for the kingdom of Rheged, focused around the Solway Firth on the western half of the border region (Cramp, 1994; Lowe, 1999). The kingdom of Strathclyde grew in power and influence to the north of Rheged and Cumbria developed to the south of the border (Lowe, 1999).

Northumbrian political and religious power grew along the eastern border region throughout the early-Medieval period and the kingdom expanded both its geographic territory and its cultural influence into neighbouring kingdoms in the sixth and seventh centuries (Cramp, 1994). The boundaries, influence, and relationships between these three kingdoms in the western borders between the 5th and 8th centuries remains largely unknown, but they were nominally absorbed by the Northumbrians from the east by the beginning of the 8th century (Lowe, 1999; Bede, 2008). The mode of Northumbria's expansion has been described as violent in some historic accounts (Cramp, 1994: 5; Savage, 2002; Bede, 2008).

Despite the mode of its expansion, Bede (2008: 289) described Northumbria in 731 AD, as peopled by the English and comprising all of the territory north of the Humber River, south of the Firth of Forth, and extending west from Lindisfarne in Northumbria to the monastic community at Whithorn, encompassing all of the modern border region. "In these favorable times of peace and prosperity, many of the Northumbrian race, both noble and simple, have laid aside their weapons and taken the tonsure, preferring that they and their children should take monastic vows rather than train themselves in the art of war" (Bede, 2008: 290).

The kingdom of Northumbria reached its zenith during the 9th century and became politically unstable in the 10th century in the face of destructive Viking raids, and the increasing military strength of the Scottish and English kingdoms forming to the north and south. War among and between the various political and ethnic groups located in northern England and southern Scotland during the 10th century transformed the border region from a stable agricultural region supporting the royal

and ecclesiastical elite of Northumbria, into a contested border region between the Scots in the north and the English in the south, with the Danes attempting to maintain their tenuous hold on their settlements in Yorkshire and Strathclyde.

Viking raids along the east coast of Britain targeted many of the Northumbrian ecclesiastical houses and reportedly robbed and burned the monasteries, killing the monks (Savage, 2002; Rollason, 2003). The destruction of the Northumbrian religious centre at Lindisfarne and scattering of the church leaders in a Viking raid in the 10th century undermined the religious and cultural cohesion of the kingdom, especially in the more remote areas of its original influence (Cramp, 1994).

Northumbrian inheritance practices among the royal lineages had lead to many conflicts within the political hierarchy over control, further destabilising the kingdom's political power (Rollason, 2003). Between approximately 896 and 954 AD, control of the Northumbrian crown passed between the bloodline of Northumbrian kings and powerful Danish rulers from York who intermittently wrest power from the blood heirs (Rollason, 2003). Mackie (1978: 30) summarised the shift in political power in the region in favour of the Scottish throne: "When after the Danish conquest Northumbria became a 'no-man's Land' where Angles, Britons, Danes of York, and Danes from Ireland were engaged in constant warfare, Constantine III (900 – 943 AD) seized the opportunity to press south." During the decline of Northumbria, Carlisle remained a population centre and the region's feudal lords allied themselves with either Northumbrian or Scottish Kings based on the political strengths of each through time, further fragmenting the border region from its ninth century status as a single socio-political entity (Mackie, 1978; Summerson, 1993: 1; MacIvor, 2001).

In the century preceding the Norman Conquest, the ruling elite of England changed many times as the country coalesced into the larger political entities that William the Conqueror encountered in 1066. In Scotland, the Can more dynasties of kings developed and maintained considerable power by uniting the regional lords of the highlands under their rule. The consolidation of Scottish power under the Can more kings created a new national power centred just north of Northumbria between the modern cities of Edinburgh and Glasgow. In England, the kings of Wessex grew in regional influence and power through conquering their neighbours in the kingdoms of Mercia and attacks on Northumbria, as the power of the Northumbrian kings diminished (Lomas, 1996a; Bartlett, 2000; Rollason, 2003). The hold on power in

England, however, was passed between the kings of Wessex and the Danish lineage of kings from York until the Norman Conquest (Bartlett, 2000). Despite the relatively superior political and military strengths of the English and Scottish crowns in the 11th century, the focus of each ruler's attention was on maintaining their power and control over their own kingdoms (Mackie, 1978; Bartlett, 2000). Instability within their own political structures distracted them from fighting with each other over the territory controlled by the waning Northumbrian dynasties. Immediately before the Norman Conquest, Northumbria was still a separate political entity that maintained control over the eastern half of the border region (Rollason, 2003). However, the northern border had retracted south in response to the strength of the Scottish Can more Kings, and the southern half of the kingdom was under the control of an Anglo-Scandinavian kingdom established by the Danes at York (Savage, 2002; Rollason, 2003).

2.3.1.2 Norman Conquest

The Norman Conquest initially involved political fighting only among the Northumbrian and Norman upper classes for nominal control over what became the Anglo-Scottish border region. The Scottish king had more power and influence in the north of England in 1066 than the former English kings from the south (Rollason, 2003). William the Conqueror nominally claimed northern England and attempted to replace the Northumbrian aristocracy with his Norman allies and friends (Rollason, 2003). The Northumbrian population, however, did not readily accept the Norman lords as their new landowners. Military conflicts erupted between the Norman and Northumbrian lords; meanwhile the general population was affected by scorched earth and siege campaigns from enemies and had the burden of supplying occupying armies, regardless of their loyalties (Platt, 1978; Lomas, 1996a). William travelled north in 1069 to conduct punitive raids throughout northern England as a punishment for the murder of his newly-appointed regional barons (Platt, 1978; Lomas, 1996a; Bartlett, 2000). Called the 'Harrying of the North', this campaign of property destruction and devastation was focused in the modern counties of Yorkshire and Durham to the south of Northumberland (Lomas, 1996a; Bartlett, 2000). William claimed Northumberland after this raid, but 'gave' it back to the Northumbrian lord, Gospatric, at the end of 1069 (Lomas, 1996a). "William did not yet feel strong enough to impose direct rule north of Yorkshire" (Lomas, 1996a: 10). The perception remained, in the former kingdom of Northumbria, that the region of northern England

and southern Scotland was one territory composed of a population united by a common culture, language, religion, and social infrastructure (Rollason, 2003). The central point of contention for the Normans and Scots in the late 11th century was who claimed rule over them (Rollason, 2003).

The populations living in the former kingdom of Northumbria experienced intensive fighting and raids from both the Scottish King Malcolm III (1058 – 1093 AD) and the Normans from the 1060s through the 1090s. In 1080, William's appointed Norman earl to Northumberland was killed by Northumbrians which brought William's destructive raiding north again (Lomas, 1996a). At this time, William also raided throughout Lothian in southern Scotland to ward off Malcolm III's ambitions of claiming Northumbria for Scotland (Bartlett, 2000; Rollason, 2003; Sadler, 2006).

William had introduced a new era of castle building to England in the late-11th century which transformed the shape of defensive architecture to motte-and-bailey constructions (Bartlett, 2000; MacIvor, 2001; Eales, 2003; Williams, 2003). His son, Robert, built a motte-and-bailey castle along the Tyne river during his military campaign on his father's behalf in 1080 (Knowles, 1925; Lomas, 1996a). The construction of this castle allowed the Normans the security to settle north of the Tyne and they began to establish a stronger presence in the region. Following four years of intense fighting between Scotland and England, between 1091 and 1095, the Normans firmly gained control of Northumberland. England's William II (1087 – 1100 AD) raided into Cumbria during this same period and captured Carlisle from it's independent ruler, Dolphin. He constructed a Norman castle here; thus introducing a new divisive line through Northumbria along the former Roman Hadrian's Wall (Lomas, 1996a; MacIvor, 2001; Rollason, 2003). The political border recognised today was not formally established until the York accord in 1237 (MacIvor, 2001; Frame, 2006: 437).

Medieval warfare consisted of two different offensive strategies: battles, where one group of armed men fought another group of armed men in hand-to-hand combat, and siege, where a group of armed men surrounded a military installation, such as a castle, and cut off the supply of resources to the people inside the installation for an extended period of time (Prestwich, 2006). Siege was the most common form of direct confrontation at the time of the Norman Conquest and partially explains the Norman emphasis on castle-building (France, 1999; Eales, 2003;

Williams, 2003; Prestwich, 2006). Residents in the surrounding countryside took refuge in walled cities and fortified buildings during sieges and border raiding which separated them from their property and possessions which were ultimately damaged, stolen, or destroyed by the invaders (Summerson and Harrison, 2000; McNamee, 2006). Sieges ended when either the military garrison in the castle surrendered their position or died, or the occupying force ran out of supplies themselves and abandoned their blockade of their military objective. When possible, Medieval commanders avoided battle, "seeking instead to wear down their opponents by waging wars of devastation" (Prestwich, 1996: 11).

A third unofficially recognized, and perhaps the most effective, method of warfare was devastation of the surrounding countryside. The destruction of enemy supplies and support systems was the policy of choice for kings that felt unable to win a battle or sustain a long siege campaign (France, 1999). For example, Richard I's (1189 – 1199 AD) battle strategy was the ravaging of enemy territory (Prestwich, 1996). Civil wars during Stephen's reign (1135 – 1154 AD), had only one major battle, which occurred at Lincoln in 1141, and were largely fought through siege and 'scorched earth' raiding campaigns (Prestwich, 1996: 11).

Although the Norman Conquest directly involved armed conflict in England, it greatly affected the socio-political and religious structure of Scotland. New continental-based monastic communities, based on St. Benedict's rules of moderation and communal living, were founded in the late 11th and early 12th centuries. Their revised form of monastic life was welcomed in Scotland, particularly the Benedictine, Augustinian, Cistercian, and Premonstratensian orders (Dilworth, 1995). Initially invited to Scotland around 1070 by Queen Margaret, these communities consisted of French-speaking monks and canons and began as off-shoots of English houses from northern England, flourishing quickly in Scotland (Dilworth, 1995). These new monastic foundations in southern Scotland also highlighted how far south the influence and power of the Scottish monarchy reached immediately following the Norman Conquest. "The [Scottish] border abbeys of Kelso, Jedburgh and Melrose were all seen by their royal patron [David I, 1124 – 1153 AD] as being at the heart of his kingdom. The king had close associations with England and these latter foundations were intended to serve territories on either side of what was to become the Scottish border. Their subsequent role as sites close to the frontier between two hostile powers was not a factor in their original foundation" (Ewart, 2001: 82).

Raids across Northumbria by both English and Scottish armies continued as Scotland and England coalesced into distinct political and geographic entities between the 11th and 12th centuries (Lomas, 1996a; Rollason, 2003). During this era, the specific national border shifted north and south through former Northumbria as the political and military strength of both kingdoms shifted (Bartlett, 2000; MacIvor, 2001; Rollason, 2003). The Scottish kings in the 11th century consolidated power, whereas their successors in the 12th century were faced with the political and territorial ambitions of the strengthening Norman kings of England to the south (Mackie, 1978). By 1135, 21 Norman baronies were reportedly established in Northumberland, of which nine had constructed motte-and-bailey castles (Lomas, 1996a: 16). Scotland, under the rule of David I, introduced similar Norman castles and appointed regional barons loyal to him, thus strengthening his claim on the border region (Mackie, 1978; Simpson and Webster, 2003). During political instability within Scotland, or in periods of regnal weakness, the Scots successfully maintained their independence from England by feigning political alliances with the English kings, and then maintaining their own autonomy when the English monarchs became distracted by political issues in Normandy and Wales (Mackie, 1978; Bartlett, 2000).

The role of the barons along the border was to primarily maintain a fully armed and competent cavalry and military troops loyal to their benefactor in exchange for large parcels of land granted by the king (Lomas, 1996a; Barrell, 2000; MacIvor, 2001). These baronies on both the English and Scottish sides of the border were later given the name 'Marches'; three 'March' districts were later officially formed on both sides of the border and the wardens in each March were charged with protecting the border from invaders. Although the nominal rule of the border tended to be held by the more powerful English or Scottish king, the local barons rarely changed (Barrell, 2000). The general populations of agricultural and semi-pastoral local residents continued to work for the same Norman families, regardless of changes in their political allegiances (Lomas, 1996a; McCord and Thompson, 1998). The political system in the newly formed border region was overall stable; the instability was in the form of nutritional insecurities caused by scorched earth battle tactics.

2.3.1.3 Scottish Wars of Independence

In the 13th century, the Scottish crown established a central political and religious authority in Edinburgh while balancing their relationships with the powerful regional

barons of the Scottish Highlands and Islands (Mackie, 1978). This distraction allowed England's king, Edward I (1272 – 1307), to finally bring Wales under the direct power and influence of England and turn his full attention to claiming Scotland in the late 1290s (Prestwich, 1987).

The Scottish Wars of Independence, beginning in 1296, were the first extended confrontation in the region which was recorded in detail by various local chroniclers (Rogers, 1879; Summerson and Harrison, 2000). Edward I pushed his military advantage over the young and weak Scottish kings of the late-1200s in a bid to subjugate Scotland as he had Wales (Prestwich, 1987; McNamee, 2006). He conquered Berwick-upon-Tweed and Dunbar in 1296, laying claim to all of Scotland (Prestwich, 1987). Edward attempted to replace the Scottish crown and aristocracy and the gentry of northern England with his military and political supporters in an effort to further enforce his claim to Scotland (Prestwich, 1987). William Wallace lead a Scottish uprising in response to Edward's advances and is credited with winning a battle against the English at Stirling Bridge (1297), which forced the English to move south again.

The struggle between Edward and Wallace ignited the most intense period of national border strife through the former kingdom of Northumbria. "For the next three centuries, England and Scotland were locked into a war which neither could win. The principal factor driving this cycle was the threat posed to England by alliance between Scotland and France, and the Anglo-Scottish wars became inextricable from the Hundred Years War, grinding painfully on, sporadic, destructive and enduring, each side endowed with the potential to inflict enormous damage on the other, but neither able to win decisive victory, to conquer or occupy the other permanently" (McNamee, 2006: 247).

This period of national war was the most intense form of conflict experienced by the local border populations. Local men would have been conscripted into fighting, local resources were commandeered to feed the passing armies, and scorched earth tactics were used by both sides to restrict access to resources for the opposite side (Prestwich, 1996, 2006; Sadler, 2006). Additionally, trade routes closed down and markets shut which restricted the economic activity within the border populations (Stevenson, 1991; Summerson, 1993; Dyer, 2002). Petitions to England's King Edward II in the mid-14th century described how Newcastle's economy was hindered by the destruction of the surrounding countryside by Robert I: "goods are stolen on

the sea by the enemy…Tradesmen of the town can find no work because the country round about is destroyed and their possessions have been spent in the defense of the town" (McNamee, 2006: 225). War usually occurred during prime planting and harvesting times of the year which restricted the ability of local populations to recover from, or prepare for food shortages in the face of advancing armies that either ate or burned their crops (Stevenson, 1991; McNamee, 2006; Prestwich, 2006). "The techniques employed by troops were simple: fire is as potent a weapon distributed by lighted torches as it is by modern incendiary bombs. Wooden buildings, with thatched roofs, offered tempting targets. One single house set alight in Carlisle in 1296 lead to the destruction of most of the city" (Prestwich, 1996: 10). This war by devastation was occasionally punctuated by battles such as those fought at Falkirk (1298), Bannockburn (1314), and Halidon Hill (1333) (Mackie, 1978; Prestwich, 1996).

Edward I began a new era of castle building both in England and throughout Scotland. "These construction projects introduced concentric defences, or a series of walls with several towered strong points built between the exterior curtain wall and the central castle, which was a defensive modification learned during the crusades and was a great improvement on the traditional motte and bailey castle layout" (Sadler, 2006: 47). Berwick, Norham, Wark, Bamburgh, Dunstanburgh, Warkworth, Alnwick, Naworth and Carlisle in England, as well as, Tantallon, Dunbar, Fast Castle, Jedburgh, Roxburgh, and the Hermitage in Scotland were built in this concentric style during the 14th century (Sadler, 2006). These efforts increased the militarization of the border through more defensive architecture and an influx of military garrisons (Prestwich, 1987). However, "the extensive scale of land grants was not matched by a similar scale of actual occupation. The permanent presence of the English in Scotland was largely confined to castles south of the Firth of Forth, which were under the command of members of the royal household" (Prestwich, 1987: 15).

Robert de Brus's leadership, and later crowning as King (1306 – 1329 AD), filled the royal void in Scotland and "brought devastation to the north of England" (Prestwich, 1996: 10). The Lanercost Chronicle recorded the events of one of Robert de Brus raids in Cumbria: "Having collected a great army, he [Robert de Brus] entered England at Solway on the Thursday before the feast of the Assumption; and he burned all the land of the lord of Gilsland and the vill of Haltwhistle and a great part of Tynedale, and after eight days he returned to Scotland, taking with him a great

booty of animals; nevertheless he had killed few men apart from those who wished to defend themselves by resistance" (McNamee, 2006: 53).

Robert adopted the policy of pulling down castles which he had recovered from Edward I, after recognizing his inability to defend these castles against Edward's modern siege technology (McNamee, 2006; Sadler, 2006). "Destruction of castles denied shelter to invaders of Scotland; and equally, it denied Scottish lairds the opportunity to sit out the war behind castle Palisades without declaring commitment" (McNamee, 2006: 42).

After the death of Edward I, Robert the Bruce was able to extract payments from the northern counties of England in exchange for temporary truces which stopped the raiding within Northern England (Fraser, 1982). The northern counties, including Cumberland, Northumberland, Durham, and Westmoreland, paid for these truces from 1311 until they ran out of money in 1313, which were estimated to have cost twice the amount which Edward II taxed these counties (McNamee, 2006: 56).

A change was observed in Scottish raiding strategy after the defeat of the English army at Bannockburn in 1314; raids were conducted deeper into northern England affecting more communities throughout Cumbria and Northumbria (Summerson, 1993). These raids, between 1314 and 1319, followed a U-shaped path through the Northumbrian plains on the East Coast, across the Pennines through the river valleys, and through the lowlands of Cumbria skirting Carlisle (Summerson, 1993). This route allowed the Scottish army and raiding parties to attack the wealthier estates of Northumbria and return to Scotland with stolen goods, animals, and prisoners, through rugged terrain which was maneuverable for lightly packed horses and animal trains but more difficult for the English army to traverse. Additionally, Robert I increased attacks on Carlisle and Berwick, the western and eastern fortified cities which anchored the English border and administered the supply chain and stores for the English army when campaigning in Scotland (McNamee, 2006: 74 - 7).

The Scottish Wars of Independence officially ended in 1327 with the Treaty of Northampton–Edinburgh, but did not greatly change the relations between Scotland and England (McNamee, 2006: 246). The north of England was raided by the Scots in 1333, 1342, 1346, 1388 (Sadler, 2006). A complaint lodged with the Prior of Durham in 1337 from the Vicar of Dalton claimed his parish was wasted and depopulated by the Scottish war (McNamee, 2006: 248). "It must also be considered, especially in relation to the Anglo-Scottish borders, that military actions were never as

clear cut as a summary of the historical events might suggest. The constant climate of strife was a catalyst for a host of local disturbances, petty raids and feuds, the details of which are scarcely recorded, if at all. Nonetheless this climate of chaos would burden local inhabitants with an equal quantum of misery as the larger but rarer baronial or national operations" (Sadler, 2006: 273).

Conflict continued along the newly formed border throughout the late-Medieval period. Violent raids operating across the international border, or border reiving, became an economic way-of-life in the region with hostility and nutritional insecurity continuing on a local level (Fraser, 1971; Sadler, 2006). During wars between the countries, resources were still commandeered to feed the passing armies or burned by an invading army (Fraser, 1982; Stevenson, 1991). The campaigns of castle-building devolved down to a more local level during the 14th and 15th centuries with the local gentry building their own castles and fortified stone dwellings, called pele towers and bastle houses, while the clergy fortified local churches (Prestwich, 1987; Brooke, 2000; MacIvor, 2001). The only difference between the Medieval Anglo-Scottish border lifestyle during periods of political truce was the reopening of trade routes and markets within the region (Dyer, 2002). During peace, conflict and its continued threat dominated the border lifestyle on a local level.

2.3.1.4 The Rough Wooing

The final episode of increased violence occurred in the late 1500s, and involved Henry VIII's (1509 – 1547 AD) efforts to both secure Scotland as a province of England and encourage the Scots to also break with the Roman Catholic Church (Goodman and Tuck, 1992). Scotland's King James V (1513 - 1542 AD) chose to refuse Henry's advise to separate from Rome by simply ignoring him (Mackie, 1978). Henry responded by sending an army north and raiding throughout the Scottish borders. James charged his Lord of the West March to return the volley by bringing an army south into England in November 1542 in another bought of border warfare (Mackie, 1978). However, the Scottish advance was halted at Solway Moss by an English army and James became ill (Mackie, 1978). James died unexpectedly from his fever and left the crown to his 6-day-old daughter, Mary (Mackie, 1978). Henry VIII saw this as an opportunity to permanently bring Scotland under his control by marrying James's minor daughter to his minor son, Edward VI. The Scottish Regent, the ruler in young Mary's stead, originally agreed to Henry's proposition (Mackie,

1978). However, the Scottish Parliament rejected his offer and Henry attempted to make the marriage happen by forceful coercion (Mackie, 1978). Henry declared war on Scotland in 1543 and both countries again intensified their border warfare (Goodman and Tuck, 1992). Local raiding continued, as ever, while Henry sacked Edinburgh in 1544 and the national armies fought battles at Ancrun Moor (1545) and Pinkie (1547) (Mackie, 1978; McCord and Thompson, 1998; Winchester, 2000). "Many monasteries lay in the path of the invading troops and thus suffered destruction of crops and buildings and even loss of life. Holyrood was despoiled, monks of Newbattle were taken prisoner to England, and monasteries in the Firths of Forth and Tay were attacked. Inchcolm was occupied by troops, first English and then French; the monks left the island and did not return" (Dilworth, 1995: 26). The Scots received aid from France which allowed them to keep Henry's armies at bay (Mackie, 1978). A final peace was agreed in 1551, the Treaty of Norham, which officially ended the last war between England and Scotland (Mackie, 1978). The permanent end of hostilities came with the crowning of Scotland's James VI as king of England in 1603 (Goodman and Tuck, 1992; Winchester, 2000).

2.3.2 Medieval Lifestyle

The socio-political changes along the Anglo-Scottish border changed the social landscape from cohesive communities of Northumbrian farmers and shepherds, to English and Scottish villages and hamlets fighting with, and stealing resources from, each other for their economic survival (Fraser, 1971; Goodman and Tuck, 1992; MacIvor, 2001; Goldberg, 2004; Horrox and Ormrod, 2006). Despite these socio-cultural landscape changes, the physical environment and the natural resources available to the populations along the border remained the same throughout the border troubles (Dyer, 1989; McCord and Thompson, 1998).

2.3.2.1 Climate, Geography, and Environment

McCord and Thompson (1998: 1) described the environment in the border region as, "a wet climate, [with] much inferior acid soil, and a high proportion of forest, moorland and mountainous country." Historical and archaeological evidence also describe changes in the climate throughout the late-Medieval period (Clarke, 1986; Dyer, 1989; McCord and Thompson, 1998; Turner and Young, 2007). The mild and wet 13th century weather was followed by a period of unstable weather in the early-

1300s (Dyer, 1989; Turner and Young, 2007). The summers in the late-14th and 15th centuries were cooler with more rainfall (Dyer, 1989). The early 1500s were warmer than the previous century, but this trend shifted gradually into the 'Little Ice Age' that characterised the end of the Medieval period and greatly affected the climate of the early Post-Medieval period (Dyer, 1989; Turner and Young, 2007).

Previous research into the affects of these changes in climate on border populations have described depopulation of the hills and moorlands, in favour of the more fertile valleys, during periods of colder and wetter weather (Platt, 1978; Dyer, 1989, 2000; Roberts and Cox, 2003: 227). Despite the plethora of historical evidence for long-term climate change in the borders during the medieval period, Wild et al (2001: 67) noted that, "to date, few relevant archaeological studies have been undertaken which allow an assessment of historical conclusions in a critical manner." Some researchers have argued that analysis has only proved redundant: "Plant macrofossil analysis has proved useful and interesting in a consideration of the economic features of archaeological sites, but the environmental results from these studies have sometimes served only to confirm the presence of a habitat already inferred from other archaeological observations" (Donaldson and Rackham, 1984: 141). Recent archaeological research into the Medieval Anglo-Scottish borders has contradicted the previous assessment of abandonment of higher altitude fields and shown evidence of simply a change in the use of the land (Turner and Young, 2007). Continued evidence of cereal cultivation in the Cheviots indicates that this land was still used for agricultural production as well as for summer grazing of cattle and sheep (Mackie, 1978; Turner and Young, 2007).

Palaeobotanical evidence from the border region also shows intentional human manipulation of the environment through deforestation and marsh modifications (Bartley, 1976). This deforestation is theorized to have been associated with land clearances to accommodate population growth and the need for more pastures for grazing livestock during the early portion of the late-Medieval period (Bartley, 1976; Winchester, 1987; Vyner, 1990). These regions then lay barren and unused during the mid-14th century population contraction during the high mortality of the Black Death (Dyer, 1989; McCord and Thompson, 1998; McNeill, 1998; Roberts and Cox, 2003). Marshland modifications have also been linked to hemp growth and processing for flax-cloth production (Bartley, 1976; Cox et al., 2000). Conscious relocation of these processing areas to remote locations on land that was not of use to farmers or

livestock showed a distinct attempt to avoid environmental pollution near population centres (Cox et al., 2000).

2.3.2.2 Diet

Because the modern border region was just north of the original territory seized during the Norman Conquest, a general survey of the people and resources in the region was not included in the original Domesday Book (Williams and Martin, 2003). However, later tax and legal records, kept by the kings and used to determine administrative and financial dues which the aristocracy owed the king, recorded similar economic information (McCord and Thompson, 1998; Dyer, 2000). These documents described seasonal production of cereals, fruits, livestock, fish, and ale in the borders (Dyer, 1998; Barrell, 2000; Winchester, 2000; Dyer, 2006; Woolgar, 2006). "Oatmeal, barley, milk and cheese were the staple foods. For the poorer classes meat may well have been uncommon, and for rich and poor alike fresh meat was unobtainable during the winter months. Owing to lack of pasture, animals had to be killed at Martinmas and their flesh was preserved in brine" (Mackie, 1978: 58).

The archaeological evidence shows a close geographical relationship between people and animals (Platt, 1978; Vyner, 1990; McCord and Thompson, 1998; Barrell, 2000; Muldner and Richards, 2006). Given that cattle and sheep were documented to be a key economic resource in this region regardless of an individual's social status, the value of such animals to their owners dictated that their constant care and protection required a living environment in direct connection with human habitations (McCord and Thompson, 1998; Dyer, 2000; Goldberg, 2004). Common grounds in urban settlements were used for livestock grazing, while the crop fields near rural settlements were used for livestock grazing during the winter months (McCord and Thompson, 1998; Petts and Gerrard, 2006). The presence of pigs is noted in the earlier dates of the Medieval period, but their numbers declined, specifically in urban sites, during the fourteenth century (Donaldson and Rackham, 1984; Dyer, 2002). Medieval peasants also relied on personal gardens maintained near their homes to provide additional fresh vegetables, herbs, and fruits (Dyer, 2006). When border conflicts destroyed common fields, grain stores, and removed access to livestock, border populations may have relied on these personal gardens and other undocumented natural resources to maintain their subsistence.

Dietary differences in the Medieval period fell along class lines. The aristocracy and monastic communities had disproportionate access to the best and richest foods produced in the rural environments (Dyer, 1989; Harvey, 2006; Woolgar, 2006). They received the benefits of the peasant and merchant class labourers in payments of rents or taxes which consisted of either labour or monetary debts based on the requirements of the land owner (Dyer, 1989; Dilworth, 1995).

2.3.2.3 Social Landscape and Settlement Patterns

"The settlement pattern of the later Medieval North-East was overwhelmingly rural" (Petts and Gerrard, 2006: 76). This pattern also accurately describes settlements throughout the rest of the border regions (Platt, 1978; Clarke, 1986). The rural environment was dominated by a feudal economic system; divided into manors and estates which were owned and managed by a resident lord (McCord and Thompson, 1998; Dyer, 2000; Goldberg, 2004; Horrox and Ormrod, 2006). Lords were typically members of the aristocracy who managed their estates while providing military and political service himself to the king (McCord and Thompson, 1998; Dyer, 2000; MacIvor, 2001; Dyer, 2002). Monastic communities, however, also functioned as estate landlords (Stevenson, 1991; Dilworth, 1994, 1995; Summerson and Harrison, 2000). "In addition to the rent, the monastery received the teinds [10 per cent of the produce] as spiritual income. Often the monastery did not want the teinds paid in kind, in which case it could increase the rent to include their value or sell the produce back for cash. Appropriated parishes provided many monasteries with considerable income" (Dilworth, 1995: 43).

The residents on these manors and estates were generally farmers and tradesmen who owed a duty to the lord of the manor in either the form of money or service (Todd, 1953; Dyer, 2000). These taxes were collected by the land owners as annual rents for the parcels of land used by the peasant classes and occasional fees, such as for the lord's permission to allow a child to move off the manor for an apprenticeship (Dyer, 2002). Peasants were: "not allowed a handmill or an oven, but had to take corn to be ground at the lord's mill and bread to be baked in the lord's oven, and for this, of course, [peasants] had to pay the lord" (Todd, 1953: 7 - 8).

2.3.2.4 Urban Development

The Medieval period also experienced a shift in settlement patterns in urban centres. Although towns existed in early medieval Britain as population centres, their focus was purely as a political and religious centre for the royal or aristocratic dominion of the surrounding rural populations (Dyer, 1989; Lowe, 1999; Rollason, 2003). In addition to providing a focus for the political, economic, and religious leadership of the rural populations, towns in Medieval Britain developed more sophisticated trade organisations and industries (Dyer, 1989; Lilley, 2002). Urban population centres developed in northern England and Scotland during the border troubles, albeit on a smaller scale than their southern counterparts (Mackie, 1978; Dyer, 1989; McCord and Thompson, 1998; Lilley, 2002). In Scotland, "a burgh was defined as a stronghold in a central geographic location, such as a hill, a ford, or a road junction, which already was a settlement before defences were built and became a centre of trade as well as a seat of military power" (Mackie, 1978: 52). Similarly, the towns in northern England tended to be focused around a castle (MacIvor, 2001; Dyer, 2002). Between 900 and 1600 AD, urban centres developed around York, Hartlepool, Newcastle-upon-Tyne, Carlisle, and Berwick-Upon-Tweed in England (McCord and Thompson, 1998). Scottish urban centres developed in Edinburgh, Haddington, Roxburgh, Peebles, Dumfries, and Whithorn (Mackie, 1978).

The wool trade, cloth processing, tanning, and mining became of key economic importance during this period and these crafts and their merchants conducted business in towns (McCord and Thompson, 1998; Dyer, 2002). The processes involved in these industries introduced air and water pollutants into the regions' natural resources during this period (Roberts and Cox, 2003). Another health concern confined to more urban environments during this period was poor sanitation (Lilley, 2002). Records show that urban build-up of human waste and rubbish was such a problem to the urban inhabitants that legislation was enacted and legal proceedings conducted to attempt to manage its disposal and removal from densely populated areas (Keene, 1982).

The traditional definition of a late medieval town describes a population center legally distinct from the surrounding countryside and composed of an industrial population which was fully supported by an agricultural surplus (Dyer, 1989). Northern England, particularly Cumbria, was often dismissed by historians and

described as a bleak landscape which lacked towns (Summerson, 1993: 3). "The basis of life was still largely agricultural; every burgher had his own portion of land, and some rights over the common land, and the subsistence economy, thus provided, was practiced also when the burghers came, as many did, to follow crafts. The first tradesmen of whom we hear – weavers and tailors, bakers and fleshers, masons and wrights, for example – produced the very things required by a self-supporting community" (Mackie, 1978: 59). Although the population centres in northern England and southern Scotland did not adhere to the strict definition of a medieval town, by only housing craftsmen, merchants, military garrisons, and the aristocracy, they were separate political entities endowed with economic privileges associated with royal charters, such as markets (Mackie, 1978; Dyer, 1989, 2000, 2002). The issuance and review of town charters by a king or regional baron was another source of income for the aristocracy, in addition to the rents and taxes they collected from the rural peasants (Todd, 1953; Stevenson, 1991; Lilley, 2002).

2.3.2.5 Housing

In contrast to housing trends in southern England, where stone and wood constructions grew in popularity in rural landscapes under the Norman kings, wooden and thatch dwellings continued as the preferred construction style in the 12th and 13th centuries in the borders (Grenville, 1997). Rural housing in particular remained easy to construct and was well ventilated (McCord and Thompson, 1998; Winchester, 2000; Goldberg, 2004). This trend also applied to urban housing of the time. Although the layout of houses was organised in similar fashion to urban dwellings to the south, the materials used for their construction remained wood for centuries longer than their southern counterparts (Grenville, 1997; McCord and Thompson, 1998; Newman et al., 2000). Given the constant threat of dwelling destruction and the relative poverty of the individuals in these populations, the need for easily reconstructed and affordable housing was a necessity (Summerson, 1992; Lomas, 1996b, a). "Raiders usually destroyed houses by setting fire to their thatch, which caused their walls to crumble. Just as in Scotland the lowland peasantry [in Cumbria] learnt to take to the forests with their cattle when the English forces approached, and made light of the destruction of their homes" (Summerson, 1992: 161).

Fortified stone constructions were used after the Norman Conquest only in the form of castles which provided accommodation for military garrisons and resident

aristocrats (Fraser, 1982; Prestwich, 1996; MacIvor, 2001). The appearance of Pele towers during the 14th and 15th centuries and Bastile houses during the later 17th century grew in popularity as stone construction became a more economic form of fortification for wealthy aristocrats, merchants, and eventually wealthier farmers (Clack and Gosling, 1976; Vyner, 1990; Brooke, 2000; MacIvor, 2001). These fortifications were simple in their layout and often reused stone from previous Roman, early and late-medieval sites which had been abandoned (Vyner, 1990; Brooke, 2000; MacIvor, 2001).

2.4 Summary

Population health in modern conflict-zones is characterised by high mortality and high prevalence rates of malnutrition, infectious diseases, and mental illness (Fabrega Jr., 1981; Avruch, 2001; Pedersen, 2002; Miller and Rasmussen, 2010; Panter-Brick, 2010; Spiegel et al., 2010). These trends are specifically observable in the infants and young children in living populations (Gibson, 1989; Goldson, 1996; Panter-Brick, 1998; Jones, 2002; Pedersen, 2002). Historical studies in the 20th and 21st centuries have demonstrated that trends of increased mortality, malnutrition, and disease observed in modern conflict regions should be present in past populations (Field, 1995; Sawchuk et al., 2004; Ellison and Kelly, 2005; Pizarro et al., 2006; Robson et al., 2009). Chapter 3 will discuss how the historical information available for the medieval Anglo-Scottish border mirrors the qualitative descriptions of modern conflict-zones, and Chapter 4 will show the conflict-zone mortality and morbidity profiles observed in the cemetery populations from the medieval borders.

3   Materials and Methods

The aim of this study was to bridge the gap between anthropological population studies of the health consequences of life in a conflict-zone and bioarchaeological population studies of indicators of stress by conducting a bioarchaeological survey of a medieval British conflict-zone. As summarised in the previous chapter, research on the effects of violent conflict on living populations described poor health and high mortality in regions of socio-political instability (Pedersen, 2002; Avogo and Agadjanian, 2010; Degomme and Guha-Sapir, 2010; Panter-Brick, 2010). The objectives of this study were link the bioarchaeological evidence for the long-term adverse mortality and morbidity effects of conflict on public health to historical evidence for chronic socio-political conflict in medieval populations from the Anglo-Scottish border. Historical documents from medieval Britain described everyday life along the Anglo-Scottish border from the decline of the Northumbrian kingdom (ca. 900 AD) until the end of the 16th century as constant exposure to endemic conflict, which destroyed local resources and exposing the local residents to chronic malnutrition and infectious diseases (Lomas, 1996a; Winchester, 2000; Rollason, 2003). To achieve the objectives, skeletons from eight cemetery sites in northern England and southern Scotland, four described as in the 'conflict-zone' by contemporary texts and four from locations nearby that were not directly involved in border warfare, were analysed using current bioarchaeological research methods and statistically compared to test the hypothesis. The following chapter summarises the skeletal materials, the bioarchaeological analysis methods, and the statistical comparisons used to test the hypothesis. The results of the analyses and comparisons carried out with these materials are presented in Chapter 4.

3.1 Materials

Eight collections of human skeletal remains recovered from medieval archaeological contexts in northern England and southern Scotland were available for this study (Figure 3.1). They were selected because they met three requirements: they contained more than 50 discrete skeletons; they were excavated from cemeteries used as communal burial grounds from 900 to 1600 AD, and they were available for

macroscopic analysis. A more complete review of the archaeological and historical background for these eight sites is included in Appendix A.
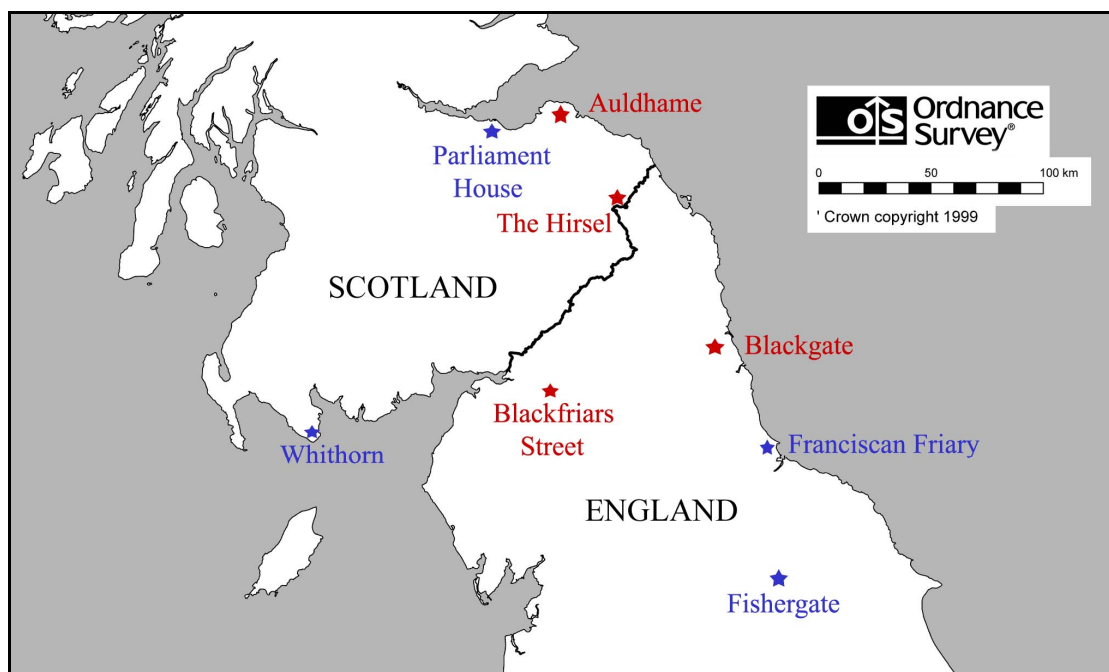
Figure 3.1: Locations of the eight human skeletal collections selected for this study in relation to the modern Anglo-Scottish border. Conflict-zone populations noted in red; neighbouring populations noted in blue.

These eight cemetery sites were assumed to be representative of the general populations from their local regions. Four sites identified near the modern political border were hypothesised to have experienced a conflict-zone lifestyle during the medieval period based on primary evidence from medieval documentary sources. Four additional sites were identified from geographically adjacent locations, two in Scotland and two in England, to represent a medieval control group. This control group, or neighbours population, was hypothesised to have experienced a typical medieval lifestyle without the additional stresses imposed by warfare. The four border populations were hypothesised to have similar demographic and palaeopathological profiles as modern conflict-zone populations when directly compared to their contemporary, unstressed neighbours.

3.1.1 Conflict-Zone Skeletal Populations

Historical and archaeological evidence from the Medieval Anglo-Scottish border suggested that people living in this region experienced nutritional and psychological stresses associated with international, socio-political conflict for control of the region. Four collections of human skeletal remains excavated from the conflict-zone region

were available to include in this study. The sites were located in or near settlements suggesting the people buried in the cemeteries were the remains of individuals who resided in the local region.

3.1.1.1 Auldhame, East Lothian

Archaeological and historical evidence indicated Auldhame cemetery (NT 6016 8476) was used as a communal burial ground by a rural, Christian community in the Scottish parish of Tyninghame during both the early-Medieval decline of Northumbria and the late-Medieval border troubles. This community may have been associated with an early-Medieval abbey dedicated to St. Baldred and later supported the late-Medieval residence of the Douglas family at Tantallon castle (Hindmarch and Melikian, 2006a). Documentary sources described Viking raids in the region during the decline of the Northumbrian kingdom, conflict among the local Scottish nobility in the 14th and 15th centuries, as well as direct involvement of the local nobility in Henry VIII's war of rough wooing (Tabraham, 1986; South, 2002). The available documentary evidence suggested Tyninghame villages experienced military occupation, crop burning, and reiving during the use of Auldhame cemetery (Lomas, 1996b; South, 2002).

Figure 3.2: Aerial photograph of the Auldhame excavation site along the sea cliffs of East Lothian (Photo Courtesy of Royal Commission on the Ancient and Historical Monuments of Scotland).

Ploughing near the East Lothian village of Auldhame in February 2005 uncovered human skeletal remains from a forgotten medieval cemetery (Hindmarch and Melikian, 2006b). The site is located at the edge of an eroding sea cliff between the Scottish towns of North Berwick and Dunbar (Figure 3.2). AOC Archaeology Group, under terms of the Historic Scotland Human Remains Call-Off Contract, conducted a field survey, test pitting, and open area excavation at this site during 2005 and 2006 (Melikian, 2009). This archaeological project aimed to determine the nature and extent of the archaeological evidence present, to remove the archaeologically significant material culture from the ploughed surface of the field, and to protect the in situ archaeological evidence below the surface of the active field from further plough damage (Hindmarch and Melikian, 2006b).

Excavation uncovered a burial ground adjacent to the stone foundation of a small, multi-phased building interpreted as a chapel (Hindmarch and Melikian, 2006a). The associated material culture indicated burials began in the 7th century and ceased by the end of the 17th century at Auldhame. Excavated burials contained few grave goods and were supine, consistent with Medieval Christian burial practices (Hindmarch and Melikian, 2006b). Changes in burial alignment were observed during excavation of the cemetery which corresponded to temporal shifts in burial practices (Hindmarch and Melikian, 2006b).

Radiocarbon dates from associated skeletal material from the various alignments indicated three distinct phases of burial at Auldhame (Hindmarch and Melikian, 2006b). The first phase dated from 680 to 880 and was aligned north-west to south-east (Hindmarch and Melikian, 2006b). The stone foundation cut through graves from this phase of interment before 900 AD, which possibly indicates an earlier chapel associated with the north-west to south-east burial alignment (Hindmarch and Melikian, 2006b). The second phase of burials, aligned east-west and concentrated on the south side of the chapel, was dated to 890 – 1030 (ibid). The third phase, aligned south-west to north-east, dated from 1280 – 1400 and consisted of many non-adults clustered near the west end of the chapel (ibid). Where identifiable from burial alignment and radiocarbon dating, skeletons from the first phase of interment were not studied and disease patterns in early-Medieval Northumbrian populations were beyond the scope of this project.

Post-excavation skeletal analysis determined that a minimum of 239 individuals, 161 adults and 78 non-adults, were present in the skeletal collection, with

71.5% preserved in a moderate or good state (Melikian, 2009). The skeletal collection is currently stored at AOC Archaeology's Edinburgh facility and is undergoing further post-excavation analysis (Crone, 2007).

Historical Context

East Lothian lies geographically between the two Roman walls and previous finds of Roman material culture in Lothian attest to Roman settlements in southern Scotland during their occupation of Britain (Lowe, 1999). The earliest documentary evidence for the area dates from Bede's writings in the 8th century AD. Bede, however, makes no specific mention of the Lothian region when describing the state of the kingdom of Northumbria in 731. He described the eastern half of an inland projection of the sea, the Firth of Forth, as a boundary between the English to the south and the Picts to the north which indicated Lothian was part of Northumbria (I. 12, Bede, 2008: 23).

Archaeological evidence from the Auldhame excavation suggested a population lived near the cemetery from the 7th century, and religious history states that St. Baldred lived in the Auldhame area during this period (Hindmarch and Melikian, 2006a). Baldred was described as living in isolation on Bass Rock which is visible from the Auldhame cemetery site (Hindmarch and Melikian, 2006a).

Auldhame is later described by Simeon of Durham as a separate parish belonging to the bishopric of Lindisfarne in 854 AD, making no reference to a religious community in the vicinity (Melikian, 2009). The information we can glean from these later references is that this region of Lothian may have been associated with Lindisfarne's religious authority since the 6th century, and the population may have later supported a monastic community dedicated to St. Baldred in the 8th century before its recorded destruction in 941 AD during a Viking raid (South, 2002).

The Anglo-Saxon Chronicles stated Anlaf the Dane destroyed the monastery of St. Baldred and burned the village of Tyninghame in 941 AD (South, 2002; Hindmarch and Melikian, 2006b). Tyninghame lies two miles to the south of Auldhame and is associated with the St. Baldred monastic community in historical documents (Hindmarch and Melikian, 2006b). East Lothian was given to the Scots in 973 following almost a century of warfare between the Scots from north of the Firth of Forth, the Saxons from south of the Humber river, the Danes from Yorkshire, and the Anglo-Scandinavians from Strathclyde (Mackie, 1978; Lowe, 1999; Savage, 2002). The Scottish King Malcolm II's victory at the Battle of Carham in 1018

confirmed the Lothian region north of the River Tweed was under Scottish rule (Lowe, 1999).

The new border between the Scots and the unifying English to the south was hotly contested between the various factions in the Scottish nobility and the last Saxon kings of England (Mackie, 1978; Savage, 2002). Historical documents described the Lothian region as particularly susceptible to changing political allegiances between England and Scotland during the 10th and 11th centuries. Lothian was attacked repeatedly by William the Conqueror's and Malcolm III's armies between 1070 and 1093 (Rollason, 2003; Sadler, 2006). Malcolm burned the fields of Lothian in advance of William's army during the 'Harrying of the North' in both 1070 and 1080 to remove the ability of William to supply his army with local resources (Sadler, 2006: 16) East Lothian appears to have remained under Scottish political control throughout the 11th century despite its susceptibility to Norman raids. The newly founded Durham religious community was granted the parish of Tyninghame, including Auldhame, in 1094 AD by the Scottish King Duncan II (Lowe, 1999: 12). This grant also suggested northern England was under Scottish control at various times following William the Conqueror's invasion.

A Cistercian nunnery was built in the immediate area around 1150 and may have been founded on the location of the previous St. Baldred's monastic community, although its exact location remains unverified by archaeological evidence (Melikian, 2009). The lack of fortifications constructed near Auldhame during the 13th century Scottish Wars of Independence was consistent with Robert de Brus's policy against castle-building, thus denying his English enemies shelter when they invaded the south of Scotland (Tabraham, 1986; McNamee, 2006). Records of a claim dispute between the Earl of Fife and the Earl of Douglas over the barony of North Berwick in the mid-1300s suggests this property was redistributed among the Scottish elite following the crowning of Robert de Brus (Tabraham, 1986).

Tantallon castle, constructed in view of the chapel and burial ground at Auldhame in 1358 by William Douglas, served as a base for the 'Red' Douglases during fighting within the border's powerful Douglas family in the 1400s (Tabraham, 1986). Despite its initial purpose as an opulent residence for the Earl of Angus, Tantallon Castle served as a military fortification and a prison for the nobility during the 15th and 16th centuries (Tabraham, 1986). Records indicate that the region of

North Berwick was plundered in 1445 (Tabraham, 1986). In 1528, Tantallon Castle was besieged by the Scottish king (Tabraham, 1986).

Records stated the Auldhame region featured prominently during Henry VIII's Rough Wooing due to the strategic location of North Berwick between both kingdoms (Tabraham, 1986). In May of 1544, the Earl of Hertford's raiding English army passed by Tantallon Castle in an attempt to rattle the military garrison (Tabraham, 1986). The castle and surrounding countryside was again attacked during the Civil War in 1651 (Tabraham, 1986). Burials at Auldhame appeared to have ceased before this attack during the Civil War (Hindmarch and Melikian, 2006a).

Archaeological evidence suggested the Auldhame cemetery was a communal burial ground throughout the formation of and contention over the Anglo-Scottish border from the 10th through the 16th centuries. The local population experienced a conflict-zone lifestyle throughout its use of the Auldhame burial ground.

3.1.1.2 Blackfriars Street, Carlisle

The modern city of Carlisle lies nine miles south of the modern political border with Scotland. Historical and archaeological evidence from Blackfriars Street, Carlisle (NY 4003 5580) indicated the human skeletal population interred there by Dominican Friars, between 1240 and 1539, was composed of individuals from the monastic community and a portion of the local secular community (Jones, 1990). Documentary evidence from the 11th through the 16th centuries described Carlisle's direct experiences of military sieges, 'scorched-earth' military raids, and border reiving (Fraser, 1971; Summerson, 1993; Summerson and Harrison, 2000; Sadler, 2006).
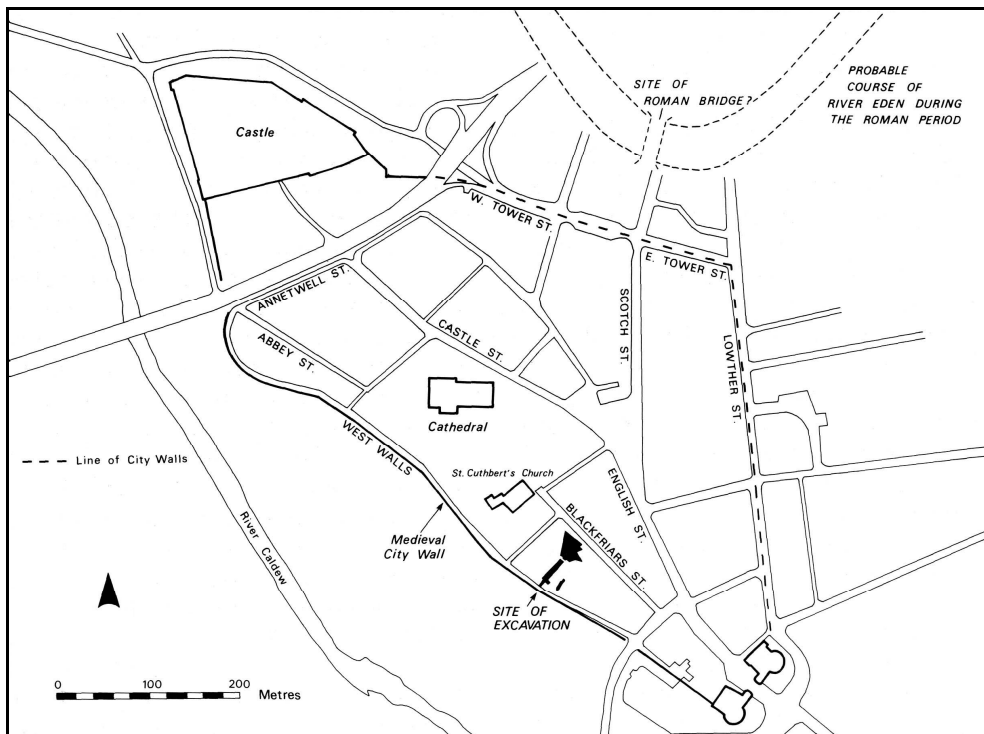
Figure 3.3: Map of modern Carlisle city centre with excavation location and Medieval city walls (McCarthy, 1990: 5).

The Medieval cathedral and castle, both still standing in the city centre, is material evidence of a large, urban, Christian population that lived Carlisle during the Medieval period (McCarthy, 1990: 359). The exact location, however, of the documented late-Medieval Dominican Friary church were largely unknown before excavations were conducted at Blackfriars Street (Figure 3.3) between 1977 and 1979 (McCarthy, 1990; Moffat, 1996).

Excavations uncovered a Medieval stone foundation with an associated burial ground (McCarthy, 1990: 4). Late-Medieval fragments of walls found in Trenches B and H confirmed the positions of the Friary church and cloister that are depicted in a bird's eye view map of Carlisle from 1560 (McCarthy, 1990: 373). Timber remains from the church confirmed the construction of the Friary with dendrochronological evidence of the late 13th century (McCarthy, 1990). Late-Medieval coins, metal objects, glass, and pottery found in association with the Friary and graves, also confirmed late-Medieval use of the site (McCarthy, 1990).

The excavated cemetery contained both supine interments, with heads aligned west, and disarticulated human remains (McCarthy, 1990). No evidence of grave cuts could be distinguished due to the shallow depth of the cemetery in relation to modern pavement levels, and because of intercutting throughout the cemetery's use

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(McCarthy, 1990). Few grave goods were found, but iron nails positioned around the edges of graves indicated the use of wooden coffins (McCarthy, 1990).

Post-excavation skeletal analysis determined a minimum number of 214 individuals (201 adults and 13 non-adults) (Henderson, 1990: 330). Only 15 skeletons in the population were described as in a good state of preservation; 78% of the skeletons present were categorised as poorly or very poorly preserved (Henderson, 1990: 331). The human skeletal remains from Blackfriars Street are currently stored at the Tullie House Museum in Carlisle (Padley, per comm.).

Historical Context

Historical records and previous archaeological excavations have shown Carlisle was a population centre from the Roman period (Hogg, 1955, 1964; McCarthy, 1990, 2000). Archaeological evidence indicated that Carlisle remained a population centre of some wealth after the Roman withdrawal from Britain (McCarthy, 2004). Historical sources describe Carlisle as the seat of power for the Celtic kingdom of Rheged which was focused around the Solway Firth (Lowe, 1999). Rheged's political boundaries, strength, and extent of regional influence, remains uncertain as no written documents from the kingdom have survived (Cramp, 1994).

Foundations of a building, a pit, and a well from the Anglian period suggested the Blackfriars Street site was occupied between 700 and 900 AD (McCarthy, 1990). Anglo-Saxon coins, pins, pottery, and remains of a Scandinavian style glass vessel also confirmed Northumbrian influence in Carlisle's early-Medieval material culture (Graham-Campbell, 1990; Hunter, 1990; McCarthy and Taylor, 1990; Pagan, 1990). Before the Norman Conquest, Carlisle was an urban settlement at the centre of a larger Cumbrian political entity which supported a landed gentry as well as the religious community (Summerson, 1993: 15). Early-Medieval documentary evidence credit Cumbrians with paying tithes to support this monastic community before 1091 (Summerson, 1993; Bede, 2008). Carlisle was ruled by Dolfin, a regional king whose loyalties shifted between King Malcolm III of Scotland and King Siward of Northumbria, immediately before the Norman Conquest affected Cumbria (Summerson, 1993).

William Rufus captured Carlisle in 1091, as he moved through northern England and southern Scotland to subdue the region and bring it under Norman rule (Summerson, 1993). Rufus is credited with rebuilding Carlisle even though a

substantial local settlement already existed there. The effect of the Norman Conquest on Carlisle lay in its transformation from an administrative and religious town to a fortified city and military garrison. The Anglo-Norman city of Carlisle was constructed first by William Rufus, building a royal castle in 1092, secondly by Rufus's redistribution of the surrounding lands to families and religious communities loyal to the new Norman monarchy, and finally the resettlement of the countryside with peasants who conformed to the newly refurbished Norman feudal system (Mackie, 1978; Summerson, 1993; Eales, 2003). The transformation was so successful that Carlisle was responsible for protecting the north-western border of England from Scotland in the 12th century and became "a base from which English forces could launch rates into Scotland" (Eales, 2003: 58).

Blackfriars Street appeared to fall out of use between the Anglian period and the foundation of the Dominican Friary in the 13th century (McCarthy, 1990). The Lanercost Chronicle recorded the arrival of the Dominican religious community in 1233 (Summerson, 1993). By that date, Carlisle had grown into a Medieval urban centre with a castle and curtain wall (McCarthy et al., 1990). The Close Rolls from 1234 to 1237 recorded the construction of a Friary outside of the Medieval city walls along the highway which was ordered to be demolished in 1237 because the building was damaging the highway (Jones, 1990; Summerson, 1993: 17). The Close Rolls again recorded construction associated with a Dominican Friary from 1238 to 1240 within the city walls indicating the community had moved to the Blackfriars Street location (Jones, 1990; Summerson, 1993).

The Blackfriars community was tangentially mentioned in city records throughout the late-Medieval period. A dispute between the Friars and Carlisle's Prior about the waste drainage was recorded in the Judicial Rolls of 1292 (Jones, 1990: 376). Walter of Guisborough, a Medieval chronicler, recorded the Blackfriars' buildings were not destroyed in the fire of 1292, which destroyed most of the city including the Priory, the parish churches, and the Franciscans' Friary (Jones, 1990: 376). Archaeological timber remnants at the site suggested the buildings might have been damaged in a 1303 fire. Dendrochronology dated the wood at the Blackfriars Street site to 1293 ± 9 years, which confirms building work at the Friary after one of these fires (Jones, 1990: 376; McCarthy, 1990).

Throughout the border troubles, Carlisle "remained an essentially military outpost, and indeed, it needs to be stressed that however much it might develop in

other respects later, the defensive and offensive functions which Carlisle acquired at this time were ones which it would continue to perform throughout the Middle Ages" (Summerson, 1993: 13). To that end, English Kings invested heavily in maintaining the March governments, the defensive architecture, and the military stores at Carlisle (Prestwich, 1987, 1996). Pipe Rolls, which listed royal expenditures on castles, recorded over £268 invested in Carlisle's castle between 1186 and 1205 (Summerson, 1993: 17). Edward I modified Carlisle castle again in the late-13th century from a motte-and-bailey to a concentric castle fortification before the onset of the Scottish Wars of Independence (Summerson, 1993; Sadler, 2006: 8).

The West March Warden's office, deputy, and constable were based at Carlisle and the warden was charged with maintaining the English border and supporting royal initiatives in western Scotland (Sadler, 2006). In addition to its defensive role along the border, Carlisle was used as a base of operations for military incursions into Scotland. As such, Carlisle maintained a role as a trade centre for both the local communities and the larger Irish Sea trade routes (Holt, 1961; Summerson, 1993). Carlisle received many of its supplies for both the city and the English royal stores from Ireland. In 1315, Edward de Brus invaded Ireland with Scottish troops, on behalf of his brother, Scottish King Robert I, which greatly affected the supply lines to Carlisle (Morgan, 2001).

Carlisle's proximity to the Scottish border and its distance from the English royal centres in London and York made it a prime target for Scottish military raids throughout the border troubles. Its location allowed a Scottish raiding party to remain in the region, destroying property and stealing valuables, for several days before reinforcements could be mustered from other regions of England (McNamee, 2006). The countryside around Carlisle was most directly affected by the visitations of the Scottish army and Scottish supported raiding parties who attempted to destroy the agricultural economy which supported both the English nobility and supplied the English army when in the region (Prestwich, 1996; McCord and Thompson, 1998; McNamee, 2006). Prestwich (1996: 10), quotes the Close Rolls of 1346 as describing the devastation of 70 Cumberland manors and villages by Scottish raids: "burned and totally destroyed, with the corn, animals and other goods therein, by hostile incursions of the King's Scottish enemies, after Michaelmas last."

Carlisle itself was besieged three times during the Scottish Wars of Independence in the early 14th century (McNamee, 2006). The city's three gates

were bricked up before Robert de Brus's siege of 1315 and remained closed for six months, during which the citizens lost all access to their lands and possessions outside of the city walls (McNamee, 2006: 221). Although this access was not essential for the wealthier community members who maintained residences and food stores within the city, peasants from the surrounding countryside abandoned their crops and livestock to the devastation and sought refuge within the defensive walls of Carlisle (McNamee, 2006; Sadler, 2006).

The threat of violent and destructive raids continued throughout the late-Medieval period for the populations in and around Carlisle (Fraser, 1971; Jones, 1990). Northwest England remained one of the first regions assaulted by Scotland when its Kings perceived a weakened or distracted English monarch might be unable to respond to their attack (Frame, 2006: 443). The Scots invaded repeatedly during the Hundred Years War, when England was heavily involved in France (Summerson, 1993). During the War of the Roses, Queen Margaret of England, the wife of Henry VI, attempted to barter Carlisle to the Scots in 1461 in exchange for helping her husband maintain his hold on the crown (Sadler, 2006: 314). Even during the 1536 Pilgrimage of Grace, a peasant revolt against Henry VIII, the citizens of Carlisle could not shift their focus from their defence of the border: "to turn their backs to the Solway and march south was to invite attack" (Sadler, 2006: 460).

Conflict continued as border reiving even after the dissolution of the Dominican Friary on Blackfriars Street and burial ceased to occur in the Friarage cemetery (Fraser, 1971; Sadler, 2006). The church was recorded in a state of disrepair and the cemetery lying waste in 1539 (Moffat, 1996: 3).

3.1.1.3 Blackgate, Newcastle

Historical and archaeological evidence for Newcastle-upon-Tyne indicated that the site of the Blackgate cemetery (NZ 250 638), was used as a communal burial ground by a rural, Northumbrian, Christian community from the decline of the Northumbrian kingdom through to the Norman Conquest. This community might have been associated with a religious house or with a royal residence in the region. This population most likely resided in dispersed rural locations or small villages which may have experienced violence associated with Viking attacks on the Northumbrian kingdom during its decline in the 9th and 10th centuries (Knowles, 1925; Nolan, 1998; Brown, 2003). Documentary evidence from the 11th century indicated these

populations directly experienced conflict associated with the Norman Conquest, including the 'Harrying of the North,' which defined Newcastle as a strategic military location near the disputed Anglo-Scottish border (Knowles, 1925; Nolan, 1998; Brown, 2003). Newcastle grew into a major urban centre of both military importance during the border troubles, and industrial importance as a key port for wool and coal (Moffat and Rosie, 2005). The cemetery at Blackgate, however, ceased to be used as a community burial ground immediately after the construction of the stone keep at Newcastle (Figure 3.4) (Nolan, 1998).
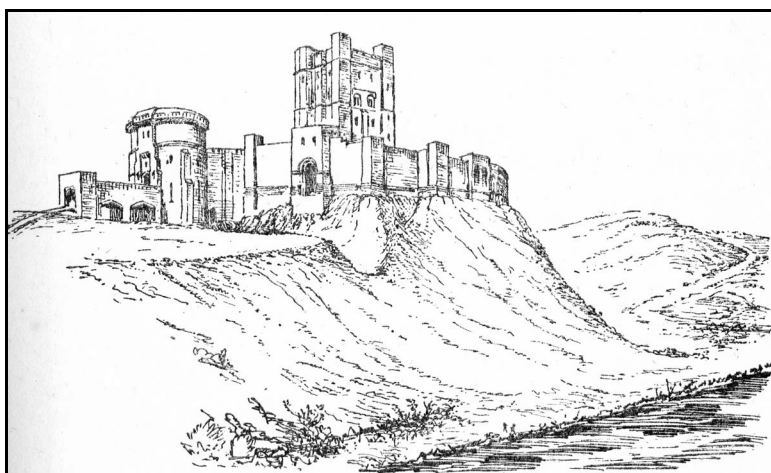
Figure 3.4: Artistic impression of the Norman stone keep and castle built in 1168 at Newcastle-Upon-Tyne over the site of the Blackgate cemetery (Knowles, 1925: 3).

Construction at a railroad bridge near the keep of the Medieval castle in Newcastle-upon-Tyne uncovered human skeletal remains from a Medieval cemetery, and eight archaeological excavations were conducted between 1977 and 1992 at the site (Nolan, 1998). A Medieval cemetery and a single-celled building, suggested as a possible chapel associated with the cemetery, were uncovered during the excavations, but the exact boundaries of the entire cemetery remained unclear (Nolan, 1998). Coins dating from 810 to 985 AD and shroud pins types dating from the 7th to the 9th centuries were found in the cemetery, suggesting that the burials at the site began in the 8th century (Nolan, 1998).   Several surface grave markers recovered were stylistically estimated to date from the end of the 11th century (Nolan, 1998). Radiocarbon dates from skeletons recovered in the 1990-92 excavations indicated the cemetery was used from approximately 880 to 1160 AD (Nolan, 1998: 2).

A change in burial practices was noted in the cemetery and the temporal sequence of interment styles is still being investigated (Chamberlain, per comm). A variety of burial styles was observed, including simple cut, supine, single graves,

supine burials in stone-built cists with recumbent stone grave markers and head and foot stones, and graves with slab-built headboxes (Nolan, 1998). There was evidence for reuse of the surface grave markers as cist lids (ibid). Additional environmental changes after use of the cemetery, specifically erosion of the Norman rampart, slippage, and levelling, commingled the burials throughout the site (ibid).

Use of the northern part of the cemetery ceased with the construction of a Norman castle in 1080, but contextual and funerary evidence in other areas of the cemetery suggested interments continued at Blackgate after construction of the first castle (Knowles, 1925; Nolan, 1998; Moffat and Rosie, 2005). The castle ditch and rampart disturbed some graves and covered other parts of the site, further disrupting the stratigraphic relationship within the cemetery (Nolan, 1998). The castle was refortified in 1168 and this construction coincided with cessation of burials at the site (Knowles, 1925; Nolan, 1998; Brown, 2003).

A minimum number of 638 individual skeletons, 407 adults and 231 sub-adults, were excavated from the site over the course of eight excavation seasons (Boulter and Rega, 1993; Nolan, 1998). Post-excavation skeletal analysis of 131 skeletons excavated during the 1977 and 1978 seasons was carried out at Durham University (Nolan, 1998). Additionally, 227 articulated burials from the 1990 and 1992 excavation seasons were analysed at the University of Sheffield (Boulter and Rega, 1993). The complete skeletal collection is currently housed at the University of Sheffield's Department of Archaeology where it is used as a research and teaching collection (Chamberlain, per comm).

Historical context

The Medieval cemetery "overlies the ruins of a Roman fort," which was abandoned after the Roman retreat from Britain (Nolan, 1998: 1). Little historical or archaeological evidence exists for populations in the Newcastle region between 400 AD and the foundation of the Norman castle in 1080 (Nolan, 1998). Bede (2008) described a royal estate 12 miles inland along Hadrian's Wall, which could be a reference to early-Medieval occupation at Newcastle. Symeon of Durham, during the late-medieval period, wrote of a settlement of monks at Monkchester on the northern side of the Tyne which fell within the political jurisdiction of Northumbria (Rollason, 2000). Monkchester has been assumed by researchers to be at Newcastle although the precise location of this settlement remains unknown (Nolan, 1998; Moffat and Rosie,

2005). The circumstantial evidence available suggested that populations living in the Newcastle region were Christian Northumbrians residing in either rural or small urban settlements which were not of a particular size or importance.

In 875, the Danish King Halfdan led an army that attacked and pillaged various monasteries in the area, and it is believed that Monkchester was assaulted during this raid (Savage, 2002). Historical accounts of the experiences of local populations during the Norman Conquest in north-east England describe both great Northumbrian resistance to the invading Norman lords and destruction inflicted on the local populations by the Norman army's retribution in the 'Harrying of the North' (Platt, 1978; Lomas, 1996a; McCord and Thompson, 1998; Rollason, 2003). Robert, the son of William the Conqueror, built a wooden motte-and-bailey castle on the site of the former Roman fort in 1080 following punishing raids to subdue Northumbria (Knowles, 1925; Rollason, 2003). Newcastle received a significant investment of over £1000 between 1167 and 1178, which accounted for the construction of a Norman stone keep to replace the timber structure (Brown, 2003). The current city derived its name from the stone castle constructed as a 'new castle upon Tyne' in 1168 (Knowles, 1925: 7). As an urban population centre grew around the castle during the 11th and 12th centuries, a defensive ditch and curtain wall was built around the city and was continuously modified throughout the late-Medieval period (Nolan et al., 1989; Nolan et al., 1993; Fraser et al., 1994). Recent archaeological excavations have highlighted Newcastle's development as an important regional urban centre during the 13th century, with a major program of reclamation along the modern quayside and evidence of an active limeburning industry where the Tyne meets the River Swirle (O'Brien et al., 1989; Ellison et al., 1993). Newcastle grew into a major urban centre of both military importance during the border troubles, and industrial importance as a key port for wool and coal exports from the 13th through the 16th centuries (Fraser, 1982; Lomas, 1996a; McCord and Thompson, 1998). The Blackgate cemetery population, however, would have only experienced the decline of the Northumbrian religious and political centres along the Tyne River, the Norman Conquest, and the foundation of the Norman castle at its current location.

3.1.1.4 The Hirsel, Coldstream

The Hirsel, located in the village of Coldstream on the Tweed River in the Scottish county of Berwickshire (NT 830 406), was a medieval parish church with an

associated cemetery adjacent to the modern Anglo-Scottish border. The skeletal population interred in the church cemetery consisted of local residents from a rural, agricultural community that economically supported the Coldstream Priory and a Cistercian Abbey at Coldstream (Cramp, 1980, 1981, 1982, 1983, 1985). Medieval records described this population's first-hand experiences of the border conflict, including military occupations, crop-burning, cattle-thefts, and border reiving, throughout the use of The Hirsel burial ground (Rogers, 1879).

The church and cemetery was discovered by ploughing in June 1977, which unearthed stones from both funerary monuments and architectural fragments (Cramp and Douglas-Home, 1979). A full excavation of the site was conducted from 1979 to 1984 (Cramp, 1980, 1981, 1982, 1983, 1985). These excavations revealed a stone church with four phases of construction followed by a fifth phase of domestic occupation in the repurposed nave (Cramp, 1985). Evidence of an earlier timber structure below the apse of the stone church suggested an earlier church possibly existed on the site (Cramp and Douglas-Home, 1979; Cramp, 1983). The nave of the church was "gutted by fire in phase 5, and very large quantities of carbonised grain have been retrieved from the floor – six crop plants were present in the samples: bread wheat, oats, barley, rye, legumes and a brittle rachis not further identified" (Cramp, 1983: 59). There was no evidence for use of the church after the fire (Cramp, 1983).

The cemetery occupied ground both to the north and to the south of the church (Cramp, 1982, 1983). A total of 345 burials were excavated from both burial locations (Cramp, 1982, 1983, 1985). Primarily traditional Medieval Christian funerary practices were observed in this cemetery population, including east-west burial alignments, supine interments, and few grave goods (Cramp, 1982, 1983). Adults were interred in earth cut graves with occasional pillowstones, head stones, and foot stones while the non-adult burials were clustered closer to the church walls (Cramp, 1982, 1983). There were also several cist graves and two crouched burials (Cramp, 1982). The burial ground to the south was more intensively used throughout the life of the church and interments continued on the south side of the derelict church even after its conversion to domestic use (Cramp, 1983). The burials to the north of the church were covered by a layer of rubble containing 14th century pottery with no evidence of later disturbance during the domestic use of the nave (Cramp, 1981). Radiocarbon dates from both northern and southern burial locations date interments from approximately 1100 – 1400 AD (Cramp, 1982; Melikian, 2009).

Post-excavation skeletal analysis identified a minimum number of 331 individuals, 181 adults and 150 non-adults, were identified in this skeletal population (Anderson, 1994). Preservation was noted as "generally in fair condition" (Anderson, 1994: 1). The skeletal collection is currently held by the Museum of Scotland in Edinburgh (Caldwell, per comm.).

Historical Context

Bede and the Anglo-Saxon Chronicles describe the expansion of Northumbrian authority into Cumbria to the west of Coldstream throughout the 6th to the 9th centuries, which also indicates that the Coldstream region was firmly under their control throughout this period (Cramp, 1994; Savage, 2002; Bede, 2008). A Viking raid in 875 brought a Scandinavian occupying army who established a winter camp along the Tyne River (Savage, 2002). Raids among the local Northumbrian communities, as well as among the Picts and Strathclyde Welsh [possibly Cumbrians], were described during this encampment (Savage, 2002).

The decline of Northumbrian political power during the 10th and 11th centuries introduced political instability to the Tweed River valley. The ambitions of the rising Scottish Kings north of the Firth of Forth brought their armies into the Berwickshire region in an effort to take fertile agricultural land away from the weakening Northumbrian Kings (Mackie, 1978; Savage, 2002; Rollason, 2003). In 1018, the Tweed River was established as a new political border between Northumbria and Scotland by Malcom II after the battle of Carham (Lowe, 1999; Rollason, 2003). This region of southern Scotland was consistently changing political affiliations before the Norman Conquest between the Scots, the Northumbrians, the Cumbrians, and the English Anglo-Saxon Kings (Mackie, 1978; Savage, 2002). The Norman Conquest itself did little to settle the issue and directly contributed to more violence in the region through the 'Harrying of the North' (Mackie, 1978; Rollason, 2003).

A Cistercian abbey was founded at Coldstream in 1165 and the nuns were granted "a carucate – that is, from sixty to a hundred acres – of the Hirsel, together with the church of that place" by the wife of the Abbey's benefactor, the Earl of Dunbar (Rogers, 1879: ix). The original grant charter suggested that The Hirsel consisted of a village with a church of established rights which contributed to the support of Coldstream Priory before 1165 (Cramp and Douglas-Home, 1979). The exact location of the medieval village or hamlet which the church served remains

unknown; however field walking to the west of the church and cemetery site has produced evidence of medieval settlement in the vicinity (Cramp, 1982). Although the property was legally owned by the regional lords, The Hirsel was repeatedly granted to, and remained within the abbey's direct control until 1545 (Rogers, 1879; Cramp and Douglas-Home, 1979).

The Chartulary of the Cistercian Abbey at Coldstream recorded first-hand accounts of the political and social instability experienced by the Coldstream region from approximately 1165 to 1545, when the abbey was burned to the ground (Rogers, 1879). The inclusion of the parish church and its surrounding property in the inventory of the Coldstream Abbey meant the material damage inflicted on these properties by the border troubles was specifically recorded in the abbey's records. These records described how The Hirsel lands were passed back and forth between Scotland and England throughout the 13th- 16th centuries. Throughout this period, the abbey begged forgiveness of taxes and requested physical protection from both Scottish and English kings (Rogers, 1879).

The region was particularly brutalised during England's King Edward I's campaigns in the 1290s to gain control over Scotland. Edward I and his army stayed in Coldstream in August 1290 and again in March 1296 (Rogers, 1879)), and the abbey claimed extensive damages to their property and foodstuffs during Edward's 1296 residence (Rogers, 1879). England's Edward III, in 1333, issued a letter of protection to the Priory and Abbey of Coldstream, showing the continued presence of English authority in the region throughout the Scottish Wars of Independence (Rogers, 1879: xviii; McNamee, 2006). In the 1450s, Scotland's James III confirmed land gifts to the Abbey bestowed by James II, which confirmed Scottish authority over the region had been reinstated (Rogers, 1879: xix; Sadler, 2006).

The political prowess of the Abbey's prioress Dame Isabella Hoppringill was well documented in correspondence from the early 16th century connected to Henry VIII's war of 'rough wooing'. The Coldstream abbey lay within Scotland, but the prioress's loyalties lay with England's Henry VIII. Records show she supported Scottish authority until the Battle of Flodden in 1513, and then worked as an informant and supporter of Henry's border raids during the 1520s (Rogers, 1879). The political manoeuvring of Prioress Isabella during Henry VIII's war of rough wooing also seem born out of hope for self-preservation; the letters of support on her behalf to Henry VIII specifically request the abbey wasnot to be assaulted during

border army raids due to her previous loyalties to the English cause (Rogers, 1879). The abbey was burned to the ground by the Earl of Hertford in 1545 (Rogers, 1879).

The church and cemetery at the Hirsel are mentioned specifically in the Coldstream Abbey's charters during the 13th and 14th centuries (Rogers, 1879). The church appears to have existed in 1561, because the *Book of the Assumption of Benefices* recorded rent for the Priory of Coldstream which consisted of land and a church at the Hirsel (Cramp and Douglas-Home, 1979: 224). After the Protestant Reformation, the previous Abbey lands were granted by Scottish Royal charter to various individuals and the Coldstream Priory was dissolved (Cramp and Douglas-Home, 1979). During parish burials at The Hirsel, the Coldstream village changed from a community located in the heart of the powerful Northumbrian kingdom to a population on an unstable international border between Scotland and England.

3.1.2 Neighbouring Skeletal Populations

Four human skeletal collections were available from archaeological excavations in the English and Scottish regions immediately adjacent to the border counties. These collections were similar to the conflict-zone skeletal populations in that they were archaeologically excavated from cemetery sites that functioned as communal burial grounds for local populations from 900 to 1600 AD and they were located in climates and environments similar to those inhabited by the border populations. Historical evidence suggested these populations did not directly experience the socio-political instability described along the Medieval Anglo-Scottish border. These populations were hypothesised to demonstrate demographic and palaeopathological trends similar to those observed in previously published late Medieval British populations (Roberts and Cox, 2003), assumed to be less 'stressed'.

3.1.2.1 Fishergate House, York

Located 350 meters south of the Medieval defensive wall surrounding the centre of York, Fishergate House (TF 0845 4367) was excavated from July 2000 to July 2002 by Archaeological Planning Consultancy in advance of a redevelopment construction project (Figure 3.5). Skeletal evidence from this excavation indicated a Medieval parish cemetery population, associated with a small church, interred at the site. Documentary evidence suggested Fishergate was an economically declining suburb of

York and consisted of individuals who farmed or were craft manufacturers. The cemetery was a communal burial ground from the end of the Anglo-Scandinavian rule of York through to the 16th century. Yorkshire was involved in William the Conqueror's 'Harrying of the North,' for it was the populations north of the Humber which actively opposed William's rule and violently overthrew their new Norman lords in the region. William's policy of laying waste to the countryside, which provided the agricultural and pastoral economic support for all the region's populations, was recorded to have left "no village [left] inhabited between York and Durham" (Prestwich, 1996: 199). Although this event could have directly affected the suburban populations of York, the city experienced nutritional deprivation associated with war only in 1070. The Medieval population at Fishergate was protected from the border wars by its distance from the Anglo-Scottish border and its proximity to the city's defensive walls. The individuals interred at the Fishergate House cemetery would have experienced a suburban medieval lifestyle.

Figure 3.5: Location of Fishergate House excavation south of the city centre of York (Dean, 2008: 43).

The Fishergate House excavation uncovered evidence of human occupation from the Roman period through the 20th century. The early-medieval occupation layers consisted of several phases of activity ranging from burials to domestic and manufacturing evidence (Spall and Toop, 2005). Four burials from the medieval

cemetery were initially excavated in 1994 (YAT, 1995), when one individual skeleton was discovered, and at nearby Marlborough Grove (FAS, 2000). Burials were expected to have been encountered in future excavations, although, the density of burial was unexpected (Spall and Toop, 2005). The 2000-2002 excavations exposed an area of 400 square meters within the grounds of Fishergate House which uncovered a total of 250 inhumation burials (Spall and Toop, 2005).

Although no remains of the chapel or church were uncovered, researchers hypothesised that it is located underneath a current standing structure (Spall and Toop, 2005). The only burials in stone coffins were encountered on the western side of the excavation and were argued to have been the 'special' burials reserved for the wealthy and privileged members of the church (Spall and Toop, 2005). In the excavation trench to the north of the House, a cluster of nine infant burials was uncovered, suggesting that this was the preferred burial location for very young children (Spall and Toop, 2005). Medieval church doctrine defined the east end of the internal and external church structure as the position for higher status burials, and the north-east corner of the church structure as the location for the burial of stillbirths or small children who died before their baptism (Shahar, 1990; Spall and Toop, 2005). The archaeological evidence from Fishergate House suggests that the church remains unexcavated beneath the foundation of the current property but was located within the boundaries of the defined cemetery (Spall and Toop, 2005).

The cemetery consisted of east-west aligned, supine interments arranged in rows. Three individuals were interred with grave goods dating from the late-medieval period; a shell pilgrimage token from Santiago de Compostella in Spain, a ring, and a metal fitting inscribed with a cross (Spall and Toop, 2005). Pottery recovered from the backfill of several graves suggested a date of the mid-14th to mid-15th century for the burials (Spall and Toop, 2005). The depth of the cemetery and high frequency of truncated burials indicated the burial ground was consistently used for an extended period of time (Spall and Toop, 2005). Radiocarbon dating of five skeletons from the earliest and latest phases of burial suggested the cemetery was used from the Anglo-Scandinavian period through the late-medieval period, and the earliest burial dated from 920 (±35 years) and the latest to 1545 (± 40 years).

Of the 250 graves uncovered in the Fishergate House cemetery, 244 were excavated (Spall and Toop, 2005). Post-excavation skeletal analysis identified 131 adult and 113 non-adult individuals (Holst, 2005). The majority of the skeletons were

described as in a good or moderate state of preservation at the time of analysis (Holst, 2005). This skeletal collection is currently held by Durham University in the Department of Archaeology and is used as a teaching and research collection.

Historical Context

The modern Fishergate Road in York follows the line of a major Roman thoroughfare (Spall and Toop, 2005). The Roman retreat from Britain in the 5th century was followed by a period of vaguely defined yet continuous occupation of York (Dean, 2008). Anglian settlers moved to Britain and archaeological evidence of influence, if not Anglian individuals, from Danish and German cemetery practices have been found in York (Dean, 2008). A fortified city at York became the principal religious and trade centre of the early-Medieval kingdom of Deira (Bede, 2008; Dean, 2008). York remained the largest urban centre in Northumbria throughout the 7th and 8th centuries, and at the time of Bede's *The Ecclesiastical History of the English People* in 731 AD, York was "the only approximation to a functioning town that would have been found in Northumbria at this time" (Bede, 2008: xxx).

Viking raids in the mid-9th century destabilised Northumbrian political and religious authority at Bamburgh and Lindisfarne, and drastically changed York. A Danish army captured York in 866 and held the city until the Norman Conquest (Savage, 2002; Dean, 2008). The Danes established a settlement, Jorvik, centred around the Roman fort ruins and controlled the region until the death of King Eric Bloodaxe in 954 (Rollason, 2000; Savage, 2002; Eales, 2003; Dean, 2008). The Anglo-Saxon Chronicles described the 9th through the 11th centuries as politically unstable and violent for the city of York (Savage, 2002). Northumbrian kings, as well as other British kings from southern England, made continuous efforts to capture York from the Danes (Rollason, 2003). The city maintained its religious significance and trade networks throughout this Anglo-Scandinavian period, although the population at York appears to have decreased (Macnab, 2003; Evans, 2004; Macnab and McComish, 2004; McComish, 2008). At the time of the Norman Conquest, York was held by English King Harold and ruled by an earl on his behalf (Dean, 2008).

The Norman Conquest marked another dramatic change for the city of York as it became William the Conqueror's most securely held northern city (McCord and Thompson, 1998; Morgan, 2001). "York became a frontier town on the limits of the Normans' northern control" (Dean, 2008: 15). The political and social instability

experienced by York continued through 1070 as the populations in northern England attempted to rebuff William's control and the Anglo-Saxon nobility fought for their claims to lordship in the face of William's Norman replacements (Rollason, 2003). William successfully countered rebellions in northern England in 1068 and 1069 and finally gained permanent control over York and its surrounding countryside after his 'Harrying of the North' in 1070 (Rollason, 2003; Dean, 2008). William also began his campaign of castle-building in the North with two motte-and-bailey structures at York (Platt, 1978; Eales, 2003; Dean, 2008). Although Northumbrian and Cumbrian populations continued to rebel against the Norman kings, York remained an English city and prospered as a royal centre of trade, religion, and administration throughout the Medieval period (Fraser, 1971; Platt, 1978; Lomas, 1996a; Dean, 2008).

The border wars of the late-Medieval period brought economic prosperity and administrative importance to York. The city was fined in the 1170s by King Henry II for smuggling arms, suggesting that the citizens were directly profiting from the border wars shortly after the Norman Conquest (Dean, 2008: 16). Between 1300 and 1327, York acted as an administrative center for the English crown (McNamee, 2006: 224). York's industries and markets also profited from aristocratic expenditure connected with the wars (McNamee, 2006). "A steep rise in food prices precipitated enactment of Civic Ordinances in 1301, and this seems to have been caused by the city's temporary status as seat of government" (McNamee, 2006: 224).

The town was protected from assault by the defensive walls constructed and maintained since the Roman occupation (Clarke, 1986; Eales, 2003). Military garrisons were stationed at York, particularly during the Scottish Wars of Independence (McNamee, 2006). These garrisons, however, were called out to confront Scottish raiding armies throughout the English borders and were not employed in defence of the city. "The York 'Custody' of 1315 assigned the defence of specific sectors [of the city walls] to men of particular city parishes. It also provided for a check on comings and goings at the city gates, for the expulsion of 'Scots and rascals', for nightly patrols; custody of keys, and penalties for contravention of security regulations" (McNamee, 2006: 222).

Yorkshire was threatened and attacked repeatedly by the Scots during the 14th century, but none of the raids directly affected York. For example, Robert I raided south from the Scottish border in 1316 through North Yorkshire from Barnard castle to Richmond (McNamee, 2006: 82). The *Prima Nova Taxatio*, a reassessment of the

value of property in Yorkshire composed in 1317, documented the damage sustained by the surrounding villages before Robert's army turned west through Wensleydale and across the Pennines into Cumbria, but no damage was recorded for York (McNamee, 2006: 83). Robert I's army 'wasted' the countryside to the east of Knaresborough towards York again in May of 1318, but the closest recorded damage was eight miles outside the city at the village of Tadcaster (McNamee, 2006: 89). The Scottish army raided south again in 1319 and tax records list 106 villages in the North and West Ridings of Yorkshire which were exempt from taxation because their property was burned by the Scots (McNamee, 2006: 91).

York citizens reportedly fought at the Battle of the Standard in 1138 against the Scots; this may have introduced stress related to conflict to the men of York who served in the battle (Dean, 2008: 16). However, the stress sustained in battle was also experienced by commoners conscripted into service throughout Britain in association with other wars, particularly wars waged against France during the medieval period.

Although it remains unclear which medieval church was associated with the Fishergate House burial ground, the evidence from the excavations and historical sources suggest a number of possibilities. By the late 10th century, three churches were founded in the area outside of the later Medieval defensive wall through Fishergate, including St Helen, St Andrews and All Saints (Spall and Toop, 2005). St. Andrews has been identified as the Gilbertine priory through previous archaeological excavations, and the southern boundary of this ecclesiastical site was identified at the Blue Bridge Lane excavation site to the north of Fishergate House (Kemp and Graves, 1996; Spall and Toop, 2005). Tentative archaeological evidence of All Saints has been found 150 meters south of the Medieval city walls on the eastern side of the Fishergate suburb which matches with documentary evidence of this church's location beneath the post-Medieval Cattle Market (Spall and Toop, 2005). St. Helen was founded before the Norman Conquest and was described as a small and unimportant church that was abandoned in the 16th century (Spall and Toop, 2005). It was granted to the monks of St Martin Marmoutier in 1100 and was described as a church with a 'toft (Spall and Toop, 2005).' Tofts in York were the standard Medieval unit of land that was a long and narrow plot generally running perpendicular to a street-front (Dean, 2008).

The dates and layout of the Fishergate House cemetery suggest that this was the location of St Helen's Church, Fishergate (Spall and Toop, 2005). St. Helen's was

described as a poor church in the tax records and only one reference to the burial of a church patron has been identified by historians (Spall and Toop, 2005). The church has also been associated in the documentary records with a hospital, which may possibly have been a leprosarium (Spall and Toop, 2005). The parish of St. Helen was combined with St Lawrence in 1585 and the church was recorded as demolished and the land sold (Spall and Toop, 2005). John Speed's map of York from 1610 indicated that Fishergate was a rural, unoccupied area outside the city walls. Archaeological evidence has identified pastoral use above the cemetery in the 17th and 18th centuries, with the site not being occupied again until Fishergate House was built on the site in the early 19th century (Spall and Toop, 2005).

3.1.2.2 Franciscan Friary, Hartlepool

Hartlepool, located in present day County Durham, is a coastal town constructed around a protected harbour on an isthmus projecting into the North Sea (Figure 3.7). A rural, agricultural settlement existed at Hartlepool before the Norman Conquest and the port was granted the status of a town in the 13th century. The local population prospered in the Post-Conquest Medieval period as the town developed into a key fishing community, a port for military supplies for the border armies, and a safe harbour for the English fleet. Throughout the Medieval border troubles, the Franciscans buried Hartlepool community members in their cemetery. Documentary evidence indicates that the burials at the Franciscan Friary's church consisted of the friars themselves, wealthier community members who paid to be interred by the Friary, and possibly the ill who were cared for by the friars. The records also indicate that Hartlepool played a role in supplying and supporting the border wars, however, the town did not play a central role in the conflicts. The cemetery population at this site consisted of individuals who experienced the height of the border wars from a safe distance.

Figure 3.6: Franciscan Friary excavation location within the Medieval town of Hartlepool (Daniels, 1984a: 261).

Re-development on the south-west corner of Friarage Field (NZ 529 338) in the early 1980s allowed Cleveland County Archaeology Section to excavate a portion of the land granted to a small group of Franciscan friars in the 1240s (Daniels, 1986). Excavations conducted between June 1982 and March 1983, uncovered nine phases of human occupation from the natural soil to ground-level (Daniels, 1986). The third and fourth phases of occupation included a stone church, burials, and structural extensions which comprised the Franciscans' Church during their residence in Hartlepool from 1240 to 1545 (Daniels, 1986). The Medieval burials occurred both within the church, below its tiled floor, and in the adjacent land surrounding the building (Daniels, 1986: 271-2). Burials within the church were observed to be more concentrated than those in the areas excavated outside of the church (Daniels, 1986: 271). Of the 74 burials uncovered in the church, 62 graves were excavated (Daniels, 1986: 271). An additional 21 burials were excavated from the graveyard outside of the church (Daniels, 1986: 272). All of the burials were coffin or shroud interments, aligned east-west, and buried in a spine position (Daniels, 1986: 271). In 1989, a portion of the Friary church choir was disturbed by modern construction. Additional graves were uncovered and excavated by Tees Archaeology to remove the skeletal remains, but no additional excavations were undertaken (Daniels, per comm.).

Of the 83 burials excavated in 1982-3, post-excavation skeletal analysis identified a minimum of 150 individuals, of which 125 were determined to be adults

and 25 to be non-adults (Birkett, 1986: 292). These skeletal remains were described as "preserved in an excellent condition" (Birkett, 1986: 292). An additional 13 skeletons were excavated in 1989, 11 adults and 2 non-adults (Daniels, per comm.). Although a large portion of the skeletons from the 1982-3 excavation was reburied in St. Hilda's parish church in Hartlepool, the remainder of this collection is currently stored with Tees Archaeology at the Hartlepool Museum (Daniels, per comm.).

Historical Context

The earliest mention of Hartlepool in documentary sources occurred in Bede's account of a monastery established there during the 640s by Heiu, the first Northumbrian nun (Colgrave and Mynors, 1969; Ward, 1999). This monastery was lead by St. Hilda from 649 to 657, when she founded a new monastery at Whitby (Colgrave and Mynors, 1969; Ward, 1999; Bede, 2008). Recent archaeological excavations have discovered the monastic settlement and indicated that there was a thriving secular early-Medieval community in existence at Hartlepool before the foundation of the monastery (Cramp and Daniels, 1987; Ward, 1999).

Historical documents cite a Viking invasion as the cause of the abandonment of the Anglo-Saxon monastic community at Hartlepool, but recent archaeological excavations suggest Hartlepool experienced a decline between the 9th and the 12th centuries rather than destruction (Daniels, 1986, 2007). Excavations at the medieval village of Hart, located four miles west of Hartlepool, provided evidence for a thriving agricultural population in the region throughout the Anglo-Saxon and Medieval periods (Austin, 1976). Medieval documentary evidence for Hart described the villagers' secular obligations to the local manor house and under the ecclesiastical jurisdiction of Durham priory (Austin, 1976). These historical and archaeological sources describe a thriving agricultural population in the eastern part of the modern County Durham during the reigns of the Northumbrian Kings, a population that was able to support a Northumbrian monastic community and their associated estates.

The effect of the Norman Conquest on Hartlepool is not well-documented. Its location suggests it was involved in the 'Harrying of the North' when William's armies ravaged the countryside between the Humber and the Tees, although no documentary evidence from Hartlepool remains to confirm its participation (Rollason, 2003). The earliest documents pertain to the grant in 1119 of the Hartlepool area, including the nearby village of Hart, all part of the endownments of Guisborough

Priory to the de Brus family (Ward, 1999: 5). The transition of power in north-east England, from the Northumbrian lords and monastic communities to the Norman elite, was complicated in the Hartlepool communities by continuous raids by the Vikings. A mid-12th century Icelandic saga reports that King Eystein raided 'Hjartapoll' and destroyed ships, suggesting a population that relied on the Hartlepool harbour for income from fishing and shipping (Ward, 1999: 5). King John's royal records from 1201 also record an outgoing payment for ship repairs at Hartlepool, demonstrating the residents reliance on the harbour for their economic prosperity (Ward, 1999: 7).

The first documentary evidence of the Franciscans' settlement in Hartlepool was a grant of fabric for tunics to the friars from Henry III in 1240 (Daniels, 1986: 260). The next reference, in 1243, was a description in the Assize Roll of a robber claiming sanctuary in the friars' church in Hartlepool which provides clear evidence that a church had been constructed by the Franciscans before this date (Daniels, 1986: 262). Few other references exist of the Franciscan community at Hartlepool throughout the late-Medieval period. Two references were documented in the 14th century to events at the church: record of an ordination service was noted in 1335, and the English King Edward III granted a license in 1358 to John, son of Elias of Brancepeth, to give three acres of his property to the friars (Daniels, 1986: 262). Town records state that the brothers relied upon local benefactors, a bursary from Durham Priory, and a portion of the revenue of the town oven for their annual income (Daniels, 1986). Records indicate that this income was supplemented by bequests from those wishing to be buried in the friary church or graveyard (Daniels, 1986). In addition, the Franciscans were known in the Medieval period as carers for the sick and infirm (Daniels, 1986).

Robert de Brus's claim to the Scottish throne in 1306 led to the revocation of his claims to property in England (McNamee, 2006). His lands in County Durham, including Hartlepool, were redistributed (Ward, 1999: 8). Interactions between Hartlepool and Robert de Brus in the early-14th century, following his crowning as Scotland's Robert I, are the only documented episodes of conflict directly affecting this coastal town during the late-Medieval period. He directly threatened the town in 1315 and in 1318 through written truce agreements purchased by the Durham Priory (McNamee, 2006). Speculation on why Hartlepool was specifically targeted focuses on two possible motives: the citizens of the surrounding countryside no longer recognized the de Brus claims of lordship over his previously held fiefdom, and the

harbor at Hartlepool was functioning as a naval base for attacks on Scottish privateers in the North Sea (McNamee, 2006: 80). Capture or destruction of Hartlepool would have both protected Scottish naval interests and extended Robert's domination over the border counties south into Cleveland. The Mayor of Hartlepool raised taxes in 1315 to build a protective wall around the city in response to these threats from Robert de Brus. Documentary sources from Guisborough, Lanercost, and Coldingham recorded Hartlepool "despoiled" and burgesses captured, including women, by Robert's force in July 1315 (Ward, 1999; McNamee, 2006: 80). Excavations in 1983 along the standing fabric of the stone Medieval wall revealed that the townspeople initially fortified their isthmus by constructing a substantial bank and ditch defence along the neck of the peninsula, which was followed by subsequent modifications (Daniels, 1984b). The later stone wall enclosed the town, including the Franciscan Friary, the harbour, and a large part of the town fields (Daniels, 1984b). Although damage caused by Scottish raids were recorded throughout County Durham in 1318 and in 1322, Hartlepool was not directly affected by these raiding parties (Ward, 1999; Sadler, 2006).

The town did play a role in the border wars as port city which supplied goods and crew for English war ships. In 1299, a ship from Hartlepool was employed by the English King Edward I to transport provisions to the English army at Stirling and Edinburgh, and it included a crew of 27 men (Ward, 1999: 8). Records indicate that in 1307 King Edward II impressed men and ships from the sea coasts of Durham and Northumberland into his war against the Scots (Ward, 1999: 8). Hartlepool also supplied the English royal ships returning south from the Scottish Front, as in 1314, when Edward II supplied his ships at Hartlepool after his defeat at Bannockburn (Ward, 1999: 8). The town also aided in England's defence in 1345, when two ships in Hartlepool were modified and used to deter marauders along the North Sea coast (Ward, 1999). Although Hartlepool provided a strategic safe-harbour for the English against the Scots, their resources were also called upon in England's other wars; Edward III used 5 ships and 145 seamen from Hartlepool at the siege of Calais in 1347 (Ward, 1999). The first evidence of the conscription of the local population into direct military service was not until 1512, when laws were passed to enforce archery practice among the townsmen (Ward, 1999).

England withdrew from Scotland in 1549 and the dissolution of the monastic communities in County Durham reduced the demand for fish; Hartlepool was "visibly

declining after the loss of the fish trade to the religious houses" (Ward, 1999: 13). Records show the friary house was leased by Henry VIII in 1538 to the keeper of the Grey Friars and sold in 1545 (Daniels, 1986). At the final dissolution of the order in 1545, an inventory of their possessions was taken and the group disbanded. Burials also ceased at the Friary at the time of the land's sale (Daniels, 1986). The final inventory indicated the Friary either adhered to their vows of poverty or lacked a significant number of benefactors to enable material prosperity (Daniels, 1986: 263). The friary church was demolished and replaced by a 16th century mansion following the dissolution (Daniels, 1986: 264).

3.1.2.3 Parliament House, Edinburgh

The modern city of Edinburgh is the capital of Scotland and is located on the southern coast of the Firth of Forth. Historical evidence described the Firth of Forth as a border region between the pagan Highland Picts and the Christian Lowland Scots from the 6th to the 10th century (Lowe, 1999). Communities in the Edinburgh region represented the most northern populations under the political and religious control of the Northumbrians (Rollason, 2003). It was also one of the first locations to become securely controlled by the Scots during the 10th century decline of Northumbria (Mackie, 1978). Edinburgh became a royal burgh and grew in size and economic importance from the 11th century throughout the Medieval period. The English sieged, burned, and sacked Edinburgh in the 14th and 15th centuries in an effort to gain control over their northern neighbours (Mackie, 1978). However, the English were not successful and Edinburgh remained the capital city of an independent nation until the unification of the crowns in 1603.

Parliament House (NT 2577 7350) is a 2-hectare building complex located in the modern centre of Edinburgh city south of, and adjacent to, St. Giles Cathedral. This location was excavated from December 2001 to December 2004 as part of a redevelopment construction project for the Parliament House building (Toolis, 2005). The site functioned as a car park before excavation began. Beneath the car park, multiple layers of occupation and activity were uncovered which ranged in date from the 13th century to the present day (Toolis, 2005). The first layer of occupation above the natural soil contained silty clay deposits associated with medieval domestic activity between the 13th century and 15th century (Toolis, 2005). Domestic debris

suggested the area was associated with either burgage plots or an early Medieval religious community at St. Giles (Toolis, 2005: 29; Collard et al., 2006).

The fourth phase of occupation observed at the Parliament House excavation was a layer of silt with graves containing 96 inhumation burials in rows (Toolis, 2005). The burials were supine and aligned west to east, consistent with medieval Christian burial practices. One mass grave was excavated containing six adult individuals hypothesised to have been victims of disease (Toolis, 2005). Although no grave goods were recovered to assist with dating the burials, late-Medieval pottery was found in the grave soil (Toolis, 2005). Consistent with other medieval cemeteries, many of the graves in the lower part of the level were truncated by subsequent grave cuts and disarticulated remains were found in the grave backfills (Toolis, 2005: 30). A sandstone cobble surface covered the graves from the fourth phase, representing a 17th to 19th century market described in historical documents as the "Meal Market of the former churchyard of St. Giles" (Toolis, 2005 1).

Post-excavation skeletal analysis identified a minimum number of 95 individuals, 55 adults and 40 non-adults (Melikian, 2005: 1). Preservation of the skeletons was described as moderate for a majority of the individuals (Melikian, 2005: 11). Stable isotope analysis of this population has indicated that the individuals interred in this portion of St. Giles' burial ground were residents of the Edinburgh region during childhood and ate protein-rich diets consistent with Medieval lay populations (Melikian and Evans, 2008). The skeletal collection is currently stored at AOC Archaeology's Edinburgh location (Toolis, per comm.).

Historical Context

Debate still remains over the size, importance, and defensive capabilities of prehistoric and early-Medieval populations living in Edinburgh (Driscoll and Yeoman, 1997; Toolis, 2005). Roman-era occupation was identified at the present Castle location, but no evidence of this settlement extended to the Parliament House site (Toolis, 2005: 3). The first written evidence of settlement in the Edinburgh region comes from a 7th century Welsh poem which tells of a people from north of Bamburgh, possibly the Picts or the Scots, who launched an attack from *Din Eidyn* against the Northumbrian kingdom of Deira (Mackie, 1978; Lowe, 1999; Toolis, 2005). Reference in an Iona annal from 638 AD described the conquest of *Etin*, which could refer to the events of Northumbrian expansion to Edinburgh (Mackie,

1978; Toolis, 2005). Bede's description of the northern border of the Northumbrian kingdom in the 8th century did not specifically describe a significant settlement at Edinburgh (Bede, 2008). Bede also described a city called Giudi, "half way along the eastern branch," of a long arm of the sea which was inhabited by Picts from the north (Bede, 2008: 22). Although previous historians are uncertain of the exact location of Giudi, they have hypothesised it to be Edinburgh, Stirling, or the Roman fort at Cramond (Bede, 2008: 365). During the 8th century, Edinburgh appears to have been located along a contested border between the Pictish kingdoms to the north and the Northumbrian kingdom to the south.

Documentary references to Edinburgh during the decline of the Northumbrian kingdom are sparse (Rollason, 2003; Toolis, 2005: 3). Researchers have inferred from the few available references that a settlement at Edinburgh was associated with Northumbrian political and religious authority in the 9th century and became a fortified settlement in the 10th century as Northumbria fragmented and the Vikings raided the eastern coast of Britain (Rollason, 2003; Toolis, 2005).

Archaeological evidence from Edinburgh Castle suggested a "thriving and wealthy communities occupying this key defensive site into the early medieval period" (Toolis, 2005: 3). This evidence supports the hypothesis that there was an Anglian *burgh* at this location which was conquered by the Scots during the decline of Northumbria in the 10th century. Edinburgh appeared to remain a minor town throughout the 11th century as Scottish royal power grew and was consolidated under the Canmore Kings (Mackie, 1978). These Kings have been credited with building a 'new' Norman town at Edinburgh and was founded as a *burgh* in 1130 (Mackie, 1978; Collard et al., 2006). A *burgh* was defined by Medieval society as a stronghold in a central geographic location, such as a hill, a ford, or a road junction, which already was a settlement before defences were built and became a centre of trade as well as a seat of military power (Mackie, 1978: 52).

Edinburgh's position as the capital city of Scotland and the administrative centre of the kingdom was a gradual progression from population centre to royal burgh (Mackie, 1978). In 1329, Edinburgh was granted a 'feu-farme charters' which created a similar tax payment relationship between the citizens and the King as in England; the townspeople paid an annual fee in lieu of the usual dues and customs of feudal subjects which involved the employment of royal officers (Mackie, 1978: 78). Although the city was defined as a royal burgh in the 13th century, the Scottish royal

government also maintained administrative functions in other Scottish cities, such as Dunbarton, Stirling, and Berwick, until the 16th century (Mackie, 1978). James IV (1488 – 1513) worked to improve the function of the government and established regular meetings of Parliament and the judiciary council in Edinburgh between 1503 and 1511 (Mackie, 1978: 117 - 8). The decentralised nature of the Scottish political authority was largely a conscious effort of the Kings to maintain mobility when confronted with a more dominant military force from England to their south (Mackie, 1978; McNamee, 2006).

Edinburgh was extensively damaged and occupied by the English army during conflicts in the 14th and 15th centuries. The residents of Edinburgh experienced one siege associated with the Scottish Wars of Independence in the 14th century; England's Edward III ravaged Edinburgh in the 'Burnt Candlemas' of 1356 (Mackie, 1978: 81). Despite the destruction these wars brought to the rural populations of southern Scotland, Edinburgh continued to grow and developed its port at Leith (Mackie, 1978: 85). In August 1385, an English army under King Richard II's command invaded Scotland as retaliation for the Franco-Scottish alliance army's raid of Northumberland the previous month; the English army burned Edinburgh as well as Dryburgh and Melrose abbeys (Sadler, 2006). The English army occupied Edinburgh in 1482 "theoretically to depose James [III, 1460 – 1488], but … the main outcome of the expedition was that the English recovered Berwick [upon-Tweed]" (Mackie, 1978: 92). Edinburgh was also sacked in 1544 by the Earl of Hereford, as part of Henry VIII's 'rough wooing' (Morgan, 2001: 293).

The extent of Medieval defensive architecture constructed around Edinburgh to protect the city remains under investigation. Recent excavations along Flodden Wall, believed to have been a Medieval defensive wall extended and refortified following the battle at Flodden Hill in 1513, demonstrated the wall was originally built in the late 16th century and subsequently modified in the 18th and 19th centuries (Lawson and Reed, 2003). This excavation indicated Edinburgh's medieval defences were less extensive than previous historical sources have suggested (Mackie, 1978).

St. Giles' Cathedral functioned as the parish church and burial ground for the city of Edinburgh throughout the Medieval period (Collard et al., 2006). The earliest documentary evidence is dated to 1178, although the archaeological evidence from the Choir aisle suggests that there was occupation at this site before the construction of the Cathedral (Collard et al., 2006). St. Giles Cathedral was burned during Richard

II's 1385 attack on Edinburgh (Mackie, 1978; Collard et al., 2006). The architectural plans for reconstruction, dating from 1387, are the earliest surviving documentary sources for building work at the cathedral (Collard et al., 2006). Burials occurred inside St. Giles' Cathedral for the wealthy and privileged citizens of Scotland, while burials occurred outside the church in the adjacent cemetery for the general lay population of Edinburgh (Collard et al., 2006; Melikian and Evans, 2008). Due to lack of space, the cemetery was extended twice in the 15th century into the Provost's garden, first in 1477 and again in 1496 (Collard et al., 2006: 5). The cemetery extension of 1496 comprised the portion of the garden which later became part of the Parliament House complex (Toolis, 2005). This garden was used as a cemetery by St. Giles' Cathedral until 1562 (Collard et al., 2006: 5). St. Giles' parish records state that the last burial in its adjacent cemetery was in 1566 (Toolis, 2005: 4).

The portion of the St. Giles' parish cemetery uncovered by the Parliament House excavations represented individuals who resided in Edinburgh during the late-15th century and the early 16th century (Melikian and Evans, 2008). Historical records indicated burial occurred in this location between 1496 and 1566 (Toolis, 2005). Although Medieval Edinburgh experienced violence associated with war, the population interred at Parliament House only experienced one episode of siege; the Earl of Hereford's siege of 1544 (Mackie, 1978). This single event would not have produced chronic health changes associated with a conflict-zone lifestyle.

3.1.2.4 Whithorn Priory, Dumfries and Galloway

Whithorn Priory (NT 444 402) is located approximately 5 km north of the southern coast of the modern county of Dumfries and Galloway in Scotland (Figure 3.7). Whithorn was a vibrant town of continuous religious significance throughout the early- and late-Medieval periods. The local populations in and around the town of Whithorn supported both the monastic community and the secular aristocratic land owners through various changes in political authority (Hill, 1997). "There appear to have been changes of foci for burial, with areas within the monastery falling in and out of use as cemeteries" (McComish and Petts, 2008: 77). The cemetery population interred along the southern side of the Priory consisted of the general lay population of Whithorn from approximately 1250 AD until 1600 AD (Hill, 1997). This population lived after the final violent event of the Scottish conquest of Galloway in 1235 and were consistently economically supported by the needs of the monastic

community and pilgrims associated with the cult of St. Ninian (Hill, 1997). Their daily lives would have reflected a typical Medieval town lifestyle without the nutritional or economic disruptions associated with the border troubles.
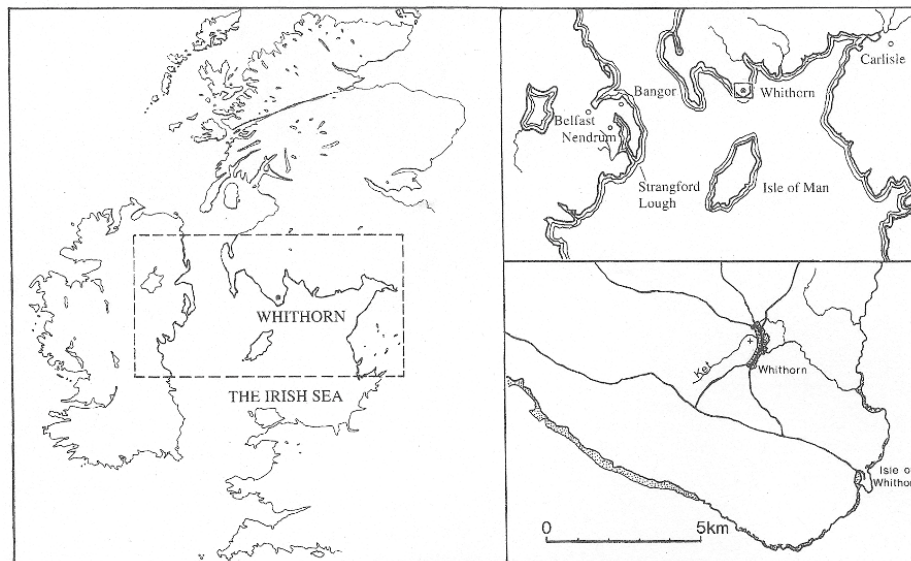
Figure 3.7: Location of Whithorn Priory on the Irish Sea Coast (left); in relation to Carlisle (top right); and its proximity to the harbour on the Isle of Whithorn (bottom right) (Hill, 1997: 5).

Archaeological excavations were conducted between 1984 and 1991 by the Whithorn Trust, in association with a proposed construction project, on Glebe Field which lies south-east of the standing Medieval Priory church ruins (Hill, 1997). These excavations uncovered six broad phases of occupation which improved the interpretation of the spatial relationship between Whithorn's monastic and lay communities during the early- and late-Medieval periods (Table 3.1).

Table 3.1: Phases of occupation at Glebe Field associated with Whithorn Priory (Hill, 1997).

Phase	Dates	Description
Period I	Late 5th/Early 6th C – 7th C	*Monasterium* established under St. Ninia.
Period II	7th C – c. 840 AD	*Monasterium* modified with Northumbrian material culture and a Northumbrian bishopric established. Destroyed by fire around 840 AD.
Period III	c. 840 AD – early 11th C	Northumbrian Minster rebuilt with Scandinavian and Irish material culture.
Period IV	early 11th C – c. 1250 AD	New Celtic settlement built over the Minster. Settlement burned and abandoned. Surrounding swampland drained naturally during this period.
Period V	c. 1250 AD – 1600 AD	Separation of the monastic and the lay communities with construction of a planned Medieval town adjacent to the Priory. Lay burials on south side of Priory.
Period VI	1600 AD – present	Cessation of activity and reversion to agricultural use.

The early-Medieval occupation strata excavated by Hill (1997), included two phases of burials. The hill on which the Priory was constructed was surrounded by

water on three sides before 1250 AD (Hill, 1997). The field drained naturally before the late Medieval burials began in this section of the parish cemetery (Hill, 1997). Hill's excavations "revealed a densely-populated medieval graveyard in the northern part of the field disturbing deep early medieval deposits" (1997: 11). Although there were three temporally separate phases of burial at Whithorn (Table 3.2), the late-Medieval burials from Period V/1-3 consisted of individuals from the general Whithorn population during the period of the border troubles (Hill, 1997). The early-Medieval burials were assessed to be from a highly select group, predominately males, from only the monastic community (Cardy, 1997). Therefore, only the skeletons excavated from the late-Medieval phase were included in this study as a comparative population for the conflict-zone individuals.

Table 3.2: Temporal differences in burial phases at Whithorn Priory (Cardy, 1997; Hill, 1997).

Burial Phases	Date
Period I	500 – 700 AD
Periods II and III/1	700 – 900 AD
Period V/1-3	1250 – 1450 AD

Excavations from the late-Medieval cemetery phase uncovered 1651 graves containing 1605 articulated skeletons, of which 1553 were excavated intact (Hill, 1997: 253). The graves were aligned east-west and were densely packed in the centre of the graveyard with subsequent burials intercutting previous graves. Many skeletons were described as truncated by the cutting of later graves (Cardy, 1997: 519). Hill (1997: 255) recognised foetal, neonate, and infant remains were under-represented in the cemetery and suggested these individuals were interred in an unexcavated portion of the cemetery.

Demographic data were collected from all 1605 skeletons during excavation; 1093 individuals were determined to be adults and 512 were determined to be non-adults at the time of their death (Cardy, 1997: 519). However, only the 1553 lifted skeletons were fully analysed during post-excavation osteological work (Cardy, 1997: 520). Preservation and completeness of the skeletons was an issue highlighted by post-excavation analysis. Only 19% of the individuals were described as in 'moderately good or better condition" (Cardy, 1997: 519). A large portion of the skeletal material from Whithorn was reburied after post-excavation analysis (Pickin, per comm.). The remaining portion of the collection that is available for analysis is currently stored at Stranraer Museum in Dumfries and Galloway (Pickin, per comm.).

Historical Context

The first excavation at Whithorn, conducted by William Galloway in the 1880s, uncovered the *Latinus* stone, which remains the only contemporary written evidence of the Christian community from the Early Medieval period (Hill, 1997: 9). Occupation patterns and material culture from the 5th to the 7th centuries suggest that Irish Celtic culture influenced Whithorn in the post-Roman era (Cramp, 1994). Early-Medieval burial practices were also similar to Irish cemeteries with specially marked graves surrounded by later burials oriented around the first grave (Cramp, 1994). The early-Medieval transition from a Celtic monastic community to a Northumbrian town remains difficult for researchers to describe. Whithorn was one of the last and the most western acquisitions of the Northumbrian kingdom, but the exact date and method of Northumbria's conquest remains uncertain (Cramp, 1994). Bede described Whithorn as part of Northumbria at two different dates; in 565, when Bishop Ninia was head of the monastic community, Bede described Whithorn as "in the kingdom of Bernicia" (Bede, 2008: 115), and in 731 Bede described Whithorn as the fourth bishopric in Northumbria (Bede, 2008: 289).

Archaeological evidence suggests the Northumbrians gained physical control over Whithorn in the late 7th century and it experienced a cultural change in response to this conquest (Hill, 1997: 17 - 8). Excavations between 1992 and 1996 in Fey Field, southwest of the standing cathedral ruins and to the north of Glebe Field, identified various phases of human settlements, industry, and burials adjacent to Priory Hill from the 6th to the 14th centuries (McComish and Petts, 2008). Early-Medieval miracle texts describe St. Ninian's shrine at Whithorn as a place of miraculous healing during the 8th century, at the height of the Northumbrian kingdom's expansion and influence (Hill, 1997). Pilgrimage and worship at the tomb and of the relics of St. Ninian were described as two distinct locations at Whithorn throughout the early- and late-medieval periods. Archaeological evidence of medicinal herbs and a possible surgeon's knife in Northumbrian strata at Whithorn lend support to the interpretation of the early Medieval *monasterium*'s role as an infirmary, as well as a religious community, from the 700s AD (Hill, 1997: 20).

The late-Medieval Whithorn Priory was part of the Premonstratensians monastic order (Hill, 1997). The White Canons came to Scotland during the 1150s, during the reign of David I (1124-1153) and established themselves at Dryburgh (Dilworth, 1994). By the 1220s, six additional Premonstatensian monasteries had

been founded by the Dryburgh community; one of these was the Whithorn Priory (Dilworth, 1994). The priory of Whithorn was centred around a large cathedral complex that included monastic cloisters for the religious community, and a large nave and burial ground which functioned as a house of worship and cemetery for the lay townspeople (Hill, 1997). Excavations from 1957 to 1967 to the west of the late Medieval crypts and beneath the remains of the quire, uncovered the 13th and 14th century graves of Whithorn's bishops and Priors as well as the early-Medieval graves and the possible Roman cremation cemetery (Hill, 1997: 10). Tabraham's excavations in 1972 identified the late-Medieval burial ground to the south of the Priory both within Glebe Field and on land to the immediate west (Hill, 1997: 10).

During the 12th and 13th centuries, Dumfries and Galloway was dominated by the Lords of Galloway and the local populations saw themselves as a different ethnicity and a separate political entity from the Scots (Hill, 1997). Galloway became part of greater Scotland in 1234 after a short-lived rebellion by the local people. A "brutally suppressed" rising of the people by Scottish King Alexander II was the last political and economic instability experienced by the people of Whithorn until the town's economic decline in the 16th century following the Protestant Reformation in Scotland (Hill, 1997; Ewart, 2001: 84).

The Priory of Whithorn held large parcels of land in Galloway which it administered as a secular barony. The earliest town charter which survives dates from 1451, but reconfirms the privileges granted in the town's three previous charters issued by Robert I (1326 AD), Edward Bruce (c. 1310 AD), and Alexander III (1249 – 86 AD) respectively. These charters all describe Whithorn as a vill or free burgh with a weekly market and an annual fair around St. Ninian's Day (Dilworth, 1994). These charters also confirmed that the grant of the town to the Priory was its source of income (Hill, 1997).

The Priory also relied upon the shipping port at the Isle of Whithorn for economic support. The relationship between the town of Whithorn, the Priory, and the Isle of Whithorn was so interconnected that early maps confused the two locations and recorded Whithorn as located on the coast (Hill, 1997). Pilgrimage to the relics of St. Ninian also brought economic prosperity to Whithorn in the Medieval period. The shrine attracted religious tourists from throughout Scotland and from abroad (Dilworth, 1995).

Despite Whithorn's geographic proximity to the Anglo-Scottish border, the wars associated with border contention from the 10th to the 16th century did not directly affect the lay populations in western Galloway. Although other monastic communities in eastern Galloway, such as Dundrennan and Sweetheart Abbeys, reported property damage and claimed tax exemption from England's King Edward I, damage was not recorded at Whithorn and the town was not attacked during the Scottish Wars of Independence (Hill, 1997; Ewart, 2001: 84; McNamee, 2006). The greatest impact of the late-Medieval border troubles was experienced by the severance of administrative connections between Whithorn Priory and the Premonstratensian communities in England. Religious administrative documents from Whithorn described a close, communal relationship between southern Scottish and northern English monastic houses during the early centuries of the Medieval period, which was later dissolved by the international political conflict between the two kingdoms (Dilworth, 1994: 4).

Although the Protestant Reformation in Scotland was less abrupt than in England, the gradual reduction of power and influence of the monastic communities produced the same effect of abandoned monasteries and derelict cathedrals. Whithorn's economy collapsed gradually with the contraction of the Priory and the Scottish parliament's ban of pilgrimages to religious relics (Ewart, 2001: 85).

Although a settlement remained in the town, its population was greatly reduced and its Catholic parish traditions changed. The nave was transformed into a parish church and a square tower was constructed on its western end in 1610 (Hill, 1997). Although burials most likely continued around the parish church, Glebe Field was no longer used for that purpose.

3.1.3 Materials Summary

These eight skeletal populations were selected to represent medieval British populations that were both affected and unaffected by conflict-zone stress (Table 3.3). Populations from both the eastern and western sides of the Pennine Mountains were specifically included to provide as complete a picture of border populations as archaeologically possible. The populations from the conflict-zone along the Anglo-Scottish border were hypothesised to have been stunted, wasted, malnourished, and with shorter life spans than their contemporary neighbours. The methods used to collect and compare the data are described in the next section.

Table 3.3: Eight skeletal populations analysed for this study.

Regional Populations	Site	Date	Settlement Type	Economic Status of Burials
Conflict-Zone				
	Auldhame	890 – 1400	Rural	Farmers
	Blackfriars Street	1240 – 1539	Urban	Monastic and wealthy lay
	Blackgate	880 – 1168	Rural	Farmers
	The Hirsel	1100 – 1400	Rural	Farmers
Neighbours				
	Fishergate House	900 – 1549	Suburban	Urban poor, farmers
	Franciscan Friary	1240 – 1538	Town	Monastic and wealthy lay
	Parliament House	1496 – 1566	Urban	Middle class, urban poor
	Whithorn	1250 – 1450	Town	Farmers and merchants

3.2 Methods

Standard methods of bioarchaeological analysis in the UK were published after initial post-excavation analyses were undertaken for six of the eight skeletal collections selected for this project (Brickley and McKinley, 2004). As a result, the initial skeletal data and previously published reports for these six populations were incompatible for direct comparison. There were reportedly 3236 skeletons available from these eight populations for future skeletal analysis, therefore a random sample of skeletons from all eight collections were slated to be re-analysed by the author using current standard methods, which are described in detail in the following sections. The use of standard methods ensured the data required to test the hypothesis in this study were consistently recorded for each skeletal population. The collections were sampled so that individuals from all eight geographic locations throughout the region could be included in this study within the available research time. A minimum of 50 skeletons from each collection was chosen from the material available in the curatorial storage locations during data collection. An expected count of 400 individual skeletons was anticipated to have resulted in counts high enough to represent the general health and disease patterns present in the medieval living populations and generated enough data for robust statistical comparisons between the conflict-zone and neighbours populations. Previous researchers descriptions of the preservation state, age, sex, and palaeopathological lesions observed was not taken into account before selecting skeletons for this study. This prevented the author from any influences from previous research or population interpretations.

Exceptions to this random selection process were made for two skeletal collections which included pre-Christian burials and for two collections which were significantly altered by reburial regulations. As previously described, skeletons in the

Auldhame and Blackgate collections were excavated from burial contexts suggesting dates of interment earlier than 900 – 1000 AD (Nolan, 1998; Melikian, 2009). These skeletons were excluded from these two populations before they were randomly sampled. For example, skeletons excavated from crouched burials were excluded from the selection process because their burial style suggested possible non-Christian funerary practices which predated the period of the Medieval border troubles (Hindmarch and Melikian, 2006b).

Prior to this study, the majority of skeletons from the Franciscan Friary and the Whithorn priory excavations had been reburied, and many of the Whithorn individuals that remained available for analysis consisted solely of dentitions and lower cranial elements associated with dental analyses. Additionally, the neighbours populations was poorly preserved overall due largely to poor excavation and curatorial practices associated with excavations from the last half of the 20th century. Unfortunately, no additional cemeteries from the northern English and southern Scottish regions adjacent to the borders have been excavated to date. As these collections could not be substituted with alternative collections that satisfied the objectives of this project, the entire remaining collections from the Franciscan Friary and Whithorn priory were included in the neighbours population sample. The lack of neighbours skeletons available for comparative analysis imposed unforeseen limitations on the scope of this study which can only be addressed by further archaeological excavation and osteological research in the future.

Despite these preservation and availability problems, comprehensive observations of individuals of all ages and sexes for palaeopathological lesions associated with nutritional indicators of stress, metabolic bone disease, and non-specific infection were possible within these eight skeletal collections. A total of 388 individual skeletons were macroscopically analysed for this study. The conflict-zone population consisted of a total of 215 individuals randomly selected from four medieval cemeteries along the politically contested Anglo-Scottish border; the neighbours population included 173 individuals from four politically stable Medieval sites adjacent to this border region (Table 3.4).

Table 3.4: Number of skeletons analysed by site.

Population	Site	No.	%
Conflict-zone		215	55.4
	Auldhame	52	13.4
	Blackfriars Street	57	14.7
	Blackgate	56	14.4
	The Hirsel	50	12.9
Neighbours		173	44.6
	Fishergate House	50	12.9
	Franciscan Friary	20	5.2
	Parliament House	51	13.1
	Whithorn	52	13.4
Total		388	100.0

The skeletons randomly selected were assigned a unique skeleton number which consisted of a two-letter site name abbreviation and the skeleton reference number created by the original excavation team and was noted on all corresponding forms and files associated with that individual skeleton (Table 3.5). This system was developed to avoid confusion between skeletons with the same reference numbers from different sites.

Table 3.5: Two-letter site abbreviations used to create a unique skeleton number.

Site Name	Abbreviation
Auldhame, East Lothian	AU
Blackfriars Street, Carlisle	BF
Blackgate, Newcastle	BG
Fishergate House, York	FH
Franciscan Friary, Hartlepool	FF
The Hirsel, Coldstream	TH
Parliament House, Edinburgh	PH
Whithorn, Dumfries and Galloway	WH

Data were initially recorded on paper forms designed specifically for this study based on previously published recording standards (Buikstra and Ubelaker, 1994; Brickley and McKinley, 2004). The skeletons were then macroscopically analysed using current bioarchaeological methods, chosen due to their common use in Britain, to create comparable sets of bioarchaeological data for the conflict-zone and neighbours populations (Brickley, 2004c). All measurements were taken using electronic digital sliding callipers (Maplin brand, Model N48AA) or a Paleo-Tech Concepts portable osteometric board.

Once recorded on paper forms, the data were entered into an SPSS database specifically designed for this study. Statistical tests were conducted to compare demographic and palaeopathological data both within each skeletal collection as well as between the conflict-zone and neighbouring populations. The following sections

encompass detailed descriptions of the methods used to collect, record, and analyse the data presented in this study.

3.2.1 Recording Forms

The objective of using paper recording forms was to ensure a standardised procedure was followed when analysing the individual skeletons (Grauer, 2008). Three different recording form templates were designed, based on the broad age categories of infants, juveniles, and adults. Age-appropriate inventory schematics, detailed recording tables, and observation checklists provided space to systematically record the demographic, metrical, and palaeopathological data required to test the hypotheses proposed. The differences between the three forms lay in the inventory diagrams, age and sex estimation methods, and metrical data tables which accommodated differences in data required to describe preservation and demographic variables.

The specific recording form selected for each skeleton was based on initial observations of the general epiphyseal fusion state, dental eruption patterns, and the general size of the long bones. Infant recording forms were used to record skeletons which showed no signs of epiphyseal fusion, possessed only deciduous teeth, and had very small long bones. Juvenile recording forms were selected to record skeletons which showed signs of incomplete epiphyseal fusion at the time of death, had a mixed dentition of deciduous and erupting permanent teeth, and had larger long bones. Adult recording forms were used to record skeletons which showed complete epiphyseal fusion and possessed fully-erupted, permanent teeth. When the incorrect form was initially selected from the three available templates, appropriate pages from another recording form template were added to record supplemental inventory, age, sex, or metrical data, as needed.

The first page of each recording form template provided space to inventory the skeletal elements present and note the state of preservation. The lower third of the first page was used to summarize the key demographic and palaeopathological data detailed in the subsequent pages to aid data entry into the SPSS database. The second page was used to record the age-at-death and sex of the individual via multiple methods of assessment. Additionally, metrical data used to estimate body size were recorded in a table on the second page. The third page included a detailed dental inventory with space for additional notes on the dentition and to record dental health. The fourth page provided space to record the presence, absence, and description of

observable pathological lesions associated with the categories of disease included in this study. The bottom of the fourth page also provided a table to note photographs taken to supplement the written observations. Two optional pages were also designed to provide additional space for supplemental data as needed. An optional fifth page was created to provide space for additional notes on observed palaeopathological lesions. An optional sixth page was created to record a detailed description of degenerative joint disease in the spine. Copies of the three recording form templates can be found in Appendix B and an example of a completed recording from can be found in Appendix C.

3.2.2 Preservation

A detailed inventory of the skeleton was recorded at the time of analysis both as a whole and by each element (Brickley, 2004a). The preservation data for each skeleton was later used to filter out individuals with incomplete elements when calculating true prevalence rates for the pathological lesions observed (Brickley, 2004a). It was also used to describe possible biases in the bioarchaeological data based on diagenesis in the burial environment, excavation, and post-excavation techniques.

Age-appropriate inventory diagrams were selected for the three recording form templates (Buikstra and Ubelaker, 1994: 212 - 7). The diagrams were shaded according to the portions of skeletal elements present at the time of observation. Additional preservation details were noted in the space around the inventory diagram as needed. Smaller elements of the cranium, spine, ribs, hands, and feet were inventoried in summary tables as their presence and state of completeness were difficult to note in detail on the diagrams alone. Details of post-mortem damage, erosion, or fragmentation were later used to determine if a skeletal element could be assessed for demographic information or if the individual could be included in true prevalence rate (TPR) calculations for pathological conditions.

A blank schematic for adult dentition was included in the adult recording template and a schematic for the deciduous dentition was included in the infant template (Buikstra and Ubelaker, 1994: 234 - 5). Both were added to the juvenile recording template so that an accurate account of both deciduous and permanent teeth could be recorded for individuals with mixed dentitions. Tooth preservation was noted both above the tooth number and by marks through the teeth which were not

present, lost, or broken. Teeth that were complete and observable at the time of analysis were left blank in the schematic and used to record dental eruption, attrition, and dental disease patterns observed.

The completeness of the total skeleton present was recorded in the *General Summary* section on the first page of the recording form as an estimated percentage. General categories of completeness were created to describe the overall state of preservation. A skeleton with 75% to 100% of its elements present and complete was described as excellent; 25% to 75% as good; and less than 25% as poor (adapted from Buikstra and Ubelaker, 1994). General observations of post-mortem fragmentation, cortical erosion, taphonomic, and pseudopathological bone changes, such as machine damage or root marks, were also noted. After recording the inventory and preservation state on the paper recording form, the completeness of each skeletal element was transformed into a number for entry into the SPSS database (Table 3.6).

Table 3.6: Ordinal scale for scoring completeness of skeletal elements.

Code Number	Completeness
0	Not Present
1	< 25%
2	25% - 50%
3	50% - 75%
4	75% - 100%

3.2.3 Demographic Data

The demographic data collected from each skeleton included estimated age-at-death and biological sex. The second page of the recording form template differed between the three template which reflected the variety of methods used by bioarchaeologists to macroscopically assess age and sex from human skeletal remains (Buikstra and Ubelaker, 1994; Scheuer and Black, 2000a). The specific methods used in this study are described in the following section.

3.2.3.1 Sex Estimation

Sex estimation in skeletal remains are based on visually assessing the morphological differences and the sexual dimorphism present in humans after puberty (Mays and Cox, 2000). As puberty is the biological process of sexual maturation, the traits of sex-based morphological and size differences between males and females are not expressed in the skeleton and are not visible to an osteologist until after the individual has reached sexual maturity (Stone et al., 1996; Mays and Cox, 2000; Scheuer and

Black, 2000a; Hauspie, 2002). Therefore, sex cannot be macroscopically determined for non-adult skeletal remains (Mays and Cox, 2000; Scheuer and Black, 2000a). Visual estimation of biological sex in an adult skeleton relies on classifying morphological differences in the cranium and pelvis as well as measurements of sexual dimorphism (Mays and Cox, 2000). Previous tests of sex estimation methods have shown pelvic morphological differences are more accurate reflections of sex than those seen in the cranium (Kelley, 1979; Meindl et al., 1985a; MacLaughlin and Bruce, 1990; Sutherland and Suchey, 1991; Ubelaker and Volk, 2002). Previous research has also shown that poor skeletal preservation can have an adverse affect on the reliability of sex estimation methods (Meindl et al., 1985a). Attention must also be paid to the reference populations used to develop the methods in comparison to the population studied; ethnic differences in the expression of sex-based morphological and sexually dimorphic differences have been observed in human populations (Mays and Cox, 2000). As preservation was expected to be a challenge in this study, all sex estimation methods available for white European populations were applied to the populations selected. Sex estimation for each variable recorded was noted as one of the following: female (F), possible female (?F), indeterminate (?), possible male (?M), male (M), and not available or observable (N/A). These methods combined both morphological observation and metrical data as described in detail below.

Cranial Morphology
Cranial shapes differ between the sexes in expression of morphological characteristics; males are generally larger and more robust than females in British populations (Brothwell, 1981; Meindl et al., 1985a; Loth and Henneberg, 1996). Cranial robusticity changes with age and the full expression of male morphological characteristics are often not achieved until the individual reaches 30 years old (Walker, 1995; Walrath et al., 2004). Conversely, post-menopausal women can appear masculine in secondary sex characteristics, particularly the cranium (Walker, 1995). When tested in documented populations, the accuracy of sex estimation by the skull was around 80% (Brothwell, 1981; Meindl et al., 1985a; Masset, 1989). Seven observable ectocranial locations with clear descriptions and diagrams of sexually dimorphic characteristics were selected for this study (Buikstra and Ubelaker, 1994: 20; Brickley, 2004b; Walrath et al., 2004).

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The female forehead is generally more vertical in profile, and males have a more rounded forehead with a flatter, more sloping frontal bone above the brow ridges (Brothwell, 1981). The general shape of the frontal bone was noted as 'low and flat' for males and 'high and rounded' indicated females. Individuals with any other descriptions or a combination of these descriptions were subjectively noted as possibly male, possibly female, or indeterminate.

Female frontal bones have well-defined frontal and parietal eminences that are palpable on the ectocranial surface (Brothwell, 1981). A note was made of the presence or absence of bossing on the frontal and/or the parietals on the recording form. Presence on both the frontal and parietals was determined to be female, while absence of both indicated a male individual. Any other description was subjectively determined to be possibly male, possibly female, or indeterminate.

The posterior root of the zygomatic process extends for some distance past the external auditory meatus as a well-defined ridge in males, but does not in females (Brothwell, 1981). The position of the root was noted on the recording form as either before, at, or past the external auditory meatus. Presence of the root extending beyond the external auditory meatus was determined to be a male individual, while indications of the root ending before was determined to be a female individual. Any other observation was recorded as indeterminate sex.
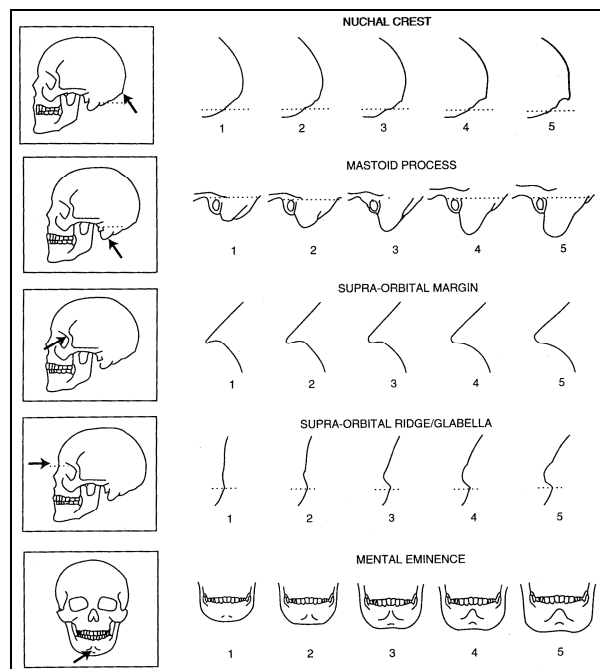
Figure 3.8: Scoring system for sex-based morphological differences in male and female crania (Acsádi and Neméskeri, 1970; as reprinted in Buikstra and Ubelaker, 1994: 20).

Five further observation points (Figure 3.8) were compared against observable, sex-based morphological differences as described by Acsádi and Neméskeri (1970). The observation points were assessed for their general robusticity within the context of the population under observation and scored using the previously described five point scale system (Brothwell, 1981; Brickley, 2004b). Specifically in British populations, the supraorbital ridges are more prominent in males, the upper margin of the orbits are more rounded in males, and the external occipital protuberance on the posterior aspect of the occipital bone (i.e. the nuchal crest) and the mastoid processes are more developed in males (Brothwell, 1981). Although the mental eminence has been observed to be a more pronounced in males, this observation has been noted to be less dimorphic in British populations (Acsádi and Neméskeri, 1970; Brickley, 2004b). Male mandibles in British populations have been noted to have more laterally flaring gonial regions (Brothwell, 1981). A score was noted for the mental eminence, but notes were also made regarding gonial flaring as this observation was more indicative of sex in the populations included in this study (Brickley, 2004b). The associated sex estimation by variable, ranging from '1' as female to '5' as male, was noted in the appropriate column of the table.

The final observation was of the posterior border of the mandibular ramus. The posterior border of the mandible was observed for signs of flexure at the line of the occlusal surface of the dentition (Loth and Henneberg, 1996). The presence or absence of flexure was noted on the recording form. Presence of flexure was determined to be a male characteristic (Loth and Henneberg, 1996). However, absence was not automatically interpreted as female given that mechanical stress, disease, and age have been shown to affect expression of flexure (Koski, 1996; Loth and Henneberg, 1996; Donnelly et al., 1998; Brickley, 2004b).

Pelvic Morphology

Descriptions of morphological differences between male and female pubic bones (Phenice, 1969), have been estimated to be between 88% and 95% accurate at visually determining sex in the skeleton (Sutherland and Suchey, 1991; Ubelaker and Volk, 2002). When tested on European skeletal collections, MacLaughlin and Bruce's (1990) results indicated that the subpubic concavity was the most reliable indicator of sex in European populations. However, this region of the skeleton is fragile and is often damaged or destroyed by diagenetic processes in archaeological contexts; even a

small amount of post-mortem damage can render the pubic bones unusable for sex estimation (Kelley, 1979). Eleven morphological differences between the sexes have been observed in the pelvic girdle (Phenice, 1969). The following section details each observation point and their sex-based differences.
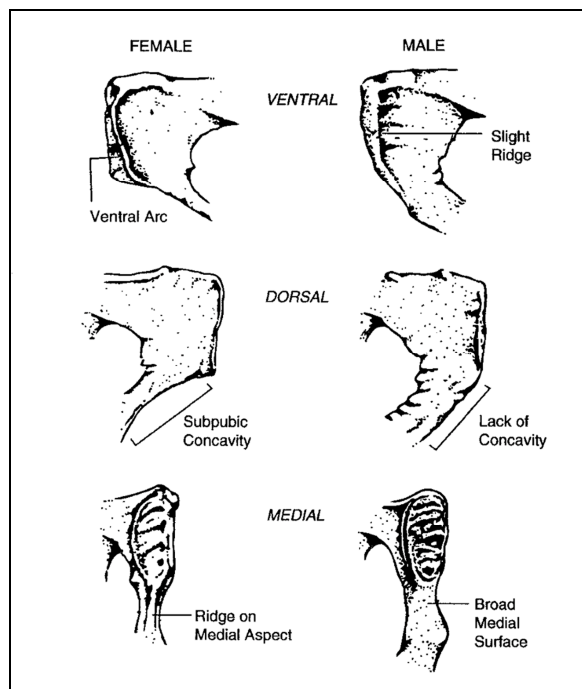
Figure 3.9: Sex differences in the pubic bone (Phenice, 1969; Buikstra and Ubelaker, 1994: 17).

Phenice (1969) described three morphological features which were present on female pubic bones and absent on male pubic bones (Figure 3.9). The presence, absence, and any distinguishing morphological characteristics of the ventral arc, the subpubic concavity, and ischiopubic ramus ridge were recorded. Despite Phenice's (1969) recommendation that these three characteristics be evaluated together, each observation was noted and assessed independently in this study as poor preservation of the pubic bone or the ischiopubic ramus was expected in the populations. The subpubic concavity has been noted to be more obviously present for females in British populations, and therefore this feature was given a higher priority than suggested in Phenice's original methodology (MacLaughlin and Bruce, 1990). The skeleton was described as female if any of these three features were present in a skeleton (Phenice, 1969). Absence was estimated to be either male, based on the robusticity of the region available for observation, or indeterminate (Phenice, 1969).

The pubic bone shape and the subpubic angle were also observed. The subpubic angle has been described as 90° or greater in females (Brothwell, 1981).

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The angle was recorded as either narrow or wide where narrow angles indicated a male individual and any observation other than wide was categorised as indeterminate (Brothwell, 1981).

The general shape of the pubic bone, specifically the length of the bone between the medial edge of the obturator foramen and the pubic symphyseal face, and the height of the pubic bone from proximal to distal edges of the pubic symphysis, has been described as wider and longer in females and narrower and shorter in males when observed in profile from the anterior aspect (Brothwell, 1981; Mays, 1998). The pubic bone shape was noted as being either wide or narrow and either short or long. Individuals determined to be male needed to be described as both narrow and short; females as both wide and long. Any other combination of descriptions recorded for individual skeletons were ultimately estimated as indeterminate sex.
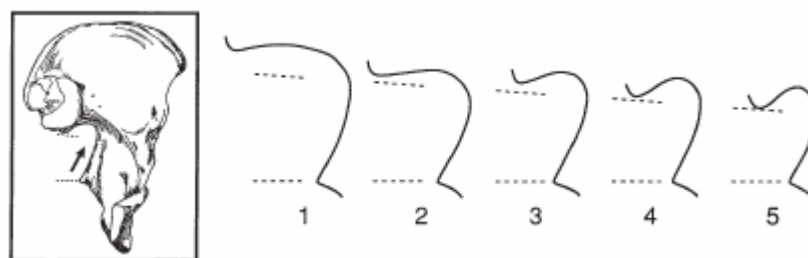
Figure 3.10: Scoring system for the greater sciatic notch (Walker, 2005: 386).

The greater sciatic notch (Figure 3.10), located at the posterior-inferior union of the ilium and ischium, has been noted to be wider in females and narrower in males (Brothwell, 1981). This difference in shape has been described as a secondary indicator of sex which is more susceptible to genetic variation, age-related changes, and disease than the sub-pubic concavity (Coleman, 1969; Brothwell, 1981; Walker, 2005; White and Folkens, 2005). Buikstra and Ubelaker (1994) identified a bias for under-representing males using this method. Walker (2005) also observed a bias in the method towards females, particularly in the English St. Bride's, London documented skeletal collection. In cases of poor skeletal preservation or post-mortem damage to the pubic bones, bioarchaeologists are required to choose alternative sex estimation methods for the os coxae despite the confounding factors that can affect the reliability of these methods. "The greater sciatic notch is especially valuable in such situations because it is highly sexually dimorphic, is resistant to damage, and thus can often be scored in poorly preserved skeletons" (Walker, 2005: 385).

The left greater sciatic notch was visually compared to the representations of the range of sex differences and scored 1 through 5 as defined by Walker (2005: 386). If the left side was not present or was too poorly preserved to assess, the right sciatic notch was observed. The presences of exostoses around the preauricular sulcus or on the posterior inferior iliac spine were not taken into account when assessing the shape of the sciatic notch (Walker, 2005: 386). The corresponding score was noted as follows: '1' was determined to be a female individual, '4' or '5' were determined to be male, and '2' or '3' were determined to be indeterminate or possibly male based on the corresponding age estimation for the individual (Buikstra and Ubelaker, 1994: 18; Brickley, 2004b; Walker, 2005).
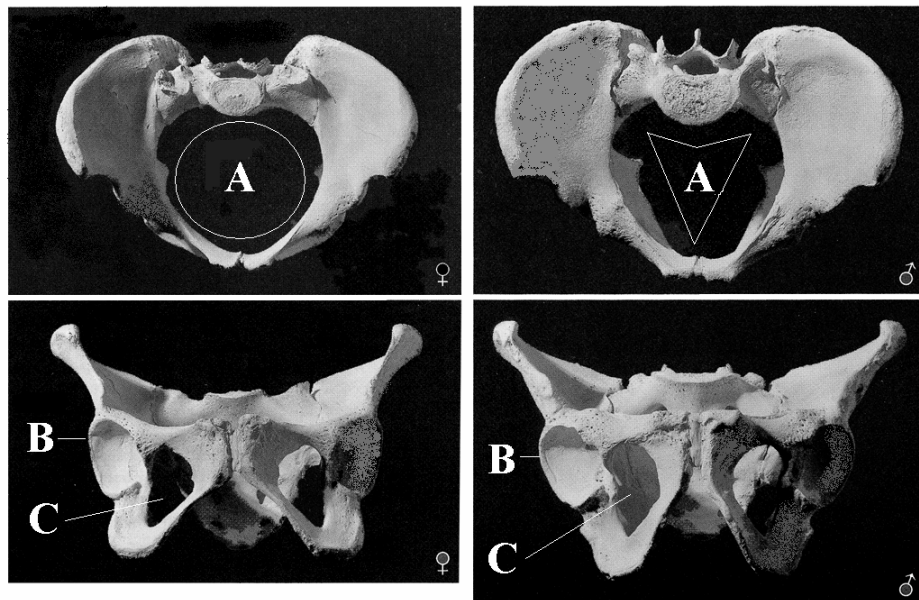
Figure 3.11: Morphological differences between female (left) and male (right) os coxae observed at (a) the pelvic inlet, (b) the acetabulum, and (c) the obturator foramen (White and Folkens, 2005: 394 - 5).

Five additional indicators of sex in the pelvic girdle were observed based on the general shape and structure of the os coxae and the sacrum (Brothwell, 1981; Mays, 1998; White and Folkens, 2005). The shape of the pelvic inlet, or the circumferential area created by the articulations of the os coxae and the sacrum, is wider in comparison to the height of the os coxae in females and is narrower in males (Coleman, 1969). Additional observations have described the pelvic inlet as rounder in females and heart-shaped in males (Brothwell, 1981). The obturator foramen is larger and oval in outline in males and smaller and more triangular in females; the corresponding description was recorded for each observable obturator foramen

(Brothwell, 1981). The acetabulum is larger in males than in females and was recorded as large or small for each individual in this study (Brothwell, 1981; White and Folkens, 2005). These pelvic landmarks were compared with the dimorphic representative images in Figure 3.12 and the corresponding descriptions were noted.

Finally, the sacrum has been described as smaller with wider sacral segments in females and narrower in males when compared to the heights of the sacral bodies (White and Folkens, 2005). The articular surfaces of the sacro-iliac joints on the lateral sufaces of the alae are aligned with the first and second sacral segments in females, and with the first through the third segments in males (Brothwell, 1981). The proximal to distal curvature of the sacrum is more gradual and continuous throughout the entire sacrum in females and is more dramatic and changes to a more anterior direction after the third sacral segment in males (Brothwell, 1981). The size and shape of each sacrum was observed for sex-based morphological differences.

Metrical Assessment of Sexual Dimorphism

Differences in the measurements of specific skeletal elements have been associated with sexual dimorphism in the human skeleton (Parsons, 1915; Brothwell, 1981; Bass, 1995; Mays and Cox, 2000). Measurements taken from various locations throughout the body can indicate a sexually male or female individual based on the robusticity or gracile nature of the skeleton (Kelley, 1979; Bass, 1995). However, differences in skeletal robusticity can be affected by many factors other than biological sex; namely genetics, environment, nutrition, population growth and maturation rates, and health (Wolfe and Gray, 1982; MacLaughlin and Bruce, 1986; Walrath et al., 2004).

Six measurements of the post-cranial skeleton were taken using either digital sliding callipers or an osteometric board and recorded to the nearest milimetre. The maximum length of the clavicle, the maximum width of the glenoid fossa, the diameter of the humeral head from the maximum proximal and maximum distal edges, the maximum diameter of the radial head, the maximum diameter of the femoral head, and the femoral bi-condylar width were measured according to Bass (1995). The measurements were compared to previously-published metrical data indicating male and female measurements for white, European populations (Table 3.7). Measurements of the clavicle and the femur were given higher priority over other measurements as they have been observed to be more dimorphic in British population (Parsons, 1914, 1915; Brothwell, 1981).

Table 3.7: Published measurements of post-cranial elements to estimate sex.

Measurement	Female	Male	Reference
Clavicle: maximum length	< 138 mm	>150mm	(Brothwell, 1981)
Scapula: glenoid cavity width	< 26.1 mm	> 28.6 mm	(Brothwell, 1981)
Humerus: proximal/distal head diameter	< 43 mm	> 47 mm	(Bass, 1995: 156)
Radius: head diameter	< 21 mm	> 23 mm	(Brothwell, 1981)
Femur: proximal/distal head diameter	< 43 mm	> 48 mm	(Parsons, 1915: 348)
Femur: bi-condylar width	< 74 mm	> 76 mm	(Bass, 1995: 230)

An estimation of male, female, or indeterminate was independently evaluated and recorded for each observation point available by individual. As with age, a multifactoral approach was used to estimate the sex of each adult skeleton, both because it has been shown to be as accurate as individual indicators in British populations, and because poor preservation in the Anglo-Scottish border collections was expected to limit the availability of pubic bones. Pelvic morphological data in general were given the highest priority and most influence over the final estimation (Mays and Cox, 2000; Ubelaker and Volk, 2002; Brickley, 2004b). Phenice's (1969) method has been proven to be the most accurate sex estimation method and was given first priority (MacLaughlin and Bruce, 1990; Ubelaker and Volk, 2002). The pelvic secondary indicators of biological sex, such as the sciatic notch, were given priority when the pubic bones were not available for observation (Walker, 2005). In the absence of the pelvic girdle, cranial morphological and metrical data were used, with caution, to estimate biological sex within the context of the populations used (Brickley, 2004b; Walrath et al., 2004). Age estimation was also taken into account in the final sex estimation as young males have been noted to appear more gracile, and older women to appear more masculine, in their expression of sex-based morphological characteristics (Walker, 1995).

3.2.3.2 Age-at-Death Estimation

The age-at-death estimation methods used in this study are broadly based on the general growth and developmental phases and degenerative processes seen in the skeleton throughout life (Cox, 2000; Scheuer and Black, 2000a). Current estimation methods have been criticised for over-estimating younger individuals and under-estimating older individuals when tested on skeletal populations of known age-at-death (Saunders et al., 1992). These errors have been shown to decrease when several estimation methods are used in combination (Lovejoy et al., 1985a; Bedford et al., 1993). In an effort to accommodate the various expected states of skeletal

preservation, and to reduce the inherent error in the various age-at-death estimation methods, a multi-factoral approach to age-at-death estimation was used for each skeleton (Lovejoy et al., 1985a).

An estimated age-at-death was summarised on the first page of the recording form as both an age range and as a number for each individual. The age range was first determined by estimating the age-at-death via each method described in the following sections. The author then assigned each individual a minimum and maximum age-at-death based on a multi-factoral estimation approach, where all of the indicators of skeletal age available were taken into account.

The mean of this age range was then calculated. For non-adult skeletal remains, the estimated skeletal age of the individual was occasionally adjusted lower or higher than the average of the age range due to differences in reliability between the three methods used for age estimation. Appropriate adjustments were made in cases where dental development or eruption suggested a non-adult individual was older or younger than their epiphyseal fusion state, or their diaphyseal lengths suggested that these last two indicators were expected to be biased in these skeletal collections because of nutritional stress.

Table 3.8: The four broad age categories used to divide the populations into life-phases based on the major stages of medieval life (Shahar, 1990).

Age Category	Age Range	Database Code
Non-adult	0 – 14 years	1
Young Adult	15 – 24 years	2
Adult	25 – 44 years	3
Older Adult	45 + years	4

Each individual skeleton was then included in a broad age category (Table 3.8), and a more specific age range (Table 3.9), so that individuals in various phases of life could be statistically compared for differences in disease prevalence rates within their age cohort. The broad age categories were defined with reference to medieval documentary sources that describe the six stages of life as defined by medieval culture. The first two phases of infancy and young childhood encompassed the non-adult age category when skeletal development and social development coincided (Shahar, 1990; Orme, 2001). The third phase (adolescence) was during the final maturation of the young adult skeleton and the individual socially acquired full adult status within Medieval society; this included the ability to own property, work, and participate fully in the church (Alexandre-Bidon and Lett, 1999; Orme, 2001). The fourth and fifth phases described the full experiences of adulthood including

marriage, sexual reproduction, and aging beyond the ability to perform manual labour (Shahar, 1990; Alexandre-Bidon and Lett, 1999). The sixth phase of life described by Medieval society was death (Shahar, 1990).

Table 3.9: Eight age ranges used to categorise age-at-death estimations for more concise age comparisons.

Age Range	Database Code
0 – 2 years	0
2 – 5 years	1
5 – 9 years	2
10 – 14 years	3
15 – 24 years	4
25 – 34 years	5
35 – 44 years	6
45 + years	7

The mean age, age category, and age range were recorded in the database for each skeleton as independent variables. The mean age number was used to calculate life tables and generate survivorship curves for the population demographic profiles (Chamberlain, 2006). The age categories and age ranges were used to calculate age-specific pathological lesion prevalence rates and to test for variability in rates both within and between age cohorts (Roberts and Connell, 2004).

3.2.3.2.a Non-adult Age Estimation

Age-at-death estimations for non-adult skeletal remains are based on observing the state of dental and skeletal development that the individual achieved before their death and attempting to correlate that developmental state with chronological age (Scheuer and Black, 2000a). Macroscopically observed dental development and eruption patterns, epiphyseal fusion states, and long-bone diaphyseal lengths were used to estimate age-at-death for non-adult skeletal remains (Buikstra and Ubelaker, 1994; Mays, 1998; Scheuer and Black, 2000a; Brickley, 2004c). As discussed in Chapter 2, long bone growth rates could be slowed and epiphyseal fusion could be delayed by dietary and environmental stress experienced during skeletal development (Norgan, 2002; Saunders, 2008). This study specifically hypothesised that developmental retardation caused by malnutrition was present in the Medieval Anglo-Scottish border populations, and therefore age-at-death estimations based on epiphyseal fusion states and long-bone diaphyseal lengths were expected to be delayed in development for age in four of the skeletal collections in this study. Dental development and dental eruption, however, is less affected by environmental and dietary differences than epiphyseal fusion and diaphyseal length development and has

been shown to be a more consistent indicator of age-at death for non-adult skeletal remains through time (Lewis and Garn, 1960; Garn et al., 1973a; Garn et al., 1973b; Liversidge and Molleson, 2004). When the dentition was present and observable, dental age was determined to be more representative of chronological age than skeletal age when applying a multi-factoral approach to estimating non-adult age-at-death (Cox, 2000). The methods used are described below.

Dental Age

Dental age for non-adult skeletal remains was determined by macroscopically assessing dental development, dental eruption patterns, and occlusal surface wear (Brothwell, 1981: 72; Buikstra and Ubelaker, 1994: 51; White and Folkens, 2005: 369). Dental development was expected to be difficult to assess due to poor preservation of the loose teeth available and occlusal surface wear was not expected to be macroscopically visible in non-adult dentitions (Hillson, 1996). Therefore, dental eruption patterns were the most influential mode of assessment for dental age estimation in this study.

Dental development has been shown to be the most reliable method of age assessment for non-adult skeletal remains in previous studies (Moorees et al., 1963b, a; Saunders et al., 1993; Liversidge and Molleson, 2004). Development states of the deciduous and permanent teeth were recorded using (Moorees et al., 1963a, b). However, accurate assessment of dental development required the entire crown and root structures of all teeth present to be visible (Moorees et al., 1963a, b; Liversidge et al., 1993; Brickley, 2004c). A complete non-adult dentition with no post-mortem tooth loss or damage required radiographs be taken to assess the developmental phase of unerupted or erupting teeth (Mays, 1998; Brickley, 2004c). As radiographs were beyond the scope of this project, development states were recorded only for the loose teeth removed from the mandible through post-mortem damage. For dentitions that had teeth in situ, dental development was observed in conjunction with dental eruption patterns to estimate age-at-death for non-adult skeletal remains (Ubelaker, 1989).
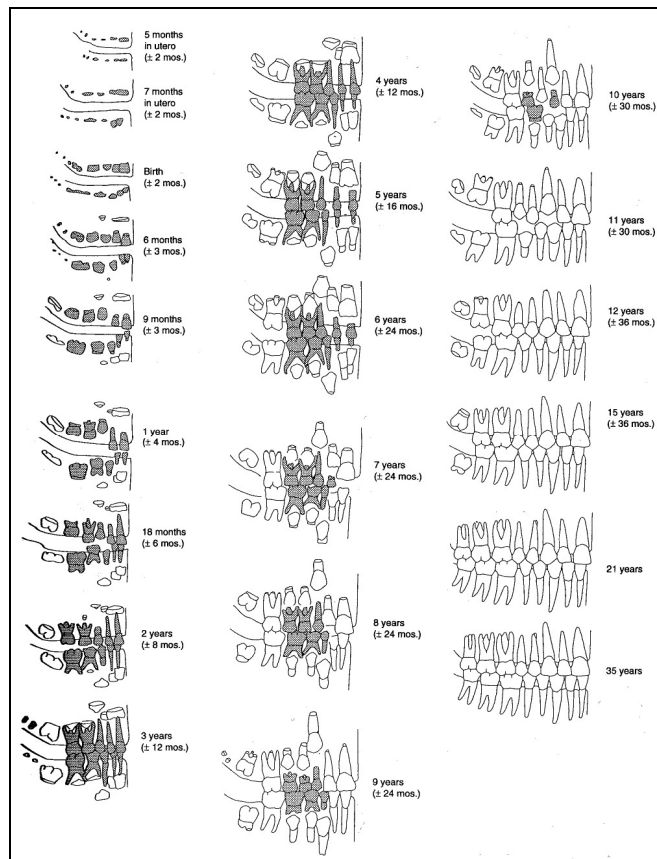
Figure 3.12: Dental development and eruption atlas developed by Ubelaker (1989) to estimate non-adult age-at-death (White and Folkens, 2005: 366).

The stage of dental eruption at time of death was macroscopically observed for each tooth present in a non-adult dentition at the time of analysis. Teeth observed to be in a state of incomplete eruption at the time of the individual's death were noted as un-erupted (U), partially erupted (PE), or erupting (E), by tooth on the dental inventory schematic. The macroscopically observed pattern of dental eruption in each individual was compared to Ubelaker's (1989) dental development and eruption atlas (Figure 3.12) as reprinted in White and Folkens (2005: 366). Although Ubelaker's eruption atlas was developed for Native American skeletal material, previous studies have shown it to be as accurate as other age estimation methods for English non-adult dentitions of known age-at-death (Miles, 1958; Liversidge, 1994; Brickley, 2004c). The dental development and eruption patterns were summarised in the *Age Estimation* table on the second page of the recording form as a numerical year, along with the published standard deviation (Moorees et al., 1963a, 1963a; Ubelaker, 1989). An age-at-death range was calculated based on the observed age category plus one standard deviation.

When present and observable, occlusal surface wear or dental attrition on the fully-erupted teeth was used to refine the age range suggested by dental development and eruption patterns. Attrition was not expected to be visible on deciduous teeth, but it was noted and used to narrow the age estimation range indicated by dental eruption when observed (Hillson, 1996). Occlusal surface wear present on erupted permanent teeth was observed and compared with two adult dental attrition schematics discussed in the following adult age section (Figures 3.17 and 3.18). Dental attrition observed on permanent teeth was recorded based on Brothwell (1981) and Lovejoy (1985). This assessment was used as a supplement to dental eruption and development observations in estimating age-at-death for non-adult individuals between 12 and 18 years old at the time of their death.

Epiphyseal Fusion

Epiphyseal fusion states for five cranial and 39 post-cranial primary and secondary fusion sites were observed and recorded. The observed fusion state was recorded as unfused (U), fusing (ING), or fused (F) in the second column. Each fusion state was assigned an age range by fusion location, based on Scheuer and Black (2000b). Previous research has shown a sex-based difference in skeletal maturation rates, with males fusing chronologically later than females (Scheuer and Black, 2000b). Although Scheuer and Black (2000b) took these sex differences into account when compiling their epiphyseal fusion age ranges, sex cannot be macroscopically determined for non-adult skeletal remains before the onset of puberty (Mays and Cox, 2000). Both male and female non-adult skeletal remains were expected to be present in the skeletal collections because the collections were assumed to represent a cross section of the medieval living population, which included both boys and girls in the medieval burial rites after infants were baptised (Lewis, 2007). Therefore, the age ranges for both male and female fusion states for pre-pubescent skeletal remains were combined to accommodate both sexes (Scheuer and Black, 2000b). See Appendix D for the concise list of fusion state age ranges used in this study by observation location.

Diaphyseal Lengths

Ten measurements were taken of nine post-cranial skeletal elements and compared with previously published metrical data to estimate age-at-death (Ubelaker, 1989;

Scheuer and Black, 2000b). Measurements were taken as shown in Figure 3.13. The left side of bilateral skeletal elements was measured where available (Buikstra and Ubelaker, 1994; Brickley and McKinley, 2004). If only the right side was present, the measurement was taken and noted as 'right'. For long bones with both proximal and distal epiphyses unfused at the time of death, diaphyseal lengths were measured without epiphyses (Scheuer and Black, 2000b). In cases where either the proximal or the distal epiphysis was fusing or fused, the unfused epiphysis was articulated with the diaphysis before the length was measured in individuals estimated to be over the age of 12 years (Scheuer and Black, 2000b). Broken, severely eroded, or fragmented diaphyses were not measured (Buikstra and Ubelaker, 1994; Brickley and McKinley, 2004).
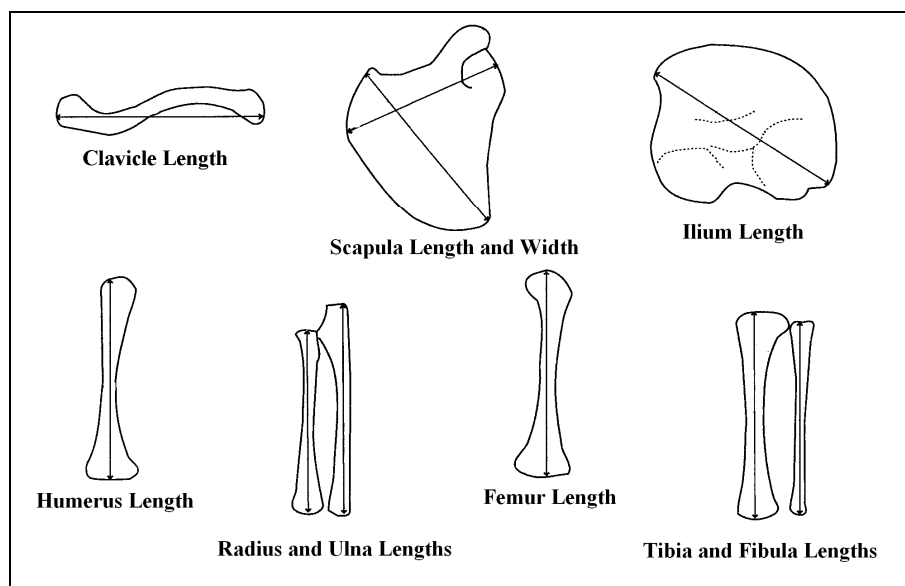
Figure 3.13: Measurements of the post-cranial skeleton recorded for non-adult individuals (Buikstra and Ubelaker, 1994: 46).

An exception was made for broken long bones only in situations of poorly preserved non-adult individuals where few other age-at-death indicators were present. The absence of the dentition and most epiphyseal fusion sites suggested a wide age-at-death estimate between infancy and puberty (Scheuer and Black, 2000b). A poorly preserved individual could at best suggest an age-at-death of between 5 to 15 years in the absence of dental and epiphyseal fusion observations.   In these specific individuals, long bone diaphyses that were broken in only one location via post-mortem damage were measured in an attempt to refine the age-at-death estimated range to a 5-year age category. These metrical data were recorded and compared with appropriate diaphyseal lengths by age published by Scheuer and Black (2000b) and

Ubelaker (1989). The summary tables of diaphyseal length ranges by age directly compared with the metrical data in this study are attached in Appendix D. The age range suggested by these tables was noted.

3.2.3.2.b Adult Age Estimation

The recording form designed for adult skeletal remains provided space to note the observed state of the final development and degenerative aging processes (Mays, 1998; Cox, 2000). The final developmental processes recorded included late-stage dental eruption, the final stages of epiphyseal fusion, and cranial suture closure (Meindl and Lovejoy, 1985; Ubelaker, 1989; Scheuer and Black, 2000b). The degenerative processes observed and recorded included dental attrition, age-related changes of the sternal ends of the 4th ribs, iliac auricular surface degeneration, and age-related changes in the pubic symphyses (Brothwell, 1981; Iscan et al., 1985; Lovejoy, 1985; Lovejoy et al., 1985b; Iscan and Loth, 1986b; Brooks and Suchey, 1990). These are discussed below.

The most reliable adult age estimation methods for British populations have been shown to be those that observe dental attrition and the pubic symphyseal degeneration (Lovejoy et al., 1985a; Saunders et al., 1992; Molleson and Cox, 1993). These two methods were given priority over other methods when the dentition and pubic bones were present and observable. Previous studies have shown that assessment of the degeneration of the iliac auricular surfaces and the sternal ends of the fourth ribs are the next most reliable indicators of adult age-at-death in white European populations (Lovejoy et al., 1985a; Saunders et al., 1992; Cox, 2000). When these four indicators of adult skeletal age-at-death were unavailable, the final stages of epiphyseal fusion, dental eruption, and cranial suture closure patterns were used to categorise individuals as either young adults, adults, or older adults.

Dental Eruption

As with non-adult skeletal remains, dental development and eruption was visually assessed for each adult individual. The prerequisite for selecting an adult recording form template was complete epiphyseal fusion of the long bones and complete dental eruption, therefore, each adult skeleton was expected to possess fully erupted second molars regardless of the sex of the individual (Hillson, 1996; Scheuer and Black, 2000b). The eruption patterns of the third molar, however, have been described as

highly variable both within and between populations (Mincer et al., 1993; Hillson, 1996). The eruption state of the third molars was observed as 'M3 E' (molars still erupting), 'M3 PE' (molars partially erupted), or 'M3' or 'M3 Pres' (molars fully erupted before death). Individuals with erupting or partially erupted third molars, who also possessed fully fused long bone epiphyses, were compared with Ubelaker (1989) (Figure 3.12). Skeletons with dentitions similar to an individual of *15 years* of age were estimated to have died between 12 and 18 years of age. Individuals with dentitions similar to an individual of *21 years* of age, but with signs of erupting third molars, were estimated to have died between 15 and 21 years of age. Individuals possessing fully erupted third molars were described simply as > 18 years of age.

Epiphyseal Fusion

Although adult skeletal elements have fully developed and fused, the clavicle and sacrum do not completely fuse until the final stages of skeletal maturation (Scheuer and Black, 2000b). Therefore, the epiphyseal fusion states of the sternal ends of the clavicles and the sacral segment bodies were observed when present. The state of fusion was recorded as unfused (U), fusing (ING), or fused (F). As with the non-adult epiphyseal fusion age estimations, an age range was created for each observable fusion site based on Scheuer and Black's (2000b) published summaries. The stages of fusion of the clavicles and the sacrum helped to determine if the individual was either in early adulthood or was older than 27 years at the time of their death. See Appendix C for a concise list of fusion state age ranges by element (Scheuer and Black, 2000b).

Cranial Suture Closure

Cranial suture closure has been shown to be roughly correlated to chronological age but can be highly variable within and between populations (Todd and Lyon, 1924, 1925; Brooks, 1955; Zivanovic, 1983; Masset, 1989). When preservation of a skeleton restricts the availability of dental and post-cranial indicator of adult age-at-death, changes in the cranial vault can be a general indicator of non-adult, young adult and older adult ages in poorly preserved skeletal assemblages (Brothwell, 1981). As poor preservation was expected in this study, the method of Meindl and Lovejoy (1985) was used in the multi-factorial age estimation process. It was used to estimate a broad category of adult (i.e. young adult, adult, or older adult) from skeletally

mature individuals who did not have a dentition or os coxae preserved (O'Connell, 2004).
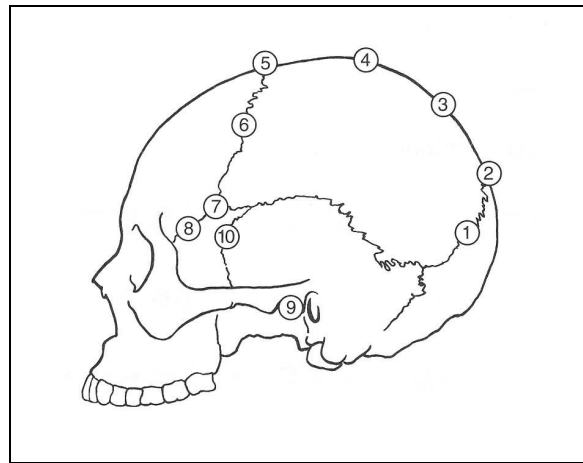
Figure 3.14: Ectocranial landmarks observed to estimate age-at-death by cranial suture closure (White and Folkens, 2005: 370).

Ten points (Figure 3.14) on the ectocranial surface of the skull were observed and the state of perceived closure was recorded for each point. The left side of skull was observed when present and unaltered by post-mortem damage. The area of observation was scored using a phased method ranging from 0, for completely open sutures, to 3, for completely fused and obliterated sutures, based on direct comparison with photographic representations of the four stages (Figure 3.15).

'Open' = 0

'Partly Closed' = 1

'Closed' = 2
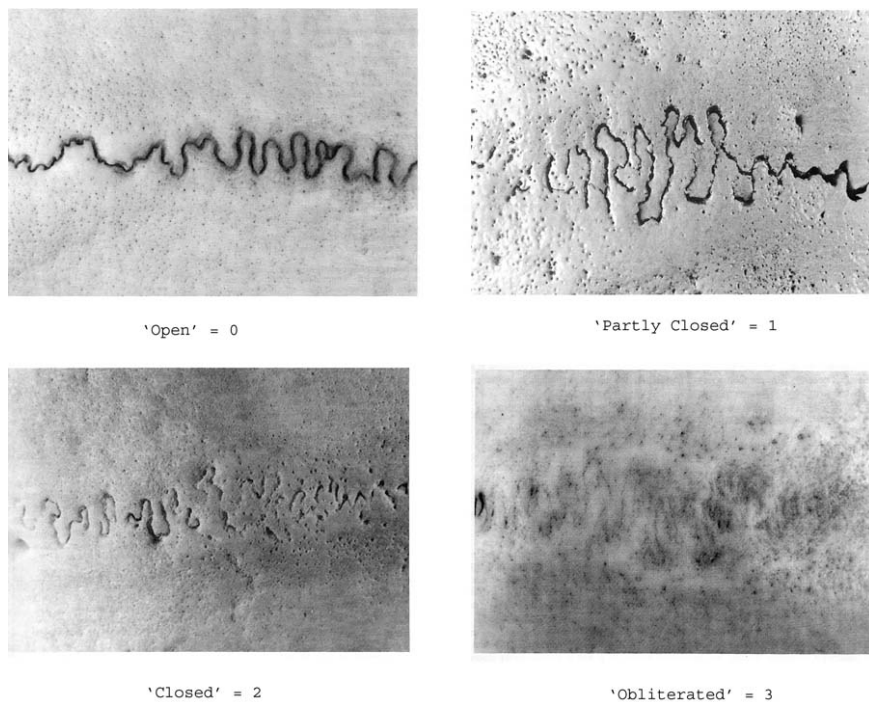
'Obliterated' = 3

Figure 3.15: Suture closure phases ranging from open to completely obliterated (Buikstra and Ubelaker, 1994: 34 - 5).

Two separate composite scores were calculated: one for the vault and one for the lateral-anterior sutures. The age-at-death estimation range was associated with the composite scores (Tables 3.10 and 3.11).

Table 3.10: Cranial suture age estimates for vault scores from observation sites 1 – 7 (Meindl and Lovejoy, 1985; as reprinted in White and Folkens, 2005: 370).

Composite Score	Mean Age	Standard Deviation
0	-	-
1 – 2	30.5	9.6
3 – 6	34.7	7.8
7 – 11	39.4	9.1
12 – 15	45.2	12.6
16 – 18	48.8	10.5
19 – 20	51.5	12.6
21	-	-

Table 3.11: Cranial suture age estimates for lateral-anterior scores from observation sites 6 – 10 (Meindl and Lovejoy, 1985; as reprinted in White and Folkens, 2005: 370).

Composite Score	Mean Age	Standard Deviation
0	-	-
1	32.0	8.3
2	36.2	6.2
3 – 5	41.1	10.0
6	43.4	10.7
7 – 8	45.5	8.9
9 – 10	51.9	12.5
11 – 14	56.2	8.5
15	-	-

Dental Attrition

The second assessment of the dentition focused on the occlusal surface wear of the teeth present and observable at the time of analysis. Dental attrition, or wear on the crown surfaces of teeth from mastication that gradually expose the tooth dentine, has proven to be the most reliable age indicator in an adult skeleton (Schour and Massler, 1941; Miles, 1958; Murphy, 1959; Liversidge, 1994; Hillson, 1996; Whittaker, 2000). Brothwell's (1981) analysis of British molar wear indicated that patterns and rates of wear did not change much from the Neolithic through the Medieval period. The attrition state was observed and compared with both Brothwell's (1981) and Lovejoy's (1985) previously published dental attrition schematics.

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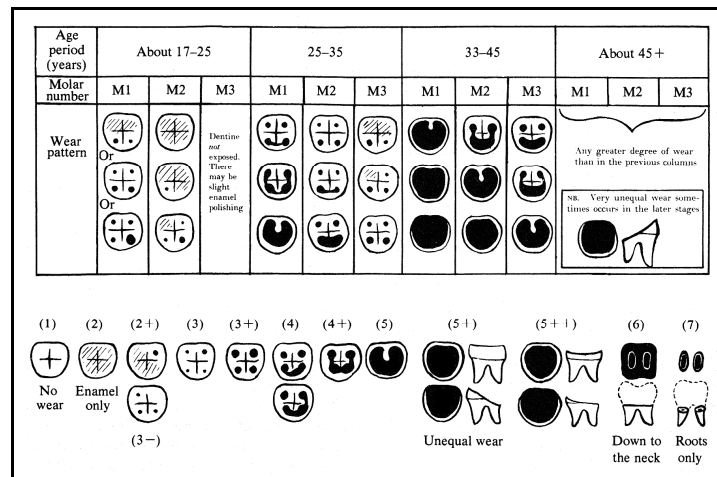
Figure 3.16: Dental attrition schematic developed with British archaeological populations and used to estimate age-at-death for adult skeletal remains in this study (Brothwell, 1981: 72).

Brothwell's (1981) molar attrition method was developed using British skeletal material dating from the Neolithic period through the Medieval period and divided attrition rates into four age phases. The occlusal surface wear patterns on the permanent molars were observed for the adult skeletons included in this study and compared to Brothwell's schematic (Figure 3.16).
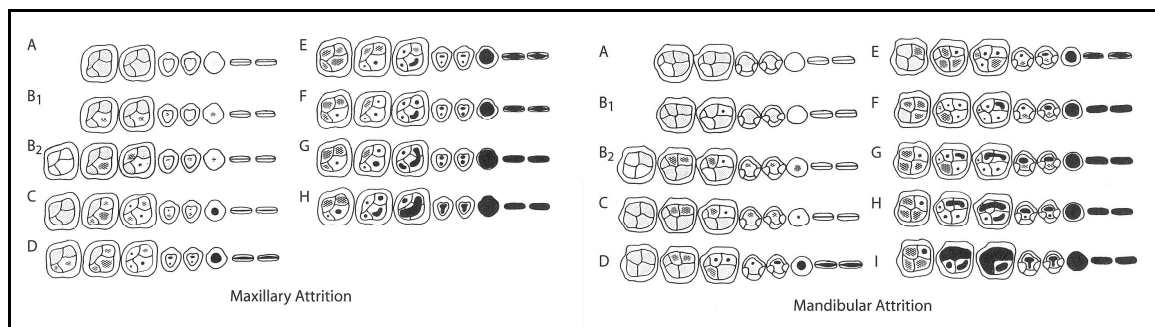
Figure 3.17: Dental attrition schematic developed with Native American archaeological populations and used to estimate age-at-death. Ages (in years) of the phases are: A = 12–18, B1 = 16–20; B2 = 16–20; C = 18–22; D = 20–24; E = 24–30; F = 30–35; G = 35–40; H(maxillary) = 40–50; H(mandibular) = 40–45; I = 45–55. (Lovejoy, 1985; as reprinted in White and Folkens, 2005: 369).

Lovejoy's (1985) schematic was created from a prehistoric Native American population from Libben, Ohio and divided dental attrition into observable phases for the right maxillary and left mandibular teeth (Figure 3.17). The occlusal surface wear patterns of the adult dentition from all of the individuals in this study were also compared with Lovejoy's schematic and the appropriate phase letters associated with the maxillary and mandibular attrition observations were recorded.

Although Brothwell's method was more appropriate for estimating the age-at-death of the Anglo-Scottish Medieval border populations, this method could only be

applied to molars. Therefore, this method was not applicable when adult individuals lost all of their molars either because of ante-mortem dental disease or post-mortem processes. Lovejoy's method included age-related occlusal surface wear patterns visible in the incisors, canines, and pre-molars as well as in the molars. Both methods were to accommodate differential preservation rates within and between the skeletal populations. In the final age estimation, preference was given to Brothwell's attrition estimation when it was available, because it was developed using reference populations more closely related genetically, culturally and environmentally to the Medieval British populations chosen for this study (O'Connell, 2004). Caution was used when assessing the attrition rates of dentition with observable dental disease, such as caries lesions, ante-mortem tooth loss, abscesses, or periodontal disease, as these pathological lesions have been associated with variability in occlusal surface wear unrelated to age changes (Brothwell, 1981).

Pubic Symphysis

A correlation between morphological changes in the pubic symphyseal face and age was first recognised in the 1920s (Todd, 1920, 1921a, b). Age-at-death estimation by visually comparing a pubic symphyseal face to industry-standard casts of age phases, and published descriptions of the phases, has been demonstrated to be the most reliable age estimation method in adult skeletal remains (Brooks, 1955; Lovejoy et al., 1985a; Meindl et al., 1990; Saunders et al., 1992; Bedford et al., 1993). The degenerative age-related changes of the pubic symphyses have been shown to differ between the sexes, and therefore this age-estimation method was applied only after estimating the sex of each adult skeleton (Suchey et al., 1979).

The Suchey-Brooks six phase scoring system was used to assess the morphology of the pubic symphysis (Katz and Suchey, 1986). The left pubic symphysis was the preferred surface for comparison, but the right side was used if the left was not present or unobservable due to post-mortem damage (Katz and Suchey, 1986). The symphyseal face was compared with male or female casts and previously published descriptions associated with the Suchey-Brooks casts (Suchey et al., 1986b, a; Brooks and Suchey, 1990). Pubic symphyses from skeletons of indeterminate sex were compared to both the male and female casts and the most representative phase from both cast sets was recorded for that individual (Table 3.12).

Table 3.12: Adult age estimations (95% confidence ranges) by phase for the Suchey-Brooks method assessing pubic symphyseal degeneration (Brooks and Suchey, 1990; as printed in White and Folkens, 2005: 379).

Female Age Estimation (years)	Phase	Male Age Estimation (years)
15 – 24	1	15 – 23
19 – 40	2	19 – 34
21 – 53	3	21 – 46
26 – 70	4	23 – 57
25 – 83	5	27 – 66
42 – 87	6	34 – 86

Fourth Rib Sternal Ends

Changes to the sternal ends of the fourth rib have been linked to age in white populations (Iscan et al., 1984, 1985). A specific test of this estimation method on the post-medieval British population of Spitalfields cemetery, a documented London burial ground in use from the 16th to 18th centuries, found that the demographic profile generated from the sternal rib ends, without access to other skeletal elements affected by age, produced a good approximation of this sample in both range and distribution of ages (Loth, 1995). Therefore, this newly developed age estimation method was added to the multi-factoral estimation method used in this study without additional prejudice (Russell et al., 1993).

The sternal end of the left fourth rib was visually compared with industry-standard casts and with the physical descriptions published by Iscan et al (1984, 1985) If post-mortem damage altered the sternal end of the fourth rib, or if it was unavailable for analysis, then other rib ends from the middle of the rib cage were used in place of the fourth rib (Loth et al., 1994; Yoder et al., 2001). The estimated age range can bee seen in Table 3.13, and was determined after sex estimation was undertaken as the ranges accommodate sex-based differences in expression.

Table 3.13: Age estimation ranges by sex based on fourth rib sternal ends (Iscan et al., 1984, 1985).

Male Age Estimation (years)	Phase	Female Age Estimation (years)
< 17	0	< 14
17 – 19	1	14 – 15
20 – 23	2	16 – 19
24 – 28	3	20 – 24
26 – 32	4	24 – 32
33 – 42	5	33 – 46
43 – 55	6	43 – 58
54 – 64	7	59 – 71
> 64	8	> 69

Auricular Surface

Lovejoy et al. (1985b) developed a method to estimate age from the auricular surface based upon assessing the macroscopic appearance of the surface when compared to a phase-based series of photographic representations of surface changes occurring between 20 and 70 years of age (Figure 3.18). This method offers an advantage over the pubic symphysis method in that it can be applied to a skeletal element which has a higher preservation rate in archaeological contexts.
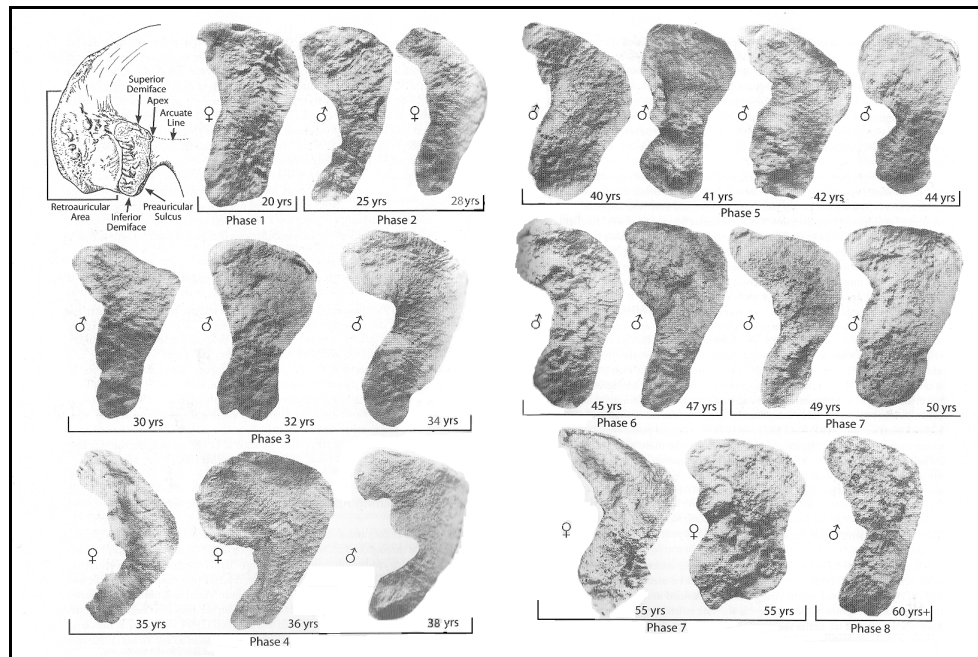
Figure 3.18: Photographic representations of the modal changes to the auricular surface related to age (as reprinted in Lovejoy et al., 1985b; White and Folkens, 2005: 382-3).

This method of age-at-death estimation was used where possible. The auricular surface was visually compared with both the descriptions of phases of the auricular surface documented by Lovejoy et al. (1985b). The left side was used when present and observable, but the right side was also used when the left was absent. Table 3.14 shows the phases for this method.

Table 3.14: Age estimations associated with degenerative changes of the auricular surface (Lovejoy et al., 1985b; as reprinted in White and Folkens, 2005: 382-3).

Phase	Age Estimation
1	20 – 24 years
2	25 – 29 years
3	30 – 34 years
4	35 – 39 years
5	40 – 44 years
6	45 – 49 years
7	50 – 59 years
8	60+ years

3.2.4 Body Shape Estimations

Body size and shape is largely determined by genetic predisposition to a specific height, body mass, and robusticity. The ultimate size and shape of an individual's body, however, can be affected throughout skeletal development by nutritional and environmental stress (Hauspie, 2002; Hindmarsh, 2002). Estimations can be made using the published regression equations and ratios summarised below.

Thirteen measurements were taken in skeletons that were estimated to be post-pubescent based on epiphyseal fusion. These measurements were used to estimate stature, body mass, and shape of the weight-bearing lower limbs of individuals. Non-adult long bones were measured during age estimation and these measurements were also applied to estimate the attained growth of each individual child at the time of their death. The measurements and methods used to describe body shape in this study are detailed in the following section. The mathematical estimations and indices associated with the methods described below were then calculated. Each measurement and mathematical calculation was recorded in the SPSS database for each skeleton.

3.2.4.1 Stature Estimation

Stature was estimated in the eight skeletal populations in this study to test the hypothesis that the conflict-zone populations were stunted in comparison to their neighbours. Stature was estimated by applying regression equations derived from modern white American populations (Table 3.15) as these were estimated to be the most representative regression equations to describe height in medieval British populations (Trotter, 1970; Bass, 1995: 26; Ruff, 2007). The maximum lengths of adult long bones, as defined by Bass (1995), from the left side of the skeleton were measured using an osteometric board and recorded in millimetres. Right sided long bones were measured only if the left side of the same element was absent or fragmented. Fragmentary long bones were not used to estimate stature in this study. The long bone lengths were then converted to centimetres for Trotter's (1970) regression equations for white males and females. Stature estimates were calculated for each individual with long bones after biological sex was estimated and was recorded in centimetres.

Table 3.15: White stature estimation equations, from most to least accurate, by sex (Trotter, 1970).

	Long Bone Length	Stature Equation	Standard Deviation
Males			
	Femur + Tibia	1.30(Length) + 63.29	± 2.99
	Femur	2.38(Length) + 61.41	± 3.27
	Fibula	2.68(Length) + 71.78	± 3.29
	Tibia	2.52(Length) + 78.62	± 3.37
	Humerus	3.08(Length) + 70.45	± 4.05
	Radius	3.78(Length) + 79.01	± 4.32
	Ulna	3.70(Length) + 74.05	± 4.32
Females			
	Femur + Tibia	1.39(Length) + 53.20	± 3.55
	Fibula	2.93(Length) + 59.61	± 3.57
	Tibia	2.90(Length) + 61.53	± 3.66
	Femur	2.47(Length) + 54.10	± 3.72
	Radius	4.74(Length) + 54.93	± 4.24
	Ulna	4.27(Length) + 57.76	± 4.30
	Humerus	3.36(Length) + 57.97	± 4.45

Non-adult stature was calculated using Ruff's (2007: 706) previously published regression equations based on skeletal growth in a sample of modern Caucasian American children. The maximum lengths of available long bones of all non-adults were measured and recorded during the age estimation process. The application of Ruff's juvenile stature estimation method requires the exact chronological age which is not possible to estimate from skeletal remains (Ruff, 2007); therefore, the mean of the estimated skeletal age range was determined to most accurately reflect the age-at-death for each non-adult skeleton during the age estimation process and was used to choose the appropriate stature estimation equation. As with adult stature estimation, the left side was preferred if both sides were present and fragmented long bones were not used to estimate stature. Stature was calculated for all non-adults who were estimated to have died between one and 17 years of age with complete long bones and corresponding epiphyses (Ruff, 2007: 706). Stature estimates were estimated to the nearest centimetre.

3.2.4.2 Body Mass Estimation

Body mass was estimated in the eight skeletal populations using the published regression equations summarised below. Two additional measurements (recorded in millimetres) were taken from the post-cranial long bones of adult skeletal remains for individuals with fully fused epiphyses to estimate body mass attained at skeletal maturity, indicating primary growth had ceased before death, (Auerbach and Ruff, 2004: 332). The antero-posterior diameter of the femoral head was measured using digital sliding callipers (Auerbach and Ruff, 2004). Bi-iliac breadth was measured as

the maximum distance between the lateral surfaces of the superior right and left os coxae when articulated with the sacrum (Ruff, 2000). Body mass was estimated for adults, after stature estimation, using the equations in Table 3.16. Stature and bi-iliac breadth were entered in these equations in centimetres, femoral head breadth was entered in millimetres, and body mass was estimated in kilograms (Auerbach and Ruff, 2004).

Table 3.16: Adult body mass estimation equations for stature/bi-iliac breadth and femoral head breadth measurements (Ruff et al., 1991; Ruff et al., 1997).

Method	Sex	Equation
Stature/Bi-iliac		
	Male	BM = 0.373 x Stature + 3.033 x Bi-iliac breadth – 82.5
	Female	BM = 0.522 x Stature + 1.809 x Bi-iliac breadth – 75.5
Femoral head breadth		
	Male	BM = (2.741 x Femoral head – 54.9) x 0.90
	Female	BM = (2.426 x Femoral head – 35.1) x 0.90
	Indeterminate	BM = (2.160 x Femoral head – 24.8) x 0.90

Ruff (2007) published body mass estimation equations for non-adult skeletal remains based on two measurements of the femur after data collection began for this study. The femoral head diameter, measured along the supero-inferior axis perpendicular to the head-neck axis, correlated with non-adult body mass (Ruff, 2007). Ruff (2007) also demonstrated the applicability of the stature/bi-iliac breadth adult body mass estimation method on non-adult individuals between the ages of 15 and 17 years. The femoral head diameter and bi-iliac breadth measurements were originally part of the data collection process for non-adult individuals estimated to have been older than 15 years at the time of their death. Although equations are not yet available for non-adults estimated to have been 15 or 16 years at the time of their death, body mass (BM) was calculated for non-adult individuals estimated to have been 17 years using the following equation (Ruff, 2007: 703):

$$BM = 1.750 \text{ x Femoral head breadth} - 17.2$$

Bi-iliac breadth body mass estimation equations were used for non-adults between the estimated ages of 15 and 17 years when preservation of the os coxae and long bones with epiphyses allowed the bi-iliac breadth and long bone measurements to be taken (Ruff, 2007). Both measurements were taken and recorded in millimetres. Body mass was estimated in kilograms (Ruff, 2007). Living bi-iliac breadth had to be

calculated by the following equation before the measurement could be used (see Table 3.17):

$$\text{Living bi-iliac breadth} = 1.17 \times \text{skeletal bi-iliac breadth} - 30$$

Table 3.17: Non-adult body mass estimation equations based on bi-iliac breadth measurements. Bi-iliac breadth measurements were converted to living (Ruff, 2007: 703).

Age (years)	Sex	Long Bone	Equation
15	Male	Femur	0.286 x LBIBa + 0.102 x LBLb – 70.2
		Tibia	0.282 x LBIB + 0.137 x LBL – 75.4
		Humerus	0.289 x LBIB + 0.137 x LBL – 66.5
		Radius	0.265 x LBIB + 0.174 x LBL – 59.1
	Female	Femur	0.342 x LBIB + 0.063 x LBL – 69.3
		Tibia	0.355 x LBIB + 0.024 x LBL – 53.8
		Humerus	0.350 x LBIB + 0.133 x LBL – 84.1
		Radius	0.343 x LBIB + 0.143 x LBL – 74.4
16	Male	Femur	0.404 x LBIB + 0.168 x LBL – 132.2
		Tibia	0.374 x LBIB + 0.186 x LBL – 118.6
		Humerus	0.394 x LBIB + 0.216 x LBL – 119.4
		Radius	0.353 x LBIB + 0.292 x LBL – 110.4
	Female	Femur	0.374 x LBIB + 0.055 x LBL – 75.8
		Tibia	0.374 x LBIB + 0.042 x LBL – 66.6
		Humerus	0.390 x LBIB + 0.104 x LBL – 88.0
		Radius	0.375 x LBIB + 0.135 x LBL – 82.7
17	Male	Femur	0.296 x LBIB + 0.153 x LBL – 92.8
		Tibia	0.234 x LBIB + 0.164 x LBL – 68.0
		Humerus	0.308 x LBIB + 0.209 x LBL – 91.3
		Radius	0.246 x LBIB + 0.270 x LBL – 73.1
	Female	Femur	0.338 x LBIB + 0.051 x LBL – 64.6
		Tibia	0.370 x LBIB - 0.005 x LBL – 48.7
		Humerus	0.308 x LBIB + 0.209 x LBL – 91.3
		Radius	0.246 x LBIB + 0.270 x LBL – 73.1

a Living bi-iliac breadth (mm).
b Long bone length (mm).

Body mass of each individual was calculated by the most reliable method available given skeletal preservation.

3.2.4.3 Platymeric Index

The playtmeric index has been used to numerically describe the shape of the superior part of the femoral diaphysis as a ratio between the antero-posterior and medio-lateral diameters of the shaft below the lesser trochanter (Brothwell, 1981). This index can vary from 56 to 128, with 75 or less being considered platymeric (Parsons, 1914; Bass, 1995). The diameter of the left femoral diaphysis was measured in both the antero-posterior plane and the medio-lateral plane below the lesser trochanter and

recorded. The platymeric index was calculated using the following equation (Bass, 1995: 225):

$$\text{Platymeric Index} = (\text{Femoral A-P diameter}/\text{Femoral M-L diameter}) \times 100$$

The index was compared to previously published index characteristics (Table 3.18).

Table 3.18: Platymeric index characteristics (Bass, 1995: 225).

Platymeric Index	Description
< 85.0	Platymeria
84.9 – 99.9	Eurymeria
> 100.0	Stenomeria

3.2.4.4 Platycnemic Index

The platycnemic index has been used to describe the shape of the proximal diaphysis of the tibia as a ratio between the antero-posterior and medio-lateral diameter of the shaft at the level of the nutrient foramen. An index range between 55.0 and 62.9 is usually regarded as platycnemic (Lovejoy et al., 1976). The diameter of the left tibial diaphysis was measured in both the antero-posterior plane and the medio-lateral plane at the nutrient foramen. The platycnemic index was calculated using the following equation (Bass, 1995: 245):

$$\text{Platycnemic Index} = (\text{Tibia M-L diameter}/\text{Tibia A-P diameter}) \times 100$$

The index was compared to previously published index characteristics (Table 3.19).

Table 3.19: Platycnemic index characteristics (Bass, 1995: 245).

Platycnemic Index	Description
< 54.9	Hyperplatycnemia
55.0 – 62.9	Platycnemia
63.0 – 69.9	Mesocnemic
>70.0	Eurycnemic

3.2.5 Palaeopathological Data

Increases in malnutrition and infectious disease prevalence rates were the two most consistent health changes experienced by populations exposed to long-term conflict (Goldson, 1996; Pedersen, 2002). Chronic forms of these conditions can be observed in human skeletal remains when researchers look for a suite of pathological lesions labelled 'indicators of stress' (Goodman et al., 1988). These indicators include cribra

orbitalia and porotic hyperostosis, enamel hypoplasia, periosteal reaction, and osteoporosis which can be observed through macroscopic skeletal analysis (Goodman et al., 1988: 179). Differences in the rates of nutritional deficiencies in the living population can be indicated by differences in the prevalence rates of metabolic bone disease, especially those associated with vitamin C and D deficiencies and osteoporosis, while difference in diet between populations can be indicated by differences in the prevalence rates of dental caries (Hillson, 1996; Brickley and Ives, 2008). Pathological data indicative of 'stress' and malnutrition were recorded using current UK recording standards as summarised in the following section (Brickley and McKinley, 2004).

Every skeleton was visually assessed for the presence or absence of abnormal bone growth or bone destruction in the elements present. The presence or absence of pathological lesions indicative of non-specific stress, metabolic bone disease, and dental caries was recorded, along with detailed descriptions of the lesions observed (Roberts and Connell, 2004). Diagnoses of disease in the individual were based on the presence, absence, and distribution of both active and healed lesions throughout the body as described by Aufderheide and Rodríguez-Martín (1998), Ortner (2003), and Mann and Hunt (2005). Diseases were initially diagnosed by category followed by a differential diagnosis of the possible specific diseases that had created the lesions observed (Miller et al., 1996; Roberts and Connell, 2004).

Prevalence rates for the indicators of stress described below were calculated as true prevalence rates (TPR): a ratio based on the number of skeletal elements affected out of the total number of observable skeletal elements rather than the total number of individuals present in the population in an effort to account for differential preservation (Roberts and Connell, 2004). Additionally, the rates were calculated as a ratio of the individuals affected out of the number of individuals available for observation (Roberts and Connell, 2004). Both rates were calculated for the two regional populations as well as the various age and sex categories within each population (Roberts and Connell, 2004).

3.2.5.1 Cribra Orbitalia and Porotic Hyperostosis

Usually bilateral, cribra orbitalia and porotic hyperostosis lesions are formed when marrow in the cranium is stimulated to produce more red blood cells (Roberts and Manchester, 2005: 229). The diplöe expands, leading to a thickening of the cranial

bone, and the ectocranial cortical surface is resorbed (Aufderheide and Rodríguez-Martín, 1998; Roberts and Manchester, 2005). The affected trabecular bone aligns in a "hair-on-end" appearance, perpendicular to the endocranial cortical bone, and is macroscopically visible only when the ectocranial cortical surface has been completely resorbed (Stuart-Macadam, 1989a). These types of lesions can occur both on the orbital surfaces of the frontal bone and on the superior surfaces of the parietals and occipital bones (Figure 3.19). Cribra orbitalia specifically refers to these lesions in the orbits and porotic hyperostosis refers to these lesions when located on the ectocranial vault (Stuart-Macadam, 1989b; Lewis and Roberts, 1997).
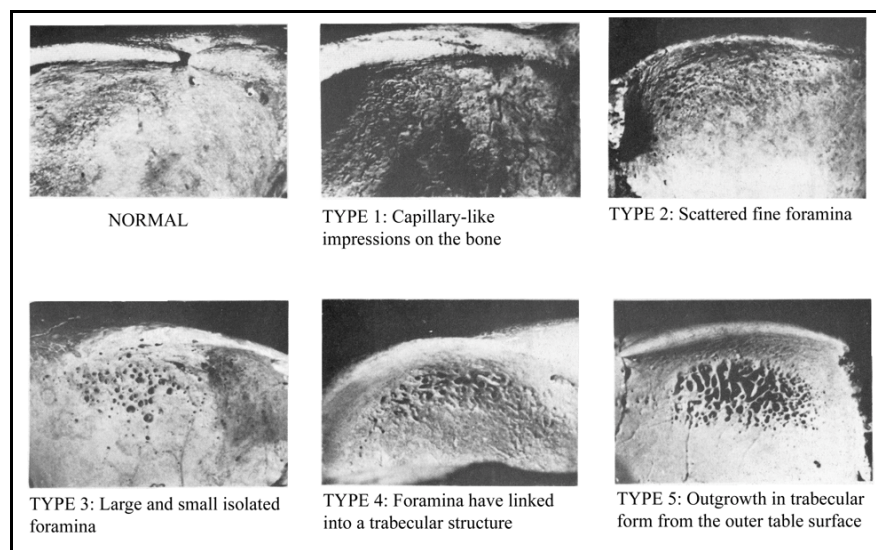
Figure 3.19: Examples of the types of cribra orbitalia lesions (Stuart-Macadam, 1991: 108 - 9).
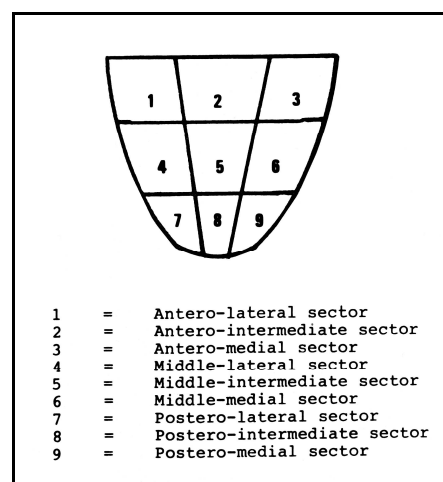
Figure 3.20: Orbit area labels used to describe locations of cribra orbitalia lesions (Stuart-Macadam, 1991: 109).

If cribra orbitalia and/or porotic hyperostosis lesions were present, a detailed description of the lesions was recorded. This description listed specifically which

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portions of the cranium were affected (Figure 3.20), if the lesions were bilateral, and a brief description of the appearance of the lesions. Words used to describe the appearance included fine porosity, large foramina, trabecular structure, and outgrowth as defined by Stuart-Macadam (1991). Finally, digital photographs were taken of the orbits or cranial vaults affected. However, slight expression of the lesions, insufficient cleaning, or poor lighting occasionally prevented clear photographs from being taken.

The expression of bone changes in response to disease is not directly representative of the presence or severity of that disease in the individual (Wood et al., 1992). Although previous researchers have developed methods which grade the severity of cribra orbitalia and porotic hyperostosis lesions, as seen in Figure 3.20 (Stuart-Macadam, 1991; Buikstra and Ubelaker, 1994), presence or absence, rather than the severity of bone changes, has been shown to be a more consistent observation (Jacobi and Danforth, 2002). As the primary goal of this study was to ascertain the prevalence of cribra orbitalia and porotic hyperostosis, the presence and absence data collected during analysis were used to test the hypothesis that the Anglo-Scottish border populations were exposed to a greater level of stress in comparison to their contemporary neighbours. These data were collected for all skeletons included in this study regardless of their estimated age-at-death or sex (Stuart-Macadam, 1991).

3.2.5.2 Enamel Hypoplasia

Enamel hypoplasia describes an area on the crown of a tooth which has a deficient amount of enamel thickness (Hillson, 1996: 165). This deficiency can appear macroscopically as linear furrows or grooves around the bucco-lingual circumference of the tooth crown parallel to the cervix (Hillson, 1996: 166 - 7). Enamel hypoplasia can also appear as pits of varying sizes on the enamel surfaces of the crown (Hillson, 1996: 166 - 7). These lesions can occur on any tooth, but are most commonly reported on incisors and canines (Aufderheide and Rodríguez-Martín, 1998: 406).

Each tooth crown present was examined for visible enamel defects. Observed defects were described as pits, lines, or grooves and the relative location of the defects and the crown surfaces affected were listed (Hillson, 1996: 167). Finally, the total number of teeth affected by enamel defects was tabulated by individual.

3.2.5.3 Non-Specific Infection Lesions

Infectious diseases in a skeletal population can be inferred from observed changes to the skeleton by identifying patterns of bone deposition and resorption throughout the skeleton (Kelley, 1989; Rogers and Waldron, 1989; Ortner, 2003). Unique patterns of bone changes have been associated with specific infections in only a few instances, such as tuberculosis, leprosy, and treponemal diseases (Aufderheide and Rodríguez-Martín, 1998; Roberts et al., 2002; Ortner, 2003; Roberts and Buikstra, 2003). The overall presence of infectious diseases in a population can be inferred from observing non-specific infection lesions (Kelley, 1989; Rogers and Waldron, 1989). Infectious diseases have been observed to change bone by both depositing new bone and destroying pre-existing bone, but the infectious disease must be present in the individual for an extended period of type to lead to bone change (Wood et al., 1992).

All the skeletal elements present for each individual were examined for signs of periostitis, osteitis, and osteomyelitis (Kelley, 1989; Ortner, 2003; Roberts and Manchester, 2005). The presence or absence of pathological lesions on the maxillary sinuses, ribs, endocranial surfaces, and lower limbs were specifically noted (Roberts et al., 1998; Roberts, 2000; Lewis, 2004; Roberts and Connell, 2004; Roberts, 2007). When lesions were observed, a complete description was made of the appearance, colour, size, and shape of the lesions, and the bone affected with bone changes was written in the pathological notes section of the recording form (Roberts and Connell, 2004). Descriptions of the appearance of the bone lesions included phrases such as pitting, vertical striations, porous new bone, and lamellar bone, to describe the changes observed (Rogers and Waldron, 1989; Roberts and Connell, 2004; Grauer, 2008).

3.2.5.4 Metabolic Bone Disease

Metabolic bone disease result from nutritional deficiencies which have been shown in previous studies to alter bone, and can therefore be observed in the archaeological record (Brickley, 2000; Brickley and Ives, 2008; Mays, 2008). Previous research has noted bone changes in individuals with vitamin C deficiencies, vitamin D deficiencies, and osteoporosis (Fildes, 1986; Stuart-Macadam, 1989a; Ortner and Mays, 1998; Cox, 2000; Brickley, 2002; Mays, 2008). The body's access to vitamin and mineral rich foods and its ability to absorb these nutrients is essential to maintain

health and a fully functioning immune system (Aufderheide and Rodríguez-Martín, 1998; Norgan, 2002; Ortner, 2003). Restricted access to dietary resources can specifically reduce the body's ability to fight infections and to maintain a healthy body (Norgan, 2002). Vitamin deficiency diseases have been described in the literature and are clearly linked to malnutrition associated with changes in diet, economy, social status, and infectious diseases (Brickley et al., 2005; Schofield, 2006; Waldron, 2006; Melikian and Evans, 2008; Wilbur et al., 2008).

Although differential preservation was anticipated to affect the metabolic disease prevalence observed in the Anglo-Scottish border (Brickley et al., 2007), an assessment of palaeopathological indications of vitamin C deficiencies, vitamin D deficiencies, and osteoporosis was necessary to test the hypothesis that the conflict-zone population experienced chronic malnutrition and nutritional deficiencies in comparison to their contemporary neighbours.

3.2.5.4.a Vitamin C Deficiency

Vitamin C is essential for the production of collagen, therefore a deficiency affects bone by depositing collage-poor new bone along the limbs and in the skull, as well as resorbing bone in the jaw causing the premature loss of teeth (Ortner, 2003; Roberts and Manchester, 2005). These bone changes have been described in both non-adult and adult skeletal remains (Ortner and Ericksen, 1997; Ortner, 2003; Roberts and Manchester, 2005; Brickley and Ives, 2006). The skeletal elements present for each individual were examined for the pathological lesions indicative of vitamin C deficiency, or scurvy (Table 3.20). Observed lesions were described and differential diagnoses determined based on previously publish descriptions of bone changes.

Table 3.20: Skeletal changes indicative of vitamin C deficiency (Ortner and Ericksen, 1997; Ortner, 2003; Brickley and Ives, 2006).

Bone Change	Location in skeleton
New bone deposits	Cranial vault
	Greater wing of sphenoid
	Orbit
	Posterior maxilla
	Internal zygomatic bone
	Infraorbital foramen
	Alveolar process/sockets
	Palate
	Medial coronoid process
Bone destruction	Cribra orbitalia
	Alveolar surfaces in mandible and maxilla

3.2.5.4.b Vitamin D Deficiency

The most characteristic skeletal changes associated with vitamin D deficiency, or rickets in children and osteomalacia in adults, are bending of the weight-bearing long bones of the legs (when walking begins) and arms (when crawling begins), thinning of the cranial vault, bossing of the frontal bone, expansion of the ends of long bones, and nodular prominences in the costochondral areas of the ribs (Ortner and Mays, 1998; Brickley et al., 2005; Roberts and Manchester, 2005). These bone changes have been described in both non-adult and adult skeletal remains (Stuart-Macadam, 1989a; Ortner and Mays, 1998; Ortner, 2003; Brickley et al., 2005; Roberts and Manchester, 2005; Brickley et al., 2010). Pathological lesions indicative of this disease were described in detail when observed and differential diagnoses were determined based on previously publish descriptions of bone changes (Table 3.21).

Table 3.21: Skeletal changes indicative of vitamin D deficiency (Stuart-Macadam, 1989a; Ortner and Mays, 1998; Brickley et al., 2005, 2010).

Region affected	Observed Bone Changes
Cranial	Wide sutures
	Persistence of fontanelles
	Flat and thin skull
	Frontal bossing
	Dental development affected
	Dental disease severe
Post-cranial	Nodules at costo-chondral rib junctions
	Thoracic kyphosis and scoliosis
	Enlarged joints
	Pelvis retarded in growth
	Bowing deformities in the limbs

3.2.5.4.c Osteoporosis

Osteoporosis, also called age-related bone loss, is a condition of bone deterioration caused by a lack of mineralisation in the skeleton due to a deficiency in calcium (Ortner, 2003; Brickley and Ives, 2008). Visually observable bone changes associated with osteoporosis are loss of stature, thinned bone cortex, fractures in association with decreased bone robusticity in the spine and limbs, and bones are much lighter in overall weight (Ortner, 2003). Osteoporosis can only be diagnosed through microscopic and radiographic research methods to verify that 30% of bone mass has been lost (Turner-Walker and Mays, 2001). Therefore, evidence of probable osteoporosis was recorded when any of the macroscopic bone changes were observed.

3.2.5.5 Caries Lesions

Dental caries are infectious lesions that appear as dark spots exposed by thinned enamel or as cavities excavated out of the body of the tooth crown (Lukacs, 1989; Hillson, 1996). Caries lesions are observed most often in the areas between teeth and along the crown/root junction (Hillson, 1996). The presence or absence of caries lesions was recorded for each skeleton. When caries lesions were observed, the position and relative size of the lesion was drawn on the tooth affected in the dental diagram (Lukacs, 1989). A detailed description of each lesion, indicating the lesion's position in the dentition, the location on the tooth, and the percent of the tooth affected (i.e. Pit/fissure, <half crown, >half of crown, all crown) were all recorded (Lukacs, 1989), and larger lesions were also measured.

3.2.6 Statistical Comparisons

Statistical comparisons both within and between the conflict-zone and neighbours populations were conducted to test the hypothesis in this study. The alpha level was defined at 5% to ensure that differences identified between the two regional populations were not random for at least 95% of cases (Wilcox, 2003: 146). The Chi-square test was used to test for significant differences in the total counts of individuals in each preservation, age, and sex category between the two groups (Chamberlain, 2006: 43). The Chi-square test was also used to test for differences in palaeopathological prevalence rates both between the populations, and between the age and sex categories within each population. The Chi-Square Goodness of Fit test was used to check the balance of the sex distribution within each population against the expected distribution of a 1:1 male to female ratio (Chamberlain, 2006). When counts for any of these variables were less than five, Fisher's Exact Test was employed to test for probable non-random relationships between variables. Life tables were constructed in SPSS based on the mean age-at-death estimated for all of the individuals in each population. Life expectancy was calculated and compared via the Wilcox-Mann-Whitney test (Chamberlain, 2006: 44). Body shape comparisons were conducted by using the T-test to compare means of stature, body mass, platymeric and platycnemic indices. Regression analysis was used to estimate growth rates based on non-adult stature and body mass when possible (Wilcox, 2003). The regression equations generated were dependent on the age variable.

4 Results and Comparisons

The following chapter consists of a summary of the results of the analysis of the 388 skeletons by population, followed by a direct statistical comparison of the two regions. The primary data collected is attached in Appendix E. Each category of data was initially summarised by site into three sections to describe the preservation state of the skeletal material observed, to summarise the demographic profile of the cemetery population, and to describe palaeopathological indicators of nutritional stress, metabolic bone disease, and dental caries observed. The preservation, demographic, and palaeopathological data for the conflict-zone population (CZP) and neighbours population (NP) are summarised in the first two sections of this chapter. The two regional populations were then statistically compared to test the hypothesis that the CZP was less likely to thrive than their contemporary neighbours due to nutritional deprivation and infectious diseases associated with the socio-political instability of the Medieval Anglo-Scottish border troubles. The results of this direct comparison are presented in the third section of this chapter. The interpretation of these results in light of biases in the data due to differential preservation and methodological issues inherent in bioarchaeology will be explored in Chapter 5.

4.1 Conflict-Zone Population

Data from the skeletal assemblages from Auldhame, Blackfriars Street, Blackgate, and The Hirsel were combined to describe health and disease patterns along the Medieval Anglo-Scottish border. Of the 1422 skeletons available from the CZP, 215 individuals were randomly selected for this study. Preservation of the skeletons in the border region ranged from excellent to poor with the majority described as in a good state of completeness. Good preservation allowed for comprehensive observations of individuals of all ages and sexes for palaeopathological lesions associated with nutritional indicators of stress, metabolic bone disease, and non-specific infection. A composite population profile for the CZP is presented in the following section.

4.1.1 Preservation

The majority of skeletons analysed from the border region were described as in a good state of preservation and completeness at the time of analysis (Table 4.1). The second most frequent description was of excellent preservation.

Table 4.1: Conflict-zone skeletal preservation.

Preservation	Skeletal Completeness	No.	%
Excellent	> 75%	56	26.0
Good	25% - 75%	117	54.4
Poor	< 25%	42	19.5

The same distribution pattern through the preservation categories was observed across the four broad age categories (Table 4.2, Figure 4.1). The highest count of individuals in each age category was observed in the good category. No significant difference in preservation was observed between the age categories in the CZP ($X^2_{(6)}$ = 2.729, p = 0.842). Preservation within the more specific age ranges was similarly distributed throughout the three categories. The majority were in good condition. Again, there was no significant difference observed in the preservation distribution in the eight age ranges ($X^2_{(14)}$ = 14.793, p = 0.392).

Table 4.2: Conflict-zone preservation by age.

Type	Age	Excellent No.	Excellent %	Good No.	Good %	Poor No.	Poor %	Total No.	Total %
Age Category	Non-adults	13	27.1	29	60.4	6	12.5	48	22.3
	Young Adults	12	28.6	20	47.6	10	23.8	42	19.5
	Adults	24	25.5	51	54.3	19	20.2	94	43.7
	Older Adults	7	22.6	17	54.8	7	22.6	31	14.4
Age (years)	0 – 2	2	12.5	11	68.8	3	18.8	16	7.4
	2 – 5	2	18.2	9	81.8	-	-	11	5.1
	5 – 9	8	53.3	6	40.0	1	6.7	15	7.0
	10 – 14	1	16.7	3	50.0	2	33.3	6	2.8
	15 – 24	12	28.6	20	47.6	10	23.8	42	19.5
	25 – 34	9	22.0	22	53.7	10	24.4	41	19.1
	35 – 44	15	28.3	29	54.7	9	17.0	53	24.7
	45+	7	22.6	17	54.8	7	22.6	31	14.4
Total		56	26.0	117	54.4	42	19.5	215	100.0
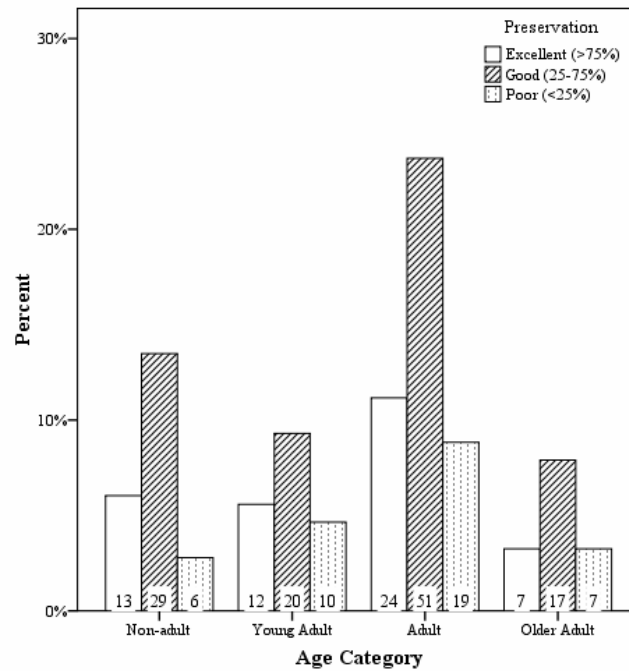
Figure 4.1: Conflict-zone preservation by age category.

There were 167 adult skeletons analysed in the CZP, of which 138 were estimated as male, possibly male, female, or possibly female. The majority of male adults were described as in a good state of preservation with a large proportion also described as excellently preserved (Table 4.3, Figure 4.2). The majority of female adults were recorded as in a good state of preservation which was consistent with the overall preservation trend in the CZP. Despite the slightly better preservation observed in the males, there was no significant difference observed in skeletal preservation between the males and females ($X^2_{(2)}$ = 1.612, p = 0.447).

Table 4.3: Conflict-zone adult preservation by sex.

Sex	Excellent No.	%	Good No.	%	Poor No.	%	Total No.	%
Males	22	31.4	37	52.9	11	15.7	70	41.9
Females	15	22.1	42	61.8	11	16.2	68	40.7
Indeterminate	6	20.7	9	31.0	14	48.3	29	17.4
Total	43	25.7	88	52.7	36	21.6	167	100.0
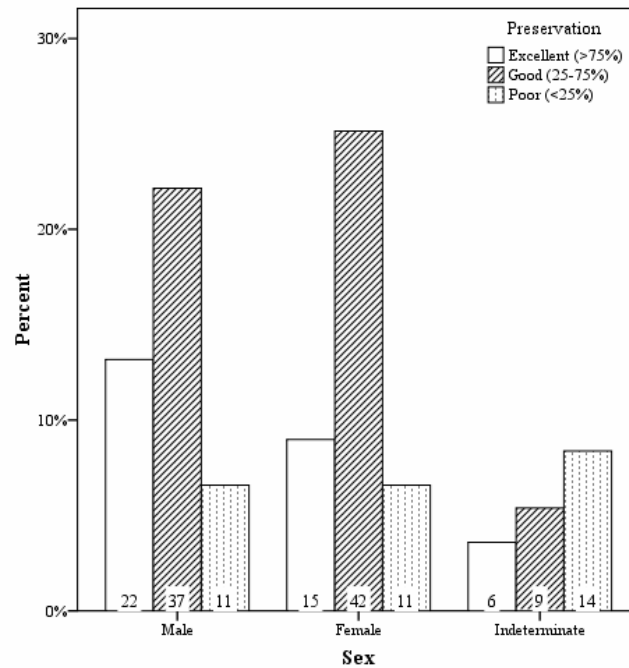
Figure 4.2: Conflict-zone adult preservation by sex.

Conversely, the adults of indeterminate sex were predominately described as poorly preserved with less than 25% of their skeletal elements present. There was a significant difference observed in preservation between the three sex categories within the CZP adults ($X^2_{(4)}$ = 16.794, p = 0.002). Both the males ($X^2_{(2)}$ = 11.547, p = 0.003) and the females ($X^2_{(2)}$ = 11.797, p = 0.003) were significantly better preserved than the adults of indeterminate sex.

A significant difference was observed in the overall distribution of individuals through the preservation categories between the four CZP sites ($X^2_{(6)}$ = 24.440, p < 0.001). Significant differences were observed in the counts of individuals in the excellent and poor preservation categories between the four sites (Table 4.4, Figure 4.3). There were significantly more poorly preserved individuals and fewer excellently preserved skeletons observed in the Blackfriars Street population when compared to the three other sites along the Medieval Anglo-Scottish border.

Table 4.4: Conflict-zone preservation by site.

| Preservation | Auldhame | | Blackfriars Street | | Blackgate | | The Hirsel | | Comparison | |
	No.	%	No.	%	No.	%	No.	%	$X^2_{(3)}$	p
Excellent	17	32.7	5	8.8	19	33.9	15	30.0	8.286	0.040
Good	23	44.2	32	56.1	34	60.7	28	56.0	2.419	0.490
Poor	12	23.1	20	35.1	3	5.4	7	14.0	15.333	0.002
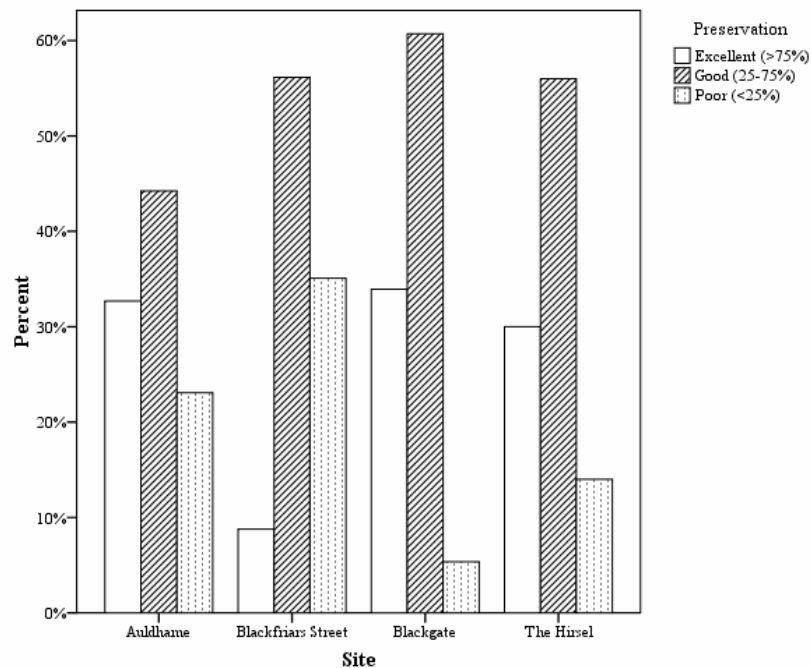
Figure 4.3: Conflict-zone preservation by site.

4.1.2 Demographic Profile

The good to excellent preservation of the CZP skeletons allowed for complete skeletal analysis of the indicators of sex, age, and body shape. The complete range of age and sex categories was observed in the 215 skeletons from the CZP. It was also possible to apply body shape estimation methods to both adult and non-adult individuals in this population. The following section summarises the results of the demographic analysis of the CZP.

4.1.2.1 Sex

A total of 167 adults were analysed from the CZP, of which 70 were estimated to have been male or possible male, 68 were female or possible female and 29 were of indeterminate sex (Table 4.5, Figure 4.4). There was a significant difference observed in the distribution of individuals across the five sex categories ($X^2_{(4)} = 15.725$, p = 0.003).

When the male/possible male and female/possible female categories were combined into simple male and female categories, the sex distribution produced a ratio of 1.03:1 in favour of males. There was no significant difference observed between the total number of males and females in the population ($X^2_{(1)} = 0.029$, p =

0.865). When the sex distribution of the CZP adults included those of indeterminate sex, with an expected ratio of 2:1:2 for males to indeterminate sex to females, there was no significant difference in the sex distribution of the adults from the expected ratio ($X^2_{(2)} = 0.754$, p = 0.686).

Table 4.5: Conflict-zone adult sex distribution.

Type	Sex	No.	%
Sex	Male	48	28.7
	Possible Male	22	13.2
	Indeterminate	29	17.4
	Possible Female	25	15.0
	Female	43	25.7
Simplified Sex	Male	70	41.9
	Female	68	40.7
	Indeterminate	29	17.4
Total		167	100
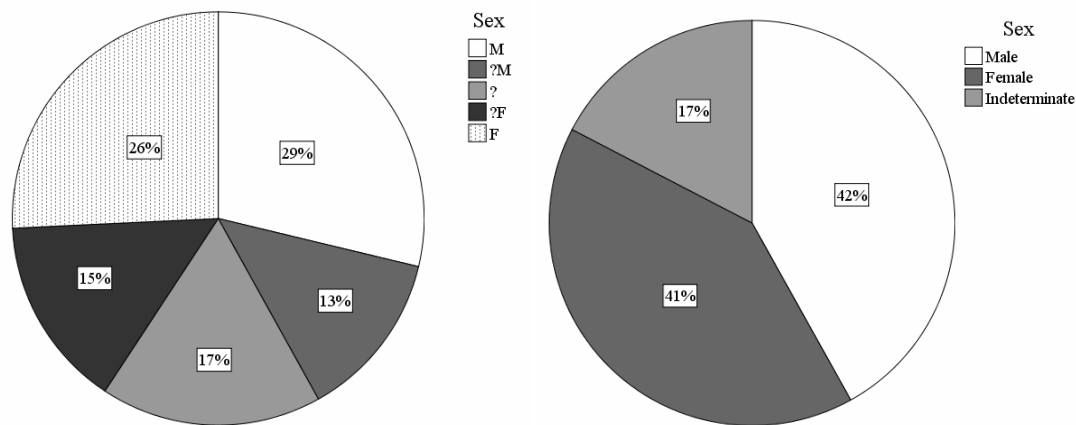
Figure 4.4: Conflict-zone adult sex distribution.

No significant differences were identified in the overall distribution of individuals through the simplified sex categories between the four CZP sites ($X^2_{(6)} = 8.191$, p = 0.224). Similarly, there were no significant differences observed in the counts of individuals within each sex category between the four sites (Table 4.6).

Table 4.6: Conflict-zone sex distribution by site.

Sex	Auldhame No.	%	Blackfriars Street No.	%	Blackgate No.	%	The Hirsel No.	%	Comparison $X^2_{(3)}$	p
Male	24	58.5	18	36.0	17	36.2	11	37.9	4.857	0.183
Female	13	31.7	20	40.0	23	48.9	12	41.4	5.059	0.168
Indeterminate	4	9.8	12	24.0	7	14.9	6	20.7	4.793	0.188

4.1.2.2 Age at Death

Of the CZP skeletons, 167 (77.7%) were identified as adults and 48 (22.3%) were non-adults younger than 15 years at the time of their death (Table 4.7).

Table 4.7: Conflict-zone population by age and sex.

Type	Age	Total No.	Total %	Male No.	Male %	Female No	Female %	Indeterminate No.	Indeterminate %
Age Category	Non-adult	48	22.3	-	-	-	-	-	-
	Young Adult	42	19.5	20	28.6	11	16.2	11	37.9
	Adult	94	43.7	42	60.0	37	54.4	15	51.7
	Older Adult	31	14.4	8	11.4	20	29.4	3	10.3
Age (years)	0 – 2	16	7.4	-	-	-	-	-	-
	2 – 5	11	5.1	-	-	-	-	-	-
	5 – 9	15	7.0	-	-	-	-	-	-
	10 – 14	6	2.8	-	-	-	-	-	-
	15 – 24	42	19.5	20	28.6	11	16.2	11	37.9
	25 – 34	41	19.1	19	27.1	15	22.1	7	24.1
	35 – 44	53	24.7	23	32.9	22	32.4	8	27.6
	45+	31	14.4	8	11.4	20	29.4	3	10.3
Total		215	100	70	32.6	68	31.6	29	13.5

The age at death rates for the CZP gradually decreased through the non-adult age ranges then increased to 20% in the young adults and peaked at 25% in the 35 to 44 year age range (Figure 4.5).
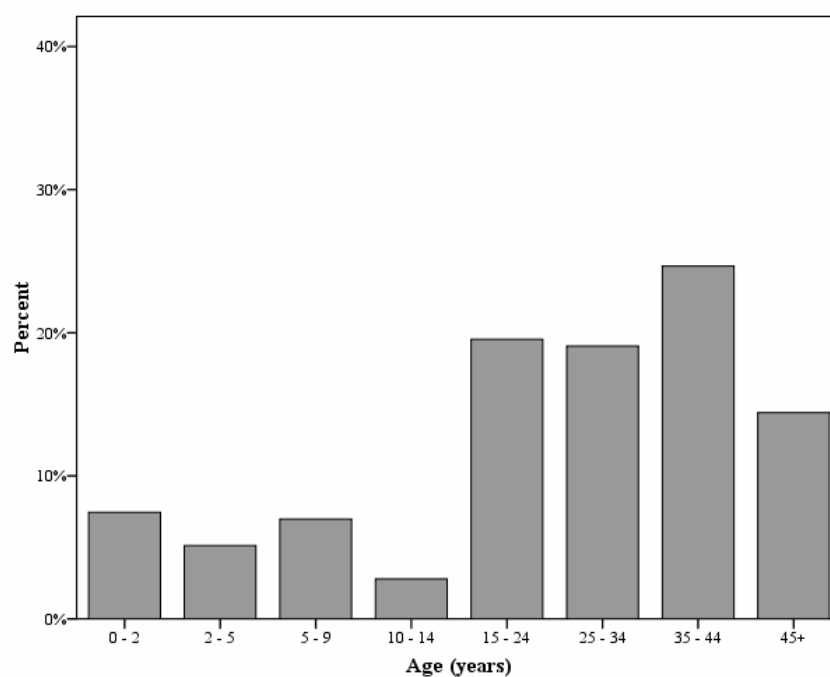
Figure 4.5: Conflict-zone age-at-death by range.

The life expectancy at birth (e_0) for the CZP as a whole was 28.80 years (Table 4.8). The mean age at death for the population was 27.46 years and the maximum estimated age-at-death was 60 years.

Table 4.8: Conflict-zone life table.

x	l_x	d_x	Q_x	L_x	T_x	e_x
0	1.00	0.13	0.13	4.68	28.80	28.80
5	0.87	0.07	0.08	4.18	24.13	27.73
10	0.80	0.02	0.03	3.95	19.95	24.94
15	0.78	0.07	0.09	3.73	16.00	20.51
20	0.71	0.13	0.18	3.23	12.28	17.29
25	0.58	0.05	0.09	2.78	9.05	15.60
30	0.53	0.14	0.26	2.30	6.28	11.84
35	0.39	0.08	0.21	1.75	3.98	10.19
40	0.31	0.16	0.53	1.13	2.23	7.18
45	0.14	0.06	0.42	0.55	1.10	7.86
50	0.08	0.03	0.39	0.33	0.55	6.88
55	0.05	0.03	0.64	0.18	0.23	4.50
60	0.02	0.02	1.00	0.05	0.05	2.50
65	0.00	0.00	0.00	0.00	0.00	0.00

It was possible to construct life tables for males and females based on the age-at-death estimates from individuals who survived through puberty. The males and females from the CZP demonstrated different mortality profiles (Table 4.9, Figure 4.6). The life expectancy for adult males (e_{15}) was 33.00 years and for females was 39.70 years. Female life expectancy was significantly longer than males for those who survived childhood (p = 0.002).

Table 4.9: Conflict-zone life table for adults by sex.

Sex	x	l_x	d_x	q_x	L_x	T_x	e_x
Males	15	1.00	0.13	0.13	4.68	18.00	18.00
	20	0.87	0.16	0.18	3.95	13.33	15.32
	25	0.71	0.07	0.10	3.38	9.38	13.20
	30	0.64	0.20	0.31	2.70	6.00	9.38
	35	0.44	0.15	0.35	1.83	3.30	7.50
	40	0.29	0.17	0.60	1.00	1.48	5.09
	45	0.11	0.07	0.63	0.38	0.48	4.32
	50	0.04	0.04	1.00	0.10	0.10	2.50
	55	0.00	0.00	0.00	0.00	0.00	0.00
Females	15	1.00	0.03	0.03	4.93	24.70	24.70
	20	0.97	0.14	0.14	4.53	19.78	20.39
	25	0.84	0.08	0.09	4.00	15.25	18.15
	30	0.76	0.14	0.19	3.45	11.25	14.80
	35	0.62	0.06	0.10	2.95	7.80	12.58
	40	0.56	0.26	0.47	2.13	4.85	8.66
	45	0.29	0.10	0.35	1.20	2.73	9.40
	50	0.19	0.04	0.23	0.85	1.53	8.03
	55	0.15	0.09	0.60	0.53	0.68	4.50
	60	0.06	0.06	1.00	0.15	0.15	2.50
	65	0.00	0.00	0.00	0.00	0.00	0.00
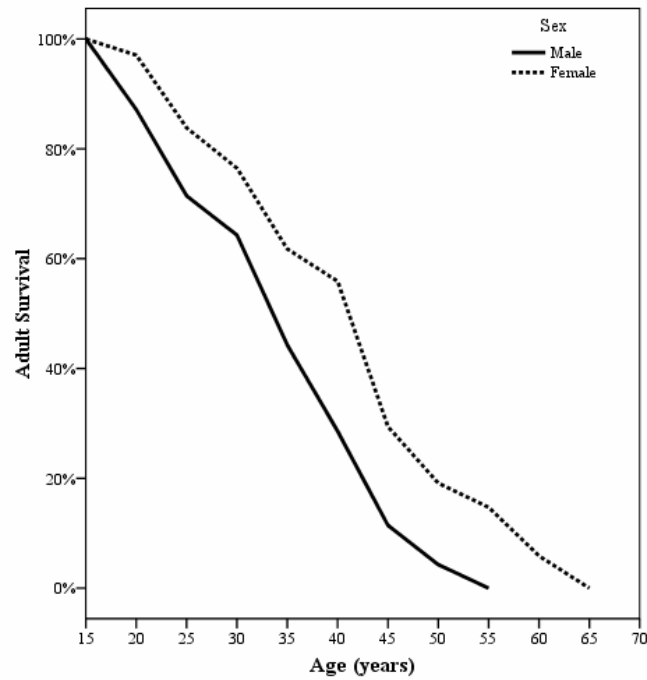
Figure 4.6: Conflict-zone adult mortality as a percentage of survival by sex.

4.1.2.3 Body Shape

Excellent preservation of the CZP skeletons allowed body shape to be at least partially estimated for the majority of individuals observed. The following section summarises estimated stature, body mass, and platymeric and platycnemic indices for the border population.

4.1.2.3.a Stature

It was possible to estimate stature for 133 adults in the CZP. Sex estimation was possible for 118 of these individuals which allowed mean stature to be calculated for each sex category (Table 4.10). The mean stature of males was significantly taller than the mean stature of females in this population (t = -8.264, p < 0.001).

Table 4.10: Conflict-zone adult stature estimates.

Sex	No.	Mean (cm)	S.D. (cm)	Min. (cm)	Max. (cm)
Males	60	168.85	5.72	155.90	183.28
Females	58	159.68	6.33	144.87	178.17
Indeterminate	15	163.73	8.47	149.99	175.77

A total of 34 non-adults in the CZP were preserved well enough to allow stature estimations to be calculated (Table 4.11). Non-adult stature gradually increased with age, although there were notable fluctuations during the first and third

years (Figure 4.8). Non-adult stature in this population could be estimated by mean age at death by the equation: Stature = 6.733(Age) + 64.963.

Table 4.11: Conflict-zone non-adult stature estimates by mean age-at-death.

Age (years)	No.	Mean (cm)	S.D. (cm)	Min. (cm)	Max. (cm)
0.00	2	50.86	2.43	49.14	52.58
0.20	1	86.39	-	-	-
0.25	1	65.11	-	-	-
0.50	1	63.89	-	-	-
0.75	3	65.01	3.51	62.56	69.03
1.00	1	70.17	-	-	-
1.50	2	77.16	1.68	75.97	78.35
2.00	1	83.53	-	-	-
2.50	1	86.59	-	-	-
3.00	2	99.57	1.61	98.43	100.70
3.50	1	75.73	-	-	-
4.00	2	95.64	3.29	93.31	97.96
5.00	1	101.34	-	-	-
6.00	5	105.14	5.36	101.63	114.55
7.00	4	115.55	11.64	102.68	128.04
9.00	3	117.85	3.58	115.06	121.88
11.00	1	134.48	-	-	-
12.00	1	146.89	-	-	-
12.50	1	153.32	-	-	-
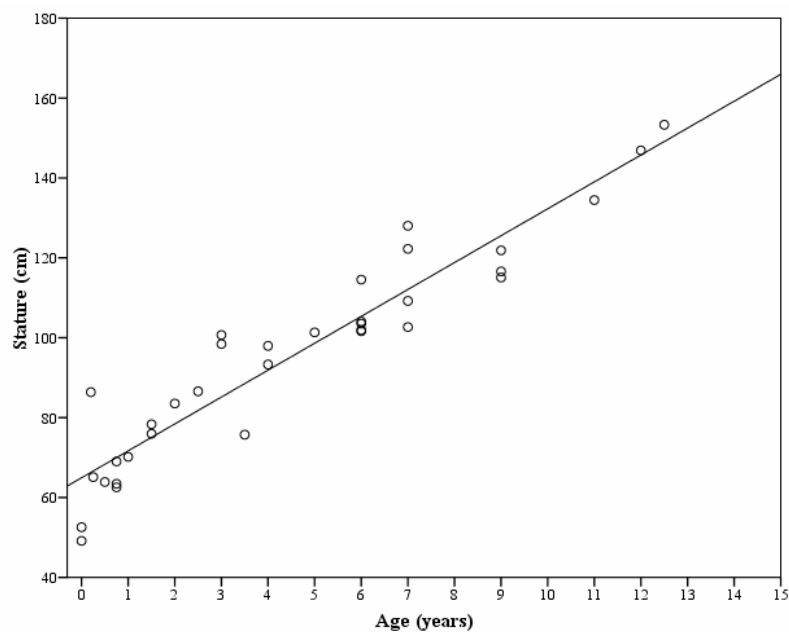
Figure 4.7: Conflict-zone non-adult stature by mean age-at-death.

4.1.2.3.b Body Mass

It was possible to estimate body mass for 117 adults in the CZP (Table 4.12). The mean body mass of the males was significantly higher than the mean body mass of the

females via both methods of calculation (Femoral Head: t = -5.853, p < 0.001, Bi-iliac Breadth: t = -3.534, p = 0.002).

Table 4.12: Conflict-zone adult body mass by sex and estimation method.

Calculation Method	Sex	No.	Mean (kg)	S.D.	Min.	Max.
Femoral Head Diameter Method	Male	59	68.61	6.21	55.41	79.61
	Female	49	61.93	5.52	52.23	76.88
	Indeterminate	9	62.20	7.54	48.44	69.55
Bi-iliac Breadth Method	Male	18	68.68	7.08	53.25	77.65
	Female	9	58.53	6.92	47.84	68.12
	Indeterminate	4	64.84	9.28	57.39	78.16

It was possible to apply both body mass estimation methods to the same individual for 31 adults in this population. There was no significant difference observed in a direct comparison of the mean body masses calculated via both methods in these individuals (Table 4.13).

Table 4.13: Comparison of conflict-zone adults with both body mass estimation methods applied.

Sex	No.	Femoral Head Diameter Method		Bi-iliac Breadth Method		Comparison	
		Mean (kg)	S.D.	Mean (kg)	S.D	t	p
Male	18	67.58	7.14	68.68	7.08	-1.033	0.316
Female	9	58.76	5.52	58.53	6.92	0.130	0.899
Indeterminate	4	67.51	1.86	64.84	9.28	0.598	0.592

There were no non-adult individuals in the CZP available for body mass estimations.

4.1.2.3.c Platymeric Index

It was possible to calculate the platymeric index for 133 adult individuals in the CZP (Table 4.14). There was no significant difference observed in the mean indices between the males and females (t = 1.864, p = 0.065).

Table 4.14: Conflict-zone platymeric index by sex.

Sex	No.	Mean	S.D.	Minimum	Maximum
Male	63	83.43	10.01	68.00	111.04
Female	56	87.76	14.61	59.48	145.21
Indeterminate	14	79.64	9.62	65.89	97.63
Total	133	84.86	12.35	59.48	145.21

Table 4.15: Conflict-zone platymeric index by type and sex.

Sex	No.	Platymeric		Eurymeric		Stenomeric	
		No.	%	No.	%	No.	%
Male	63	40	63.5	18	28.6	5	7.9
Female	56	27	48.2	22	39.3	7	12.5
Indeterminate	14	10	71.4	4	28.6	-	-
Total	133	77	57.9	44	33.1	12	9.0

The largest proportion of individuals was classified as platymeric in the CZP regardless of their estimated sex (Table 4.15). There was no significant difference identified in the distribution of the index types through the three adult sex categories ($X^2_{(4)} = 6.096$, p = 0.192).

4.1.2.3.d Platycnemic Index

The platycnemic index was calculated for 119 adult individuals in the CZP (Table 4.16). There was no significant difference in the mean indices between the males and females (t = 1.038, p = 0.302).

Table 4.16: Conflict-zone platycnemic index by sex.

Sex	No.	Mean	S.D.	Minimum	Maximum
Male	59	69.21	6.14	52.59	87.94
Female	47	70.50	6.63	58.51	90.15
Indeterminate	13	70.42	6.89	58.51	77.83
Total	119	69.85	6.40	52.59	90.15

The males and females in this population were evenly divided between the mesocnemic and eurycnemic categories while the majority of the adults of indeterminate sex were categorised as eurycnemic (Table 4.17). There was a significant difference observed in the distribution of individuals through the index types between the three adult sex categories ($X^2_{(6)} = 16.066$, p = 0.013). There was no difference observed between the males and females in the distribution patterns ($X^2_{(3)} = 1.343$, p = 0.719). The difference was observed specifically between the males and adults of indeterminate sex ($X^2_{(3)} = 14.638$, p = 0.002), and between the females and the adults of indeterminate sex ($X^2_{(2)} = 12.607$, p = 0.002).

Table 4.17: Conflict-zone platycnemic index by type and sex.

Sex	No.	Hypoplatycnemic No.	Hypoplatycnemic %	Platycnemic No.	Platycnemic %	Mesocnemic No.	Mesocnemic %	Eurycnemic No.	Eurycnemic %
Male	59	1	1.7	6	10.2	26	44.1	26	44.1
Female	47	-	-	6	12.8	20	42.6	21	44.7
Indeterminate	13	-	-	4	30.8	-	-	9	69.2
Total	119	1	0.8	16	13.4	46	38.7	56	47.1

4.1.3 Palaeopathological Profile

Palaeopathological data were recorded for all 215 CZP skeletons included in this population survey. However, differential preservation restricted the counts available for each observation location. The following section tabulates the rates of pathological indicators of stress, metabolic bone diseases, and non-specific infection lesions recorded for the CZP.

4.1.3.1 Cribra Orbitalia and Porotic Hyperostosis

There were 137 individuals in the CZP with observable orbits and 49 of those individuals had cribra orbitalia lesions. A total of 82 lesions were observed in the 253 orbits available for observation. The non-adults had a prevalence rate higher than 50%, in contrast to the adults with prevalence rates lower than 32% (Table 4.18). There was a significant difference in the number of individuals with cribra orbitalia ($X^2_{(3)} = 15.855$, p = 0.001), and in the count of orbits affected ($X^2_{(3)} = 23.281$, p < 0.001), across the four broad age categories. The rates observed in the more specific age ranges mirrored the patterns in the age categories. There was also a significant difference in both the count of individuals ($X^2_{(7)} = 25.082$, p < 0.001), and the count of orbits affected ($X^2_{(7)} = 40.980$, p < 0.001), between the eight age ranges.

Table 4.18: Conflict-zone cribra orbitalia prevalence rates by age.

Type	Age	*Individuals Affected*			*Orbits Affected*		
		No.	*CO*	*TPR %*	*No.*	*CO*	*TPR %*
Age Category	Non-adults	37	23	62.2	66	37	56.1
	Young Adults	29	8	27.6	53	13	24.5
	Adults	52	12	23.1	99	22	22.2
	Older Adults	19	6	31.6	35	10	28.6
Age (years)	0 – 2	12	7	58.3	21	12	57.1
	2 – 5	9	6	66.7	16	8	50.0
	5 – 9	12	10	83.3	21	17	81.0
	10 – 14	4	-	-	8	-	-
	15 – 24	29	8	27.6	53	13	24.5
	25 – 34	22	5	22.7	40	9	22.5
	35 – 44	30	7	23.3	59	13	22.0
	45+	19	6	31.6	35	10	28.6
Total		137	49	35.8	253	82	32.4

When the counts of individuals affected were directly compared, the prevalence rate in non-adults was significantly higher than the rates observed in the three adult age categories (Table 4.19).

Table 4.19: Comparison of conflict-zone cribra orbitalia prevalence rates by age category.

Calculation Method	Age	*Non-adults*		*Young Adults*		*Adults*		*Older Adults*	
		$X^2_{(1)}$	*p*	$X^2_{(1)}$	*p*	$X^2_{(1)}$	*p*	$X^2_{(1)}$	*p*
Individuals	Non-adults	-	-	7.803	0.005	13.841	<0.001	4.703	0.030
Affected	Young Adults	7.803	0.005	-	-	0.204	0.652	0.089	0.766
	Adults	13.841	<0.001	0.204	0.652	-	-	0.532	0.466
	Older Adults	4.703	0.030	0.089	0.766	0.532	0.466	-	-
Orbits Affected	Non-adults	-	-	11.997	0.001	19.739	<0.001	6.946	0.008
	Young Adults	11.997	0.001	-	-	0.104	0.748	0.178	0.673
	Adults	19.739	<0.001	0.104	0.748	-	-	0.573	0.449
	Older Adults	6.946	0.008	0.178	0.673	0.573	0.449	-	-

Similarly, when the counts of orbits affected were directly compared, the prevalence rate in non-adults was significantly higher than the rates observed in the three adult age categories.

Direct comparison of the rates of individuals affected across the age ranges identified the rate observed in the children between five to nine years old was significantly higher than the rates recorded for the 10 to 14 year non-adults as well as all of the adults (Table 4.20). Similarly, the rate observed in the children between two and five years old was significantly higher than the rates recorded for the adults in the 25 to 34 years and the 35 to 44 years age ranges.

Table 4.20: Comparison of conflict-zone cribra orbitalia prevalence rates as individuals affected by age

Age (years)	0 – 2 $X^2_{(1)}$	0 – 2 F	2 – 5 $X^2_{(1)}$	2 – 5 F	5 – 9 $X^2_{(1)}$	5 – 9 F	10 – 14 $X^2_{(1)}$	10 – 14 F	15 – 24 $X^2_{(1)}$	15 – 24 F/p	25 – 34 $X^2_{(1)}$	25 – 34 F/p	35 – 44 $X^2_{(1)}$	35 – 44 F/p
0 – 2	-	-	0.151	1.000	1.815	0.371	4.148	0.088	3.459	0.083	4.310	0.062	4.725	0.067
2 – 5	0.151	1.000	-	-	0.788	0.611	4.952	0.070	4.508	0.052	5.387	0.038	5.850	0.039
5 – 9	1.815	0.371	0.788	0.611	-	-	8.889	0.008	10.710	0.002	11.568	0.001	12.808	0.001
10–14	4.148	0.088	4.952	0.070	8.889	0.008	-	-	1.457	0.550	1.126	0.555	1.175	0.559
15–24	3.459	0.083	4.508	0.052	10.710	0.002	1.457	0.550	-	-	0.156	0.693	0.141	0.708
25–34	4.310	0.062	5.387	0.038	11.568	0.001	1.126	0.555	0.156	0.693	-	-	0.003	0.959
35–44	4.725	0.067	5.850	0.039	12.808	0.001	1.175	0.559	0.141	0.708	0.003	0.959	-	-
45+	2.162	0.262	3.070	0.114	7.888	0.009	1.709	0.539	0.089	0.766	0.407	0.524	0.406	0.524

Comparison of the rates calculated as orbits affected highlighted the significantly higher rates recorded in the younger children when compared to the rates observed in the teenagers and adults (Table 4.21). Specifically, the prevalence rates in the infants, from birth to two years, and the children five to nine years, were significantly higher than the rates in the 10 to 14 year old non-adults and all four of the adult age ranges. The rate recorded in the two to five year old non-adults was also significantly higher than the rates in the 10 to 14 year non-adults, and the adults between 25 and 44 years old.

Table 4.21: Comparison of conflict-zone cribra orbitalia prevalence rates as orbits affected by age

Age (years)	0 – 2 $X^2_{(1)}$	0 – 2 F/p	2 – 5 $X^2_{(1)}$	2 – 5 F/p	5 – 9 $X^2_{(1)}$	5 – 9 F/p	10 – 14 $X^2_{(1)}$	10 – 14 F/p	15 – 24 $X^2_{(1)}$	15 – 24 F/p	25 – 34 $X^2_{(1)}$	25 – 34 F/p	35 – 44 $X^2_{(1)}$	35 – 44 F/p
0 – 2	-	-	0.187	0.666	2.785	0.095	7.798	0.009	7.152	0.007	7.321	0.007	8.886	0.003
2 – 5	0.187	0.666	-	-	3.970	0.046	6.000	0.022	3.766	0.067	4.088	0.043	4.883	0.027
5 – 9	2.785	0.095	3.970	0.046	-	-	15.651	<0.001	19.875	<0.001	19.239	<0.001	22.939	<0.001
10–14	7.798	0.009	6.000	0.022	15.651	<0.001	-	-	2.494	0.184	2.215	0.322	2.187	0.338
15–24	7.152	0.007	3.766	0.067	19.875	<0.001	2.494	0.184	-	-	0.052	0.820	0.097	0.755
25–34	7.321	0.007	4.088	0.043	19.239	<0.001	2.215	0.322	0.052	0.820	-	-	0.003	0.956
35–44	8.886	0.003	4.883	0.027	22.939	<0.001	2.187	0.338	0.097	0.755	0.003	0.956	-	-
45+	4.492	0.034	2.208	0.137	14.423	<0.001	2.978	0.165	0.178	0.673	0.364	0.546	0.508	0.476

There were 36 males and 46 females in the CZP adults with orbits present and a total of 152 orbits among them to observe for cribra orbitalia lesions (Table 4.22). There was no significant difference identified in the cribra orbitalia prevalence rates

between the sexes, when calculated as either individuals or orbits affected, in both the overall rates by sex and within the more specific adult age ranges.

Table 4.22: Conflict-zone adult cribra orbitalia prevalence rates by sex and adult age.

Calculation Method	Age (years)	Males			Females			Comparison	
		No.	CO	TPR %	No.	CO	TPR%	$X^2_{(1)}$	F/p
Individuals Affected		36	12	33.3	46	12	26.1	0.512	0.474
	15 – 24	14	5	35.7	9	2	22.2	0.471	0.657
	25 – 34	7	2	28.6	11	3	27.3	0.004	1.000
	35 – 44	11	4	36.4	13	3	23.1	0.509	0.659
	45+	4	1	25.0	13	4	30.8	0.004	1.000
Orbits Affected		67	22	32.8	85	19	22.4	2.090	0.148
	15 – 24	26	8	30.8	16	3	18.8	0.740	0.485
	25 – 34	13	4	30.8	19	5	26.3	0.076	1.000
	35 – 44	21	8	38.1	26	5	19.2	2.066	0.151
	45+	7	2	28.6	24	6	25.0	0.036	1.000

Variability was observed in the cribra orbitalia rates between the four sites comprising the CZP, with The Hirsel individuals noted with the highest prevalence rate of both individuals and orbits affected (Table 4.23). This difference was not statistically significant when prevalence was calculated as individuals affected ($X^2_{(3)}$ = 4.046, p = 0.257). However, there was a significant difference when calculated as orbits affected ($X^2_{(3)}$ = 8.719, p = 0.033).

Table 4.23: Conflict-zone cribra orbitalia prevalence rates by site.

Site	Individuals Affected			Orbits Affected		
	No.	CO	TPR %	No.	CO	TPR %
Auldhame	26	7	26.9	46	13	28.3
Blackfriars Street	30	11	36.7	53	16	30.2
Blackgate	41	12	29.3	79	19	24.1
The Hirsel	40	19	47.5	75	34	45.3
Total	137	49	35.8	253	82	32.4

When the rates for the four sites were individually compared, the prevalence in The Hirsel sample was significantly higher than the rate observed in the Blackgate population (Table 4.24).

Table 4.24: Comparison of conflict-zone cribra orbitalia prevalence rates as orbits affected by site.

Site	Auldhame		Blackfriars Street		Blackgate		The Hirsel	
	$X^2_{(1)}$	p	$X^2_{(1)}$	p	$X^2_{(1)}$	p	$X^2_{(1)}$	p
Auldhame	-	-	0.044	0.834	0.271	0.603	3.498	0.061
Blackfriars Street	0.044	0.834	-	-	0.613	0.434	2.992	0.084
Blackgate	0.271	0.603	0.613	0.434	-	-	7.721	0.005
The Hirsel	3.498	0.061	2.992	0.084	7.721	0.005	-	-

A total of 163 skeletons of the 215 selected from the CZP sites had parietal bones available for observation. A minimum of 293 parietal bones were examined for porotic hyperostosis lesions, but no lesions were observed in these CZP individuals.

4.1.3.2 Enamel Hypoplasia

A total of 162 individuals in the CZP had teeth present. However, four of those individuals did not have tooth enamel present due to dental attrition and post-mortem damage. Therefore, 158 individuals in the CZP were observed for enamel hypoplasia and 108 of those individuals had lesions. A total of 857 lesions were noted on the 2993 teeth available for observation.

The highest prevalence rate was recorded in the teenagers and young adults and the lowest was observed in the young children (Table 4.25). There was a significant difference in the number of individuals with enamel hypoplasia ($X^2_{(3)} = 20.596$, p < 0.001), and in the count of teeth affected ($X^2_{(3)} = 146.981$, p < 0.001), across the four broad age categories. These differences were also significant for both the number of individuals ($X^2_{(7)} = 45.532$, p < 0.001), and teeth affected ($X^2_{(7)} = 228.981$, p < 0.001), between the eight more specific age ranges.

Table 4.25: Conflict-zone enamel hypoplasia prevalence rates by age.

Type	Age	Individuals Affected			Teeth Affected		
		No.	EH	TPR %	No.	EH	TPR %
Age Category	Non-adults	41	19	46.3	573	129	22.5
	Young Adults	36	32	88.9	786	337	42.9
	Adults	60	46	76.7	1294	357	27.6
	Older Adults	21	11	52.4	340	34	10.0
Age (years)	0 – 2	12	-	-	66	-	-
	2 – 5	11	4	36.4	157	6	3.8
	5 – 9	14	11	78.6	267	82	30.7
	10 – 14	4	4	100.0	83	41	49.4
	15 – 24	36	32	88.9	786	337	42.9
	25 – 34	29	21	72.4	607	174	28.7
	35 – 44	31	25	80.6	687	183	26.6
	45+	21	11	52.4	340	34	10.0
Total		158	108	68.4	2993	857	28.6

When the prevalence rate was calculated as a percentage of individuals affected, the young adult and adult age category rates were significantly higher than those observed in the non-adult and older adult individuals (Table 4.26). When the prevalence rate was calculated as a percentage of teeth affected, significant differences were observed in the rates between all four age categories. The rate in the young adults was significantly higher than the rates in the three other age categories. In contrast, the older adult rate was significantly lower than the rates in the other three age categories. The second highest rate, observed in the adults, was also significantly higher than the third highest rate which was recorded in the non-adults.

Table 4.26: Comparison of conflict-zone enamel hypoplasia prevalence rates by age category.

Calculation Method	Age	Non-adults		Young Adults		Adults		Older Adults	
		$X^2_{(1)}$	p	$X^2_{(1)}$	p	$X^2_{(1)}$	P	$X^2_{(1)}$	p
Individuals Affected	Non-adults	-	-	15.516	<0.001	9.764	0.002	0.203	0.652
	Young Adults	15.516	<0.001	-	-	2.206	0.137	9.541	0.002
	Adults	9.764	0.002	2.206	0.137	-	-	4.400	0.036
	Older Adults	0.203	0.652	9.541	0.002	4.400	0.036	-	-
Teeth Affected	Non-adults	-	-	60.983	<0.001	5.314	0.021	22.782	<0.001
	Young Adults	60.983	<0.001	-	-	51.394	<0.001	116.107	<0.001
	Adults	5.314	0.021	51.394	<0.001	-	-	45.761	<0.001
	Older Adults	22.782	<0.001	116.107	<0.001	45.761	<0.001	-	-

Comparison of the rates for individuals affected between the age ranges showed the 0% prevalence in the birth to two year old infants was significantly lower than the rates in the seven other age ranges (Table 4.27, Figure 4.8). The second lowest rate, in the non-adults between two and five years, was also significantly lower than the rates in the five to nine year non-adults, the 15 to 24 year old young adults, and the 35 to 44 year old adults. The prevalence rate in the adults over 45 years was also significantly lower than the rates observed in the 15 to 24 year and 35 to 44 year old adults.

Table 4.27: Comparison of conflict-zone enamel hypoplasia prevalence rates as individuals affected by age range.

Age (years)	0 – 2		2 – 5		5 – 9		10 – 14		15 – 24		25 – 34		35 – 44	
	$X^2_{(1)}$	F/p	$X^2_{(1)}$	F/p	$X^2_{(1)}$	F/p	$X^2_{(1)}$	F/p	$X^2_{(1)}$	F/p	$X^2_{(1)}$	F/p	$X^2_{(1)}$	F/p
0 – 2	-	-	5.282	0.037	16.343	<0.001	16.000	<0.001	32.000	0.001	17.814	<0.001	23.118	<0.001
2 – 5	5.282	0.037	-	-	4.573	0.049	4.773	0.077	12.967	0.001	4.422	0.065	7.449	0.019
5 – 9	16.343	<0.001	4.573	0.049	-	-	1.029	1.000	0.891	0.384	0.188	1.000	0.026	1.000
10–14	16.000	<0.001	4.773	0.077	1.029	1.000	-	-	0.494	1.000	1.457	0.550	0.934	1.000
15–24	32.000	<0.001	12.967	0.001	0.891	0.384	0.494	1.000	-	-	2.896	0.089	0.891	0.495
25–34	17.814	<0.001	4.422	0.065	0.188	1.000	1.457	0.550	2.896	0.089	-	-	0.568	0.451
35–44	23.118	<0.001	7.449	0.019	0.026	1.000	0.934	1.000	0.891	0.495	0.568	0.451	-	-
45+	9.429	0.002	0.744	0.388	2.468	0.116	3.175	0.125	9.541	0.002	2.122	0.145	4.695	0.030
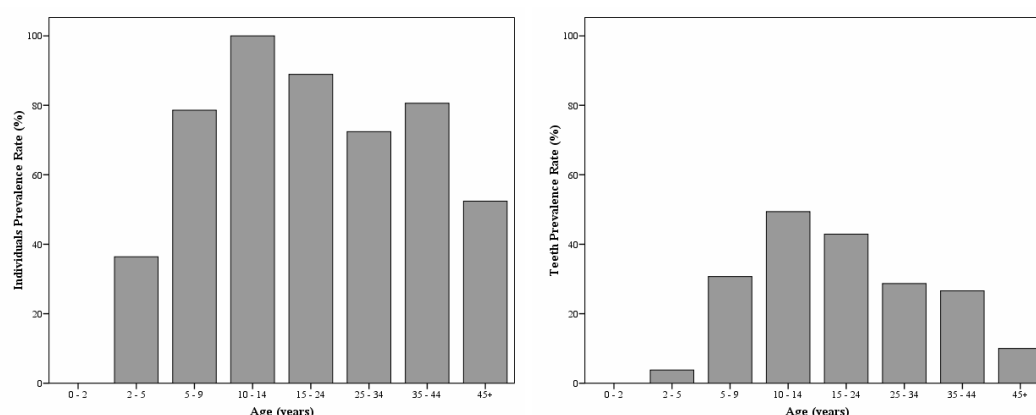
Figure 4.8: Conflict-zone enamel hypoplasia prevalence rates by age range as individuals (left) and teeth affected (right).

Comparison of the rates of teeth affected also revealed significant differences across all age ranges (Table 4.28). The teenagers and young adults between 10 and 24 years had significantly higher prevalence rates than those observed in the three younger non-adult age ranges, and the three older adult age ranges. In contrast, the rates in the children between birth and five years were significantly lower than the rates observed in all other age ranges. The adults over 45 years also had a significantly lower prevalence rate than those noted in the age ranges between five and 44 years.

Table 4.28: Comparison of conflict-zone enamel hypoplasia prevalence rates as teeth affected by age range.

Age (years)	0 – 2 $X^2_{(1)}$	F/p	2 – 5 $X^2_{(1)}$	F/p	5 – 9 $X^2_{(1)}$	p	10 – 14 $X^2_{(1)}$	p	15 – 24 $X^2_{(1)}$	p	25 – 34 $X^2_{(1)}$	p	35 – 44 $X^2_{(1)}$	p
0 – 2	-	-	2.592	0.183	26.892	<0.001	44.979	<0.001	46.815	<0.001	25.516	<0.001	23.225	<0.001
2 – 5	2.592	0.183	-	-	43.465	<0.001	71.615	<0.001	86.241	<0.001	42.750	<0.001	38.280	<0.001
5 – 9	26.892	<0.001	43.465	<0.001	-	-	9.700	0.002	12.308	<0.001	0.375	0.540	1.591	0.207
10–14	44.979	<0.001	71.615	<0.001	9.700	0.002	-	-	1.299	0.254	14.631	<0.001	18.596	<0.001
15–24	46.815	<0.001	86.241	<0.001	12.308	<0.001	1.299	0.254	-	-	29.775	<0.001	42.319	<0.001
25–34	25.516	<0.001	42.750	<0.001	0.375	0.540	14.631	<0.001	29.775	<0.001	-	-	0.663	0.415
35–44	23.225	<0.001	38.280	<0.001	1.591	0.207	18.596	<0.001	42.319	<0.001	0.663	0.415	-	-
45+	7.203	0.007	5.540	0.019	41.502	<0.001	70.990	<0.001	116.107	<0.001	44.299	<0.001	37.778	<0.001

Within the CZP adults, there were 46 males and 49 females observable for enamel hypoplasia lesions (Table 4.29). There was no significant difference in the total prevalence rates between the sexes when calculated as either individuals or teeth affected. However, the females had a significantly higher prevalence of teeth affected in the 15 to 24 year age range while the males had a significantly higher prevalence of teeth affected in the 25 to 34 year age range.

Table 4.29: Conflict-zone adult enamel hypoplasia prevalence rates by sex.

Calculation Method	Age (years)	Males No.	EH	TPR %	Females No.	EH	TPR%	Comparison $X^2_{(1)}$	p
Individuals Affected		46	35	76.1	49	40	81.6	0.439	0.508
	15 – 24	15	15	100.0	11	11	100.0	-	-
	25 – 34	12	8	66.7	12	8	66.7	0.000	1.000
	35 – 44	14	10	71.4	13	12	92.3	1.947	0.326
	45+	5	2	40.0	13	9	69.2	1.298	0.326
Teeth Affected		1001	309	30.9	979	272	27.8	2.273	0.132
	15 – 24	375	151	40.3	233	122	52.4	8.496	0.004
	25 – 34	232	63	27.2	258	49	19.0	4.616	0.032
	35 – 44	318	90	28.3	275	72	26.2	0.334	0.563
	45+	76	5	6.6	213	29	13.6	2.671	0.102

Differences in enamel hypoplasia prevalence rates were observed between the four sites within the CZP (Table 4.30). These differences were statistically significant when calculated both as individuals ($X^2_{(3)} = 28.619$, p < 0.001), and as teeth affected ($X^2_{(3)} = 203.361$, p < 0.001).

Table 4.30: Conflict-zone enamel hypoplasia prevalence rates by site.

	Individuals Affected			Teeth Affected		
Site	No.	EH	TPR %	No.	EH	TPR %
Auldhame	32	26	81.3	665	202	30.4
Blackfriars Street	40	27	67.5	735	180	24.5
Blackgate	44	39	88.6	839	376	44.8
The Hirsel	42	16	38.1	754	99	13.1
Total	158	108	68.4	2993	857	28.6

When calculated as individuals affected, The Hirsel population had a significantly lower prevalence rate than those in the three other CZP sites and the rate in the Blackgate population was significantly higher than the rate in the Blackfriars Street population (Table 4.31). When calculated as teeth affected, significant differences were observed between all four of the CZP site prevalence rates. The Blackgate rate was significantly higher and The Hirsel rate was significantly lower than the rates in the other CZP samples. The Auldhame rate was also significantly higher than the rate recorded for the Blackfriars Street population.

Table 4.31: Comparison of conflict-zone enamel hypoplasia prevalence rates by site.

Calculation Method	Site	Auldhame $X^2_{(1)}$	p	Blackfriars Street $X^2_{(1)}$	p	Blackgate $X^2_{(1)}$	p	The Hirsel $X^2_{(1)}$	p
Individuals	Auldhame	-	-	1.730	0.188	0.817	0.366	13.781	<0.001
Affected	Blackfriars Street	1.730	0.188	-	-	5.560	0.018	7.103	0.008
	Blackgate	0.817	0.366	5.560	0.018	-	-	23.810	<0.001
	The Hirsel	13.781	<0.001	7.103	0.008	23.810	<0.001	-	-
Teeth	Auldhame	-	-	6.097	0.014	32.688	<0.001	62.884	<0.001
Affected	Blackfriars Street	6.097	0.014	-	-	70.845	<0.001	31.543	<0.001
	Blackgate	32.688	<0.001	70.845	<0.001	-	-	190.515	<0.001
	The Hirsel	62.884	<0.001	31.543	<0.001	190.515	<0.001	-	-

4.1.3.3 Non-Specific Infections

A total of 136 individuals of 215 examined from the CZP had observable signs of non-specific infection (63.3%). The highest prevalence rate within the disease category was observed in the maxillary sinuses and the lowest rate was recorded in rib lesions within this population (Table 4.32).

Table 4.32: Conflict-zone non-specific infection rates by type.

Category	No.	Cases	TPR %
Non-Specific Infections	215	136	63.3
Endocranial Lesions	167	29	17.4
Maxillary Sinusitis	117	66	56.4
Rib Lesions	186	13	7.0
Periosteal Lesions	204	92	45.1

The highest prevalence rate was observed in the older adults (Table 4.33). The prevalence rates stayed consistently above 50% throughout the age categories and

there were no significant differences observed ($X^2_{(3)}$ = 1.963, p = 0.580). The same trends were observed in the more specific age ranges with the exception of the 10 to 14 year age range. A decrease in non-specific infection lesions was recorded in this age bracket. Despite this difference in one age range, there were no significant differences observed between the eight ranges ($X^2_{(7)}$ = 12.832, p = 0.076).

Table 4.33: Conflict-zone non-specific infection prevalence rates by age.

Type	Age	No.	Cases	TPR %
Age Category	Non-adults	48	32	66.7
	Young Adults	42	27	64.3
	Adults	94	55	58.5
	Older Adults	31	22	71.0
Age (years)	0 – 2	16	9	56.3
	2 – 5	11	9	81.8
	5 – 9	15	13	86.7
	10 – 14	6	1	16.7
	15 – 24	42	27	64.3
	25 – 34	41	24	58.5
	35 – 44	53	31	58.5
	45+	31	22	71.0
Total		215	136	63.3

Within the 167 adult individuals, a total of 70 males and 68 females were observed for indications of non-specific infections. All of the prevalence rates observed in both sexes were above 45%. There were no significant differences observed in the prevalence rates between the sexes overall or within the more specific age ranges (Table 4.34).

Table 4.34: Conflict-zone adult non-specific infection prevalence rates by sex and age range.

Age (years)	Males			Females			Comparison	
	No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F/p
15 – 24	20	15	75.0	11	7	63.6	0.445	0.683
25 – 34	19	13	68.4	15	8	53.3	0.808	0.369
35 – 44	23	14	60.9	22	12	54.5	0.184	0.668
45+	8	5	62.5	20	14	70.0	0.147	1.000
Total	70	47	67.1	68	41	60.3	0.700	0.403

There was variation within the CZP region in the non-specific infection prevalence rates, with the highest rate recorded in The Hirsel population and the lowest recorded in the Blackgate population (Table 4.35). The differences noted between the four CZP sites were statistically significant ($X^2_{(3)}$ = 15.383, p = 0.002).

Table 4.35: Conflict-zone non-specific infection prevalence rates by site.

Site	No.	Cases	TPR %
Auldhame	52	32	61.5
Blackfriars Street	57	31	54.4
Blackgate	56	30	53.6
The Hirsel	50	43	86.0

Specifically the prevalence rate in The Hirsel population was significantly higher than the rates in the other three CZP sites (Table 4.36).

Table 4.36: Comparison of conflict-zone non-specific infection prevalence rates by site.

Site	Auldhame $X^2_{(1)}$	p	Blackfriars Street $X^2_{(1)}$	p	Blackgate $X^2_{(1)}$	p	The Hirsel $X^2_{(1)}$	p
Auldhame	-	-	0.570	0.450	0.700	0.403	7.836	0.005
Blackfriars Street	0.570	0.450	-	-	0.008	0.931	12.481	<0.001
Blackgate	0.700	0.403	0.008	0.931	-	-	12.956	<0.001
The Hirsel	7.836	0.005	12.481	<0.001	12.956	<0.001	-	-

4.1.3.3.a Endocranial Lesions

A total of 28 individuals of 167 available from the CZP had endocranial surfaces affected by non-specific infectious lesions (16.8%). The prevalence rates ranged within the age categories between 10% and 23%, with the highest rate observed in the non-adults (Table 4.37). These differences in rates were not statistically significant either within the four age categories ($X^2_{(3)} = 3.152$, p = 0.369) or the age ranges ($X^2_{(7)} = 6.571$, p = 0.475).

Table 4.37: Conflict-zone endocranial lesions prevalence rates by age.

Type	Age	No.	Cases	TPR %
Age Category	Non-adults	44	10	22.7
	Young Adults	34	7	20.6
	Adults	65	7	10.8
	Older Adults	24	4	16.7
Age (Years)	0 – 2	14	5	35.7
	2 – 5	11	2	18.2
	5 – 9	15	3	20.0
	10 – 14	4	-	-
	15 – 24	34	7	20.6
	25 – 34	27	3	11.1
	35 – 44	38	4	10.5
	45+	24	4	16.7
Total		167	28	16.8

Within the 123 adult individuals with cranial vaults available in the CZP, a total of 45 males and 53 females were observed for indications of non-specific infections on their endocranial surfaces. There were no significant differences observed between the sexes in the prevalence rates observed, either overall or within the more specific age ranges (Table 4.38).

Table 4.38: Conflict-zone adult endocranial lesions prevalence rates by sex and age range.

Age (years)	Males No.	Cases	TPR %	Females No.	Cases	TPR %	Comparison $X^2_{(1)}$	F/p
15 – 24	14	5	35.7	10	-	-	4.511	0.053
25 – 34	10	1	10.0	12	1	8.3	0.018	1.000
35 – 44	15	1	6.7	16	3	18.8	1.006	0.600
45+	6	-	-	15	3	20.0	1.400	0.526
Total	45	7	15.6	53	7	13.2	0.110	0.741

There was variation in the non-specific infection lesions observed on endocranial surfaces, with the highest rate recorded in the Auldhame population and the lowest recorded in the Blackgate population (Table 4.39). The differences noted between the four CZP sites were statistically significant ($X^2_{(3)} = 10.973$, $p = 0.012$).

Table 4.39: Conflict-zone endocranial lesions prevalence rates by site.

Site	No.	Cases	TPR %
Auldhame	39	10	25.6
Blackfriars Street	43	7	16.3
Blackgate	45	1	2.2
The Hirsel	40	10	25.0

Specifically, the prevalence rate in the Blackgate population was significantly lower than the rates in the other three CZP sites (Table 4.40).

Table 4.40: Comparison of conflict-zone endocranial lesions prevalence rates by site.

Site	Auldhame $X^2_{(1)}$	F/p	Blackfriars Street $X^2_{(1)}$	F/p	Blackgate $X^2_{(1)}$	F/p	The Hirsel $X^2_{(1)}$	F/p
Auldhame	-	-	1.091	0.296	10.069	0.002	0.004	0.948
Blackfriars Street	1.091	0.296	-	-	5.257	0.028	0.968	0.325
Blackgate	10.069	0.002	5.257	0.028	-	-	9.752	0.002
The Hirsel	0.004	0.948	0.968	0.325	9.752	0.002	-	-

4.1.3.3.b Maxillary Sinusitis

A total of 67 individuals of 118 available from the CZP had observable signs of maxillary sinusitis (56.8%). The highest prevalence rate was observed in the adult, although the rates remained between 54% and 59% throughout the age categories (Table 4.41). There was no significant difference observed in the rates between the age categories ($X^2_{(3)} = 0.132$, $p = 0.988$). The prevalence rates observed in the age ranges highlighted more variability by age, specifically in the non-adults. This increased variability within the age ranges, however, was not statistically significant ($X^2_{(7)} = 8.687$, $p = 0.276$).

Table 4.41: Conflict-zone maxillary sinusitis prevalence rates by age.

Type	Age	No.	Cases	TPR %
Age Category	Non-adults	22	12	54.5
	Young Adults	29	16	55.2
	Adults	48	28	58.3
	Older Adults	19	11	57.9
Age (years)	0 – 2	2	1	50.0
	2 – 5	6	5	83.3
	5 – 9	10	6	60.0
	10 – 14	4	-	-
	15 – 24	29	16	55.2
	25 – 34	19	9	47.4
	35 – 44	29	19	65.5
	45+	19	11	57.9
Total		118	67	56.8

Within the 96 adult individuals available, a total of 33 males and 43 females were observed for indications of maxillary sinusitis. There were no significant differences observed in the prevalence rates between the sexes either overall or within the more specific adult age ranges (Table 4.42).

Table 4.42: Conflict-zone adult maxillary sinusitis prevalence rates by sex and age range.

Age (years)	Males			Females			Comparison	
	No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F/p
15 – 24	13	8	61.5	8	5	62.5	0.002	1.000
25 – 34	6	1	16.7	9	6	66.7	3.616	0.119
35 – 44	11	7	63.6	13	9	69.2	0.084	1.000
45+	3	2	66.7	13	7	53.8	0.163	1.000
Total	33	18	54.5	43	27	62.8	0.526	0.468

There was variation within the border region in the maxillary sinusitis prevalence rates observed, with the highest rate recorded in the Auldhame population and the lowest in the Blackgate population (Table 4.43). The differences noted between the four CZP sites were statistically significant ($X^2_{(3)} = 8.477$, p = 0.037).

Table 4.43: Conflict-zone maxillary sinusitis prevalence rates by site.

Site	No.	Cases	TPR %
Auldhame	24	17	70.8
Blackfriars Street	31	19	61.3
Blackgate	39	15	38.5
The Hirsel	24	16	66.7

Specifically, the prevalence rate in the Blackgate population was significantly lower than in the Auldhame and The Hirsel populations (Table 4.44).

Table 4.44: Comparison of conflict-zone maxillary sinusitis prevalence rates by site.

Site	Auldhame		Blackfriars Street		Blackgate		The Hirsel	
	$X^2_{(1)}$	F/p	$X^2_{(1)}$	F/p	$X^2_{(1)}$	F/p	$X^2_{(1)}$	F/p
Auldhame	-	-	0.545	0.460	6.229	0.013	0.097	0.755
Blackfriars Street	0.545	0.460	-	-	3.603	0.058	0.169	0.681
Blackgate	6.229	0.013	3.603	0.058	-	-	4.729	0.030
The Hirsel	0.097	0.755	0.169	0.681	4.729	0.030	-	-

4.1.3.3.c Rib Lesions

A total of 13 individuals of 186 available from the CZP had observable signs of non-specific infection on the ribs (7.0%). The highest prevalence rate of rib lesions was observed in the non-adults, specifically in the infants (Table 4.45). Prevalence rates gradually decreased with age in this population. The differences in rates between the ages, however, were not significant either within the four categories ($X^2_{(3)} = 0.670$, p = 0.880), or the eight age ranges ($X^2_{(7)} = 1.784$, p = 0.971).

Table 4.45: Conflict-zone rib lesions prevalence rates by age.

Type	Age	No.	Cases	TPR %
Age Category	Non-adults	47	4	8.5
	Young Adults	38	3	7.9
	Adults	74	5	6.8
	Older Adults	27	1	3.7
Age (years)	0 – 2	16	2	12.5
	2 – 5	11	1	9.1
	5 – 9	14	1	7.1
	10 – 14	6	-	-
	15 – 24	38	3	7.9
	25 – 34	31	2	6.5
	35 – 44	43	3	7.0
	45+	27	1	3.7
Total		186	13	7.0

Within the 139 adult individuals with ribs available, a total of 60 males and 59 females were observed for indications of non-specific infection on the ribs. The highest prevalence rate was observed in the males between 15 and 24 and between 35 and 44 years (Table 4.46). The slight differences observed between the sexes were not significant in either the overall CZP or in the more specific age rates.

Table 4.46: Conflict-zone adult rib lesions prevalence rates by sex and age.

	Males			Females			Comparison	
Age (years)	No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F/p
15 – 24	19	2	10.5	10	-	-	1.131	0.532
25 – 34	15	1	6.7	12	1	8.3	0.027	1.000
35 – 44	19	2	10.5	19	1	5.3	0.362	1.000
45+	7	-	-	18	1	5.6	0.405	1.000
Total	60	5	8.3	59	3	5.1	0.501	0.717

There was variation within the CZP in the rib lesions prevalence rates observed, with the highest rate recorded in the Auldhame population and the lowest in the Blackgate population (Table 4.47). These differences between the four CZP sites, however, were not statistically significant ($X^2_{(3)}$ = 1.836, p = 0.607).

Table 4.47: Conflict-zone rib lesions prevalence rates by site.

Site	No.	Cases	TPR %
Auldhame	51	5	9.8
Blackfriars Street	38	2	5.3
Blackgate	52	2	3.8
The Hirsel	45	4	8.9

4.1.3.3.d Periosteal Lesions

A total of 95 individuals of 204 available from the CZP had observable signs of periosteal lesions (46.6%). The highest prevalence rate was observed in the non-adults younger than five years of age (Table 4.48). There were no significant

differences observed between either the broad age ranges ($X^2_{(3)}$ = 3.745, p = 0.290), or the eight age ranges ($X^2_{(7)}$ = 9.331, p = 0.230).

Table 4.48: Conflict-zone periosteal lesion prevalence rates by age.

Type	Age	No.	Cases	TPR %
Age Category	Non-adults	46	25	54.3
	Young Adults	39	21	53.8
	Adults	91	36	39.6
	Older Adults	28	13	46.4
Age (years)	0 – 2	16	10	62.5
	2 – 5	11	7	63.6
	5 – 9	14	7	50.0
	10 – 14	5	1	20.0
	15 – 24	39	21	53.8
	25 – 34	39	19	48.7
	35 – 44	52	17	32.7
	45+	28	13	46.4
Total		204	95	46.6

Within the 158 adult individuals, a total of 69 males and 65 females were observed for indications of periosteal lesions. The prevalence rate observed in the males was significantly higher than that observed in the female individuals overall (Table 4.49). This difference was specifically observed in the adults between 15 and 24 years and 35 and 44 years old at the time of their death.

Table 4.49: Conflict-zone adult periosteal lesion prevalence rates by sex and age range.

	Males			Females			Comparison	
Age (years)	No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F/p
15 – 24	20	15	75.0	10	3	30.0	5.625	0.045
25 – 34	19	12	63.2	14	5	35.7	2.431	0.119
35 – 44	23	11	47.8	22	4	18.2	4.447	0.035
45+	7	5	71.4	19	7	36.8	2.462	0.190
Total	69	43	62.3	65	19	29.2	14.740	<0.001

When divided by region of the skeleton affected, the lower leg, consisting of the tibia and fibula, was the most affected region of the body (Table 4.50). Periostiteal lesions were observed on the cranium as the second most common location in the CZP. Of the 19 individuals with lesions observed in the cranium, 16 were described as porosity on the ectocranial surfaces of the parietal and occipital bones indicative of a minor scalp infection (10.8%).

Table 4.50: Conflict-zone periosteal lesion prevalence rates by elements affected.

Elements Affected	No.	Cases	TPR %
Cranium	148	19	12.8
Arm	180	7	3.9
Upper and Lower Leg	174	18	10.3
Lower Leg	145	35	24.1
Throughout the skeleton	204	16	7.8
Total Individuals	204	95	46.6

There was variability within the CZP sites, with the highest rate recorded in the Auldhame population and the lowest recorded in the Blackgate population (Table 4.51). However, these differences were not significant ($X^2_{(3)} = 2.555$, p = 0.465).

Table 4.51: Conflict-zone periosteal lesion prevalence rates by site.

Site	No.	Cases	TPR %
Auldhame	52	27	51.9
Blackfriars Street	48	22	45.8
Blackgate	55	21	38.2
The Hirsel	49	25	51.0

4.1.3.4 Metabolic Bone Disease

A total of 35 individuals, out of 208 available from the CZP, had observable signs of nutritional deficiencies (16.8%). Pathological lesions indicative of vitamin C, vitamin D, and osteoporosis were observed in all of the age ranges and in both males and females. The following section summarises the rates observed in the CZP for specific deficiencies and for metabolic bone disease overall (Table 4.52).

Table 4.52: Conflict-zone metabolic bone disease prevalence rates by category and deficiency.

Type	No.	Cases	TPR %
Metabolic Bone Disease	208	35	16.8
Vitamin C Deficiency	207	13	6.3
Vitamin D Deficiency	205	16	7.8
Osteoporosis	205	5	2.4

The highest prevalence rate of metabolic bone disease overall was observed in the non-adult individuals (Table 4.53). There was a significant difference identified in the rates between the age categories ($X^2_{(3)} = 13.689$, p = 0.003). The same trend and significant difference was noted in the more specific age ranges ($X^2_{(7)} = 20.444$, p = 0.005), where the highest rate was recorded in the infant age range.

Table 4.53: Conflict-zone metabolic bone disease prevalence rates by age.

Type	Age	No.	Cases	TPR %
Age Category	Non-adults	46	16	34.8
	Young Adults	40	5	12.5
	Adults	91	10	11.0
	Older Adults	31	4	12.9
Age (years)	0 – 2	15	7	46.7
	2 – 5	11	4	36.4
	5 – 9	14	5	35.7
	10 – 14	6	-	-
	15 – 24	40	5	12.5
	25 – 34	39	4	10.3
	35 – 44	52	6	11.5
	45+	31	4	12.9
Total		208	35	16.8

Specifically, the overall metabolic bone disease prevalence rate in the non-adult age category was significantly higher than the rates observed in the three adult age categories (Table 4.54).

Table 4.54: Comparison of conflict-zone metabolic bone disease prevalence rates by age categories.

Age Category	Non-adults $X^2_{(1)}$	F/p	Young Adults $X^2_{(1)}$	F/p	Adults $X^2_{(1)}$	F/p	Older Adults $X^2_{(1)}$	F/p
Non-adults	-	-	5.758	0.016	11.250	0.001	4.611	0.032
Young Adults	5.758	0.016	-	-	0.063	0.802	0.003	1.000
Adults	11.250	0.001	0.063	0.802	-	-	0.083	0.751
Older Adults	4.611	0.032	0.003	1.000	0.083	0.751	-	-

When the age ranges were individually compared, the rate in the infants was found to be significantly higher than the rates observed in the older children between 10 and 14 years and in all of the adult age ranges (Table 4.55). Additionally, the rate observed in the children from five to nine years was significantly higher than the rates recorded for the adults between 25 and 44 years.

Table 4.55: Comparison of conflict-zone metabolic bone disease prevalence rates by age ranges.

Age (years)	0 – 2 $X^2_{(1)}$	F	2 – 5 $X^2_{(1)}$	F/p	5 – 9 $X^2_{(1)}$	F/p	10 – 14 $X^2_{(1)}$	F/p	15 – 24 $X^2_{(1)}$	F/p	25 – 34 $X^2_{(1)}$	F/p	35 – 44 $X^2_{(1)}$	F/p
0 – 2	-	-	0.276	0.701	0.358	0.550	4.200	0.040	7.466	0.006	8.854	0.006	9.186	0.002
2 – 5	0.276	0.701	-	-	0.001	1.000	2.853	0.237	3.381	0.087	4.351	0.059	4.190	0.063
5 – 9	0.358	0.550	0.001	1.000	-	-	2.857	0.260	3.704	0.103	4.736	0.044	4.642	0.046
10 – 14	4.200	0.040	2.853	0.237	2.857	0.260	-	-	0.841	1.000	0.675	1.000	0.772	1.000
15 – 24	7.466	0.006	3.381	0.087	3.704	0.103	0.841	1.000	-	-	0.098	1.000	0.020	1.000
25 – 34	8.854	0.006	4.351	0.059	4.736	0.044	0.675	1.000	0.098	1.000	-	-	0.037	1.000
35 – 44	9.186	0.002	4.190	0.063	4.642	0.046	0.772	1.000	0.020	1.000	0.037	1.000	-	-
45+	6.333	0.024	2.898	0.174	3.137	0.111	0.868	1.000	0.003	1.000	0.120	1.000	0.034	1.000

Within the CZP adults, there were 70 males and 66 females available to observe for lesions indicative of metabolic bone disease. There was a significantly higher prevalence rate in the females when compared to the males (Table 4.56). This difference was significant specifically in the 15 to 24 and 35 to 44 years age ranges.

Table 4.56: Conflict-zone adult metabolic bone disease prevalence rates by sex and age range.

Age (years)	Males No.	Cases	TPR%	Females No.	Cases	TPR%	Comparison $X^2_{(1)}$	F/p
15 – 24	20	-	-	10	4	40.0	9.231	0.008
25 – 34	19	3	15.8	14	-	-	2.432	0.244
35 – 44	23	-	-	22	5	22.7	5.881	0.022
45+	8	-	-	20	4	20.0	1.867	0.295
Total	70	3	4.3	66	13	19.7	7.772	0.005

Variability in the metabolic bone disease rates was observed between the four sites within the CZP, with the highest rate recorded in The Hirsel population and the lowest in the Auldhame sample (Table 4.57). However, these differences were not significant ($X^2_{(3)} = 5.030$, p = 0.170).

Table 4.57: Conflict-zone metabolic bone disease prevalence rates by site.

Site	No.	Cases	TPR %
Auldhame	52	4	7.7
Blackfriars Street	50	9	18.0
Blackgate	56	10	17.9
The Hirsel	50	12	24.0

4.1.3.4.a Vitamin C Deficiency

A total of 13 individuals, out of 207 observable from the CZP, had bone changes indicative of vitamin C deficiency (6.3%). All the lesions observed were indicative of scurvy. No lesions indicative of osteopenia were observed in any of the individuals in the CZP.

The highest prevalence rate was observed in the non-adult individuals (Table 4.58). The difference in scurvy rates between the age categories was statistically significant ($X^2_{(3)}$ = 39.730, p < 0.001). The same trend and significant difference was observed in the age ranges ($X^2_{(7)}$ = 63.006, p < 0.001), where the highest rate was specifically observed in the infants between birth and two years of age.

Table 4.58: Conflict-zone vitamin C deficiency prevalence rates by age.

Type	Age	No.	Cases	TPR %
Age Category	Non-adults	46	12	26.1
	Young Adults	41	1	2.4
	Adults	90	-	-
	Older Adults	30	-	-
Age (years)	0 – 2	15	7	46.7
	2 – 5	11	1	9.1
	5 – 9	14	4	28.6
	10 – 14	6	-	-
	15 – 24	41	1	2.4
	25 – 34	39	-	-
	35 – 44	51	-	-
	45+	30	-	-
Total		207	13	6.3

Specifically, the non-adult rate was significantly higher than the rate recorded in the adult individuals (Table 4.59).

Table 4.59: Comparison of conflict-zone vitamin C deficiency prevalence rates by age categories.

Age Category	Non-adults $X^2_{(1)}$	F/p	Young Adults $X^2_{(1)}$	F/p	Adults $X^2_{(1)}$	F/p	Older Adults $X^2_{(1)}$	F/p
Non-adults	-	-	9.538	0.002	25.750	<0.001	9.293	0.002
Young Adults	9.538	0.002	-	-	2.212	0.313	0.742	1.000
Adults	25.750	<0.001	2.212	0.313	-	-	-	-
Older Adults	9.293	0.002	0.742	1.000	-	-	-	-

The rate observed in the infants was significantly higher than those observed in all of the adult age ranges (Table 4.60). The rate observed in the children from five to nine years was also significantly higher than those recorded for all the adults.

Table 4.60: Comparison of conflict-zone vitamin C deficiency prevalence rates between age ranges.

Age (years)	$X^2_{(1)}$ 0–2	F/p	$X^2_{(1)}$ 2–5	F/p	$X^2_{(1)}$ 5–9	F/p	$X^2_{(1)}$ 10–14	F/p	$X^2_{(1)}$ 15–24	F/p	$X^2_{(1)}$ 25–34	F/p	$X^2_{(1)}$ 35–44	F/p
0–2	-	-	4.206	0.084	1.007	0.316	4.200	0.061	17.544	<0.001	20.911	<0.001	26.624	<0.001
2–5	4.206	0.084	-	-	1.461	0.341	0.580	1.000	1.038	0.382	3.618	0.220	4.712	0.177
5–9	1.007	0.316	1.461	0.341	-	-	2.143	0.267	8.624	0.012	12.052	0.003	15.527	0.001
10–14	4.200	0.061	0.580	1.000	2.143	0.267	-	-	0.150	1.000	-	-	-	-
15–24	17.544	<0.001	1.038	0.382	8.624	0.012	0.150	1.000	-	-	0.963	1.000	1.258	0.446
25–34	20.911	<0.001	3.618	0.220	12.052	0.003	-	-	0.963	1.000	-	-	-	-
35–44	26.624	<0.001	4.712	0.177	15.527	0.001	-	-	1.258	0.446	-	-	-	-
45+	16.579	<0.001	2.795	0.268	9.429	0.007	-	-	0.742	1.000	-	-	-	-

Palaeopathological lesions indicative of scurvy were observed in only one adult individual, estimated to have been a possible female, within the CZP. Therefore, a comparison of vitamin C deficiency prevalence rates between the sexed adults was not possible in this population.

There was significant variability in the vitamin C deficiency prevalence rates between the four sites within the CZP ($X^2_{(3)}$ = 11.280, p = 0.010). The highest prevalence rate was recorded in The Hirsel population and the lowest was recorded in the Auldhame population (Table 4.61).

Table 4.61: Conflict-zone vitamin C deficiency prevalence rates by site.

Site	No.	Cases	TPR %
Auldhame	52	1	1.9
Blackfriars Street	49	1	2.0
Blackgate	56	3	5.4
The Hirsel	50	8	16.0

The rate in The Hirsel population was significantly higher than those in both the Auldhame and the Blackfriars Street samples (Table 4.62).

Table 4.62: Statistical comparison of conflict-zone vitamin C deficiency prevalence rates by site.

Site	Auldhame $X^2_{(1)}$	F	Blackfriars Street $X^2_{(1)}$	F	Blackgate $X^2_{(1)}$	F	The Hirsel $X^2_{(1)}$	F
Auldhame	-	-	0.002	1.000	0.892	0.619	6.279	0.015
Blackfriars Street	0.002	1.000	-	-	0.784	0.621	5.835	0.031
Blackgate	0.892	0.619	0.784	0.621	-	-	3.217	0.110
The Hirsel	6.279	0.015	5.835	0.031	3.217	0.110	-	-

4.1.3.4.b Vitamin D Deficiency

A total of 16 individuals of 205 available from the CZP, had pathological lesions indicative of vitamin D deficiency (7.8%). A total of three individuals (1.5%) demonstrated lesions indicative of rickets; 13 individuals (6.3%) possessed lesions indicative of healed or residual rickets, but no individuals from the CZP had lesions indicative of osteomalacia.

The highest prevalence rate of vitamin D deficiency was observed in the young adult age category, specifically between the ages of two and five years (Table

4.63). There were no significant differences identified in the prevalence rates for the deficiency overall ($X^2_{(3)}$ = 0.595, p = 0.898), or in the distribution of healed or residual rickets ($X^2_{(3)}$ = 2.376, p = 0.498), between the four broad age categories. However, there were significantly more non-adults affected by rickets than in the adult age categories ($X^2_{(3)}$ = 10.524, p = 0.015). Again, there were no significant differences observed in the overall prevalence rates of vitamin D deficiency ($X^2_{(7)}$ = 8.239, p = 0.312), or in the rates of healed rickets ($X^2_{(7)}$ = 3.352, p = 0.851), between the eight age ranges. However, the non-adults between two and five years old, diagnosed with active rickets at the time of their deaths, had a significantly higher rate of rickets than those recorded in the other age ranges ($X^2_{(7)}$ = 53.695, p < 0.001).

Table 4.63: Conflict-zone vitamin D deficiency prevalence rates by age.

Type	Age	Vitamin D Deficiency			Rickets			Healed Rickets		
---	---	No.	Cases	TPR %	No.	Cases	TPR %	No.	Cases	TPR %
Age	Non-adults	46	4	8.7	46	3	6.5	46	1	2.2
Category	Young Adults	39	4	10.3	39	-	-	39	4	10.3
	Adults	91	6	6.6	91	-	-	91	6	6.6
	Older Adults	29	2	6.9	29	-	-	29	2	6.9
Age (years)	0 – 2	15	-	-	15	-	-	15	-	-
	2 – 5	11	3	27.3	11	3	27.3	11	-	-
	5 – 9	14	1	7.1	14	-	-	11	1	7.1
	10 – 14	6	-	-	6	-	-	6	-	-
	15 – 24	39	4	10.3	39	-	-	39	4	10.3
	25 – 34	39	3	7.7	39	-	-	39	3	7.7
	35 – 44	52	3	5.8	52	-	-	52	3	5.8
	45+	29	2	6.9	29	-	-	29	2	6.9
Total		205	16	7.8	205	3	1.5	205	13	6.3

Within the CZP adults, there were 69 males and 65 females observed for lesions indicative of vitamin D deficiencies. There were two males and seven females diagnosed with healed or residual rickets. This difference in rate was significantly higher in the females when compared to the males only in the specific 15 to 24 years age range (Table 4.64).

Table 4.64: Conflict-zone adult healed rickets prevalence rates by sex and age range.

Age (years)	Males			Females			Comparison	
	No.	Cases	TPR%	No.	Cases	TPR%	$X^2_{(1)}$	F
15 – 24	20	-	-	10	3	30.0	6.667	0.030
25 – 34	19	2	10.5	14	-	-	1.569	0.496
35 – 44	23	-	-	22	2	9.1	2.188	0.233
45+	7	-	-	19	2	10.5	0.798	1.000
Total	69	2	2.9	65	7	10.8	3.309	0.090

There was variability in the vitamin D deficiency prevalence rates observed between the four sites within the CZP. Specifically, the highest prevalence rate was observed in the Blackfriars Street population and the lowest was recorded in the

Auldhame population (Table 4.65). However, these differences between the CZP samples were not statistically significant for the overall disease category ($X^2_{(3)}$ = 1.148, p = 0.765), for rickets prevalence rates ($X^2_{(3)}$ = 3.742, p = 0.291), or for healed rickets prevalence rates ($X^2_{(3)}$ = 3.137, p = 0.371).

Table 4.65: Conflict-zone vitamin D deficiency prevalence rates by site.

Site	Vitamin D Deficiency			Rickets			Healed Rickets		
	No.	Cases	TPR %	No.	Cases	TPR %	No.	Cases	TPR %
Auldhame	52	3	5.8	52	-	-	52	3	5.8
Blackfriars Street	47	5	10.6	47	-	-	47	5	10.6
Blackgate	56	5	8.9	56	1	1.8	56	4	7.1
The Hirsel	50	3	6.0	50	2	4.0	50	1	2.0

4.1.3.4.c Osteoporosis

A total of five of 205 individuals available from the CZP, demonstrated bone changes consistent with osteoporosis (2.4%). The highest prevalence rate was observed in the older adult individuals (Table 4.66). Despite the differences in count, there was no difference identified in the osteoporosis prevalence rates between the age categories ($X^2_{(3)}$ = 4.828, p = 0.185), or the age ranges in the CZP ($X^2_{(7)}$ = 4.982, p = 0.662).

Table 4.66: Conflict-zone osteoporosis prevalence rates by age.

Type	Age	No.	Cases	TPR %
Age Category	Non-adults	46	-	-
	Young Adults	39	-	-
	Adults	91	3	3.3
	Older Adults	29	2	6.9
Age (years)	0 – 2	15	-	-
	2 – 5	11	-	-
	5 – 9	14	-	-
	10 – 14	6	-	-
	15 – 24	39	-	-
	25 – 34	39	1	2.6
	35 – 44	52	2	3.8
	45+	29	2	6.9
Total		205	5	2.4

Table 4.67: Conflict-zone adult osteoporosis prevalence rates by sex and age range.

Age (years)	Males			Females			Comparison	
	No.	Cases	TPR%	No.	Cases	TPR%	X^2	F
15 – 24	20	-	-	10	-	-	-	-
25 – 34	19	1	5.3	14	-	-	0.760	1.000
35 – 44	23	-	-	22	2	9.1	2.188	0.233
45+	7	-	-	19	2	10.5	0.798	1.000
Total	69	1	1.4	65	4	6.2	2.062	0.198

Within the adults, there were 69 males and 65 females observed for lesions indicative of osteoporosis. Although the lesions were found more frequently in the female individuals, there was no difference observed in the rates between the sexes both overall and within the specific adult age ranges (Table 4.67).

There was variability in the osteoporosis prevalence rates observed between the four CZP sites. Specifically, the highest prevalence rate was observed in the Blackfriars Street population and no evidence was observed in the Auldhame population (Table 4.68). However, these differences between the four sites were not statistically significant ($X^2_{(3)}$ = 2.294, p = 0.514).

Table 4.68: Conflict-zone osteoporosis prevalence rates by site.

Site	No.	Cases	TPR %
Auldhame	52	-	-
Blackfriars Street	47	2	4.3
Blackgate	56	2	3.6
The Hirsel	50	1	2.0

4.1.3.5 Caries Lesions

Of the 162 individuals in the CZP with teeth present, caries lesions were observed in a total of 62 of those individuals. A total of 175 lesions were observed affecting 155 teeth out of the 3017 teeth present. There was an average of 2.50 lesions per individual in the population. The highest prevalence rate of both individuals and teeth affected was in the adults; specifically those between 25 and 34 years old (Table 4.69). There was a significant difference in the number of individuals with caries between age categories ($X^2_{(3)}$ = 17.302, p = 0.001). However, there was not a significant difference in the count of teeth affected ($X^2_{(3)}$ = 7.467, p = 0.058). There was a significant difference in both the count of individuals ($X^2_{(7)}$ = 20.066, p = 0.001), and teeth affected ($X^2_{(7)}$ = 13.685, p = 0.006), within the eight age ranges.

Table 4.69: Conflict-zone caries lesions prevalence rates by age.

Type	Age	Individuals Affected			Teeth Affected		
		No.	CL	TPR %	No.	CL	TPR %
Age Category	Non-adults	43	6	14.0	587	19	3.2
	Young Adults	36	14	38.9	786	37	4.7
	Adults	61	33	54.1	1303	80	6.1
	Older Adults	22	9	40.9	341	19	5.6
Age (years)	0 – 2	14	-	-	80	-	-
	2 – 5	11	1	9.1	157	2	1.3
	5 – 9	14	4	28.6	267	15	5.6
	10 – 14	4	1	25.0	83	2	2.4
	15 – 24	36	14	38.9	786	37	4.7
	25 – 34	29	16	55.2	607	38	6.3
	35 – 44	32	17	53.1	696	42	6.0
	45+	22	9	40.9	341	19	5.6
Total		162	62	38.3	3017	155	5.1

When the prevalence rate was calculated as a percentage of individuals affected by caries lesions, the prevalence rate in the non-adult age category was

significantly lower than the rate in all three adult categories (Table 4.70). There were no significant differences observed within the three adult age categories.

Table 4.70: Comparison of conflict-zone caries lesions prevalence rates as individuals affected by age category.

Age Category	Non-adults $X^2_{(1)}$	p	Young Adults $X^2_{(1)}$	p	Adults $X^2_{(1)}$	p	Older Adults $X^2_{(1)}$	p
Non-adults	-	-	6.444	0.011	17.343	<0.001	5.957	0.015
Young Adults	6.444	0.011	-	-	2.097	0.148	0.023	0.879
Adults	17.343	<0.001	2.097	0.148	-	-	1.125	0.289
Older Adults	5.957	0.015	0.023	0.879	1.125	0.289	-	-

The prevalence rate of individuals affected differed specifically between the youngest non-adults and the adults (Table 4.71). The rates in all of the adults were significantly higher than the 0% rate recorded for the infants. The rates in the adults between 15 and 44 years were also significantly higher than the 9.1% recorded for the children from two to five years old.

Table 4.71: Comparison of conflict-zone caries lesions prevalence rates as individuals affected by age.

Age (years)	0 – 2 $X^2_{(1)}$	F/p	2 – 5 $X^2_{(1)}$	F	5 – 9 $X^2_{(1)}$	F	10 – 14 $X^2_{(1)}$	F	15 – 24 $X^2_{(1)}$	F/p	25 – 34 $X^2_{(1)}$	F/p	35 – 44 $X^2_{(1)}$	F/p
0 – 2	-	-	1.326	0.440	4.667	0.098	3.706	0.222	7.562	0.005	12.301	<0.001	11.797	0.001
2 – 5	1.326	0.440	-	-	1.461	0.341	0.642	0.476	3.443	0.078	6.930	0.012	6.522	0.014
5 – 9	4.667	0.098	1.461	0.341	-	-	0.020	1.000	0.466	0.495	2.686	0.101	2.366	0.199
10–14	3.706	0.222	0.642	0.476	0.020	1.000	-	-	0.296	1.000	1.281	0.335	1.125	0.603
15–24	7.562	0.005	3.443	0.078	0.466	0.495	0.296	1.000	-	-	1.714	0.191	1.384	0.239
25–34	12.301	<0.001	6.930	0.012	2.686	0.101	1.281	0.335	1.714	0.191	-	-	0.026	0.873
35–44	11.797	0.001	6.522	0.014	2.366	0.199	1.125	0.603	1.384	0.239	0.026	0.873	-	-
45+	7.636	0.006	3.515	0.109	0.564	0.452	0.362	1.000	0.023	0.879	1.018	0.313	0.779	0.377

Similarly, the prevalence rates of teeth affected in the children from birth to five years were significantly lower than the rates in the children from five to nine years old and all the adult prevalence rates (Table 4.72).

Table 4.72: Comparison of conflict-zone caries lesions prevalence rates as teeth affected by age.

Age (years)	0 – 2 $X^2_{(1)}$	F	2 – 5 $X^2_{(1)}$	F/p	5 – 9 $X^2_{(1)}$	F/p	10 – 14 $X^2_{(1)}$	F/p	15 – 24 $X^2_{(1)}$	F/p	25 – 34 $X^2_{(1)}$	F/p	35 – 44 $X^2_{(1)}$	F/p
0 – 2	-	-	1.028	0.551	4.697	0.027	1.952	0.497	3.934	0.041	5.301	0.016	5.104	0.016
2 – 5	1.028	0.551	-	-	4.848	0.028	0.427	0.610	3.891	0.049	6.251	0.012	5.934	0.015
5 – 9	4.697	0.027	4.848	0.028	-	-	1.410	0.380	0.352	0.553	0.134	0.714	0.060	0.806
10–14	1.952	0.497	0.427	0.610	1.410	0.380	-	-	0.925	0.573	1.982	0.212	1.828	0.216
15–24	3.934	0.041	3.891	0.049	0.352	0.553	0.925	0.573	-	-	1.621	0.203	1.288	0.256
25–34	5.301	0.016	6.251	0.012	0.134	0.714	1.982	0.212	1.621	0.203	-	-	0.029	0.865
35–44	5.104	0.016	5.934	0.015	0.060	0.806	1.828	0.216	1.288	0.256	0.029	0.865	-	-
45+	4.668	0.032	4.917	0.027	0.001	0.980	1.418	0.395	0.376	0.540	0.183	0.669	0.088	0.766

Within the adults, there were 46 males and 51 females with teeth available to observe for caries lesions (Table 4.73). The female rate of caries lesions was significantly higher in the 35 to 44 year adults than the male rates in the same age range for both individuals and teeth affected. The female rate overall was also significantly higher when calculated as teeth affected.

Table 4.73: Conflict-zone adult caries lesions prevalence rates by sex and age.

Calculation Method	Age (years)	Males No.	Males CL	Males TPR%	Females No.	Females CL	Females TPR%	Comparison $X^2_{(1)}$	F/p
Individuals Affected		46	10	41.3	51	27	52.9	1.314	0.252
	15 – 24	15	6	40.0	11	5	45.5	0.077	0.781
	25 – 34	12	6	50.0	12	7	58.3	0.168	0.682
	35 – 44	14	4	28.6	14	10	71.4	5.143	0.023
	45+	5	3	60.0	14	5	35.7	0.891	0.603
Teeth Affected		1001	45	4.5	989	66	6.7	4.480	0.034
	15 – 24	375	19	5.1	233	14	6.0	0.248	0.618
	25 – 34	232	11	4.7	258	16	6.2	0.500	0.479
	35 – 44	318	9	2.8	284	24	8.5	9.147	0.002
	45+	76	6	7.9	214	12	5.6	0.504	0.478

Significant differences in caries lesion rates were observed between the four sites within the CZP when calculated both as individuals ($X^2_{(3)}$ = 9.125, p = 0.028), and as teeth affected ($X^2_{(3)}$ = 29.920, p < 0.001) (Table 4.74).

Table 4.74: Conflict-zone caries lesions prevalence rates by site.

Site	Individuals Affected No.	Individuals Affected CL	Individuals Affected TPR %	Teeth Affected No.	Teeth Affected CL	Teeth Affected TPR %
Auldhame	35	15	42.9	688	56	8.1
Blackfriars Street	40	22	55.0	735	49	6.7
Blackgate	45	11	24.4	840	23	2.7
The Hirsel	42	14	33.3	754	27	3.6
Total	162	62	38.3	3017	155	5.1

Direct comparison of the prevalence rates of individuals affected demonstrated that the Blackfriars Street sample had a significantly higher rate than the Blackgate and The Hirsel populations (Table 4.75). Comparison of the rates when calculated as teeth affected identified both the Auldhame and Blackfriars Street rates as significantly higher than the rates in the Blackgate and The Hirsel populations.

Table 4.75: Comparison of conflict-zone caries lesions prevalence rates as individuals affected by site.

Calculation Method	Site	Auldhame $X^2_{(1)}$	Auldhame p	Blackfriars Street $X^2_{(1)}$	Blackfriars Street p	Blackgate $X^2_{(1)}$	Blackgate p	The Hirsel $X^2_{(1)}$	The Hirsel p
Individuals	Auldhame	-	-	1.101	0.294	3.043	0.096	0.738	0.390
Affected	Blackfriars Street	1.101	0.294	-	-	8.324	0.004	3.905	0.048
	Blackgate	3.043	0.096	8.324	0.004	-	-	0.838	0.360
	The Hirsel	0.738	0.390	3.905	0.048	0.838	0.360	-	-
Teeth	Auldhame	-	-	1.128	0.288	22.507	<0.001	13.782	<0.001
Affected	Blackfriars Street	1.128	0.288	-	-	13.868	<0.001	7.317	0.007
	Blackgate	22.507	<0.001	13.868	<0.001	-	-	0.929	0.335
	The Hirsel	13.782	<0.001	7.317	0.007	0.929	0.335	-	-

4.2 Neighbours Population

Data from the skeletal populations of Fishergate House, the Franciscan Friary, Parliament House, and Whithorn were combined to describe health and disease patterns in populations adjacent to the Medieval Anglo-Scottish border. Of the 2055

individuals excavated from the neighbouring cemeteries, 173 skeletons were analysed for this study. A composite population profile for the NP as a whole is presented in the following section.

4.2.1 Preservation

The most skeletons analysed in the NP were less than 25% complete at the time of their analysis (Table 4.76). The majority of the remaining skeletons were described as in a good state of completeness.

Table 4.76: Neighbours skeletal preservation.

Preservation	Skeletal Completeness	No.	%
Excellent	> 75%	30	17.3
Good	25% - 75%	66	38.2
Poor	< 25%	77	44.5

The majority of the poorly preserved skeletons were observed in the young adult and adult broad age categories (Table 4.77, Figure 4.9). In contrast, the highest count of individuals described as in a good state of preservation was in the non-adult age category. The observed differences in preservation were statistically significant both between the age categories ($X^2_{(6)} = 23.252$, p = 0.001), and the eight age ranges ($X^2_{(14)} = 33.672$, p = 0.002).

Table 4.77: Neighbours preservation by age.

Type	Age	No.	Cases	TPR %
Age Category	Non-adults	7	17.1	27
	Young Adults	6	16.2	7
	Adults	13	17.1	26
	Older Adults	4	21.1	6
Age (years)	0 – 2	4	36.4	7
	2 – 5	-	-	6
	5 – 9	2	14.3	10
	10 – 14	1	16.7	4
	15 – 24	6	16.2	7
	25 – 34	5	10.9	19
	35 – 44	8	26.7	7
	45+	4	21.1	6
Total		30	17.3	66
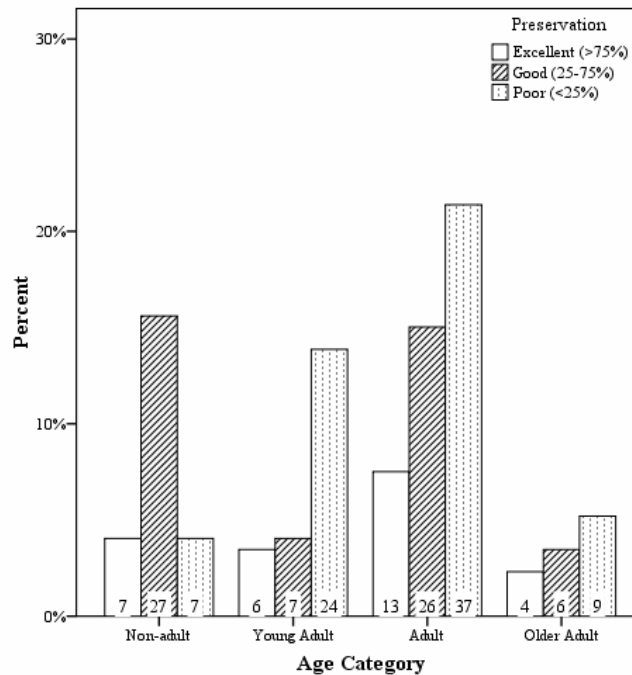
Figure 4.9: Neighbours preservation by age category.

This difference in preservation in the NP was statistically significant between the non-adult and adult age groups ($X^2_{(2)}$ = 19.900, p < 0.001). Specifically, the rates observed in the non-adult age category were significantly lower than the rates observed in all three adult broad age categories (Table 4.78). There were no significant differences observed in preservation between the adult age categories.

Table 4.78: Comparison of preservation between neighbours age categories.

Age Category	Non-adults $X^2_{(2)}$	p	Young Adults $X^2_{(2)}$	p	Adults $X^2_{(2)}$	p	Older Adults $X^2_{(2)}$	p
Non-adults	-	-	21.014	<0.001	12.963	0.002	7.354	0.025
Young Adults	21.014	<0.001	-	-	3.211	0.201	1.683	0.431
Adults	12.963	0.002	3.211	0.201	-	-	0.169	0.919
Older Adults	7.354	0.025	1.683	0.431	0.169	0.919	-	-

There was no statistically significant difference in preservation observed within the four adult age ranges ($X^2_{(6)}$ = 8.144, p = 0.228). In contrast, there was a statistically significant difference observed within the non-adult age ranges ($X^2_{(6)}$ = 9.317, p = 0.157). When the rates in all of the age ranges were directly compared on an individual basis, the infants between the ages of birth and two years were significantly better preserved than the toddlers, between the ages of two and five years (Table 4.79). No other significant differences were observed in the preservation rates between the three older non-adult age ranges. Additionally, the infants were significantly better preserved than all of the adults observed in the NP. The children

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between five and nine years old were also significantly better preserved than the adults in the 35 to 44 year age range. Finally, the adults between 15 and 24 years were in a significantly poorer state of preservation than all of the non-adults observed.

Table 4.79: Comparison of neighbours preservation by age.

Age (years)	$X^2_{(2)}$ 0 – 2	p	$X^2_{(2)}$ 2 – 5	p	$X^2_{(2)}$ 5 – 9	p	$X^2_{(2)}$ 10 – 14	p	$X^2_{(2)}$ 15 – 24	p	$X^2_{(2)}$ 25 – 34	p	$X^2_{(2)}$ 35 – 44	p
0–2	-	-	8.048	0.018	2.878	0.237	2.351	0.309	14.600	0.001	9.886	0.007	9.587	0.008
2–5	8.048	0.018	-	-	3.086	0.214	2.347	0.309	7.242	0.027	1.838	0.399	5.927	0.052
5–9	2.878	0.237	3.086	0.214	-	-	0.045	0.978	13.522	0.001	5.141	0.076	9.510	0.009
10–14	2.351	0.309	2.347	0.309	0.045	0.978	-	-	6.665	0.036	2.092	0.351	4.523	0.104
15–24	14.600	0.001	7.242	0.027	13.522	0.001	6.665	0.036	-	-	4.797	0.091	1.649	0.438
25–34	9.886	0.007	1.838	0.399	5.141	0.076	2.092	0.351	4.797	0.091	-	-	4.381	0.112
35–44	9.587	0.008	5.927	0.052	9.510	0.009	4.523	0.104	1.649	0.438	4.381	0.112	-	-
45+	7.475	0.024	3.464	0.177	5.490	0.064	2.522	0.283	1.683	0.431	1.338	0.512	0.464	0.793

There were 132 adult skeletons analysed in the NP; of which 84 were estimated as either male, possibly male, female, or possibly female. While the highest count of both males and females were described as in a good state of preservation, the male individuals were more or less evenly distributed throughout the preservation categories, while the majority of females were described as good or poorly preserved (Table 4.80, Figure 4.10). Despite these differences in distribution, there was no significant difference observed between the males and females in there skeletal preservation ($X^2_{(2)} = 0.963$, p = 0.618).

Table 4.80: Neighbours adult preservation by sex.

Sex	Excellent No.	%	Good No.	%	Poor No.	%	Total No.	%
Males	11	27.5	16	40.0	13	32.5	40	30.3
Females	9	18.8	21	43.8	18	37.5	48	36.4
Indeterminate	3	6.8	2	4.5	39	88.6	44	33.3
Total	23	17.4	39	29.5	70	53.0	132	100.0

In contrast, the adults of indeterminate sex were poorly preserved. There was a statistically significant difference observed in preservation within the three sex categories in the NP ($X^2_{(4)} = 35.166$, p < 0.001). Both the males ($X^2_{(2)} = 28.334$, p < 0.001), and the females ($X^2_{(2)} = 26.308$, p < 0.001), were significantly better preserved than the NP adults of indeterminate sex.
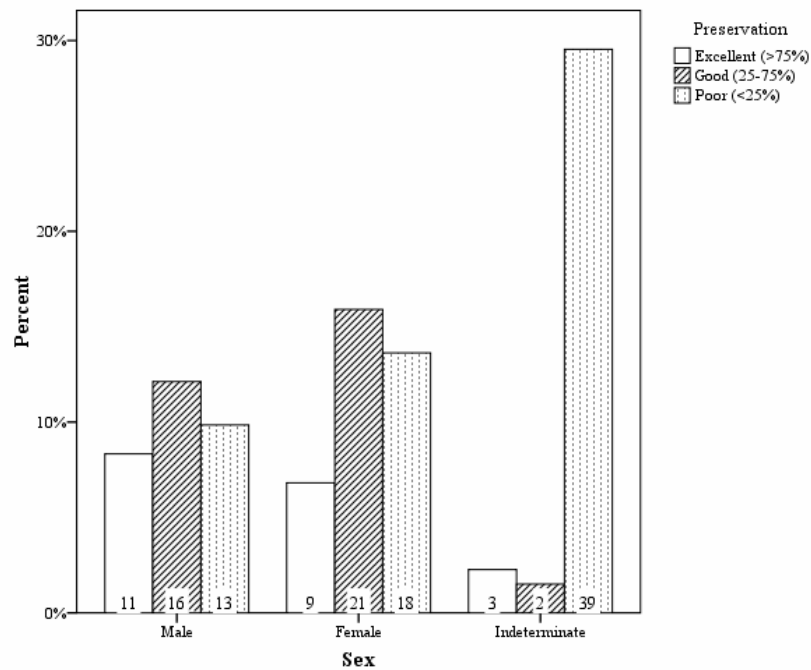
Figure 4.10: Neighbours adult preservation by sex.

A significant difference was observed in the overall distribution of individuals through the preservation categories between the four NP sites ($X^2_{(6)} = 47.627$, p < 0.001). The significant differences were observed in the counts of individuals across all three preservation categories between the four sites (Table 4.81, Figure 4.11). The Whithorn population had significantly more poorly preserved individuals and significantly fewer individuals in the good preservation category than the other three NP sites. There were also significantly fewer excellently preserved individuals in the Parliament House and Whithorn populations than in the Fishergate House and Franciscan Friary populations.

Table 4.81: Neighbours preservation distribution by site

| Preservation | Fishergate House | | Franciscan Friary | | Parliament House | | Whithorn | | Comparison | |
	No.	%	No.	%	No.	%	No.	%	$X^2_{(3)}$	p
Excellent	17	34.0	5	25.0	5	9.8	3	5.8	16.400	0.001
Good	23	46.0	7	35.0	28	54.9	8	15.4	20.424	<0.001
Poor	10	20.0	8	40.0	18	35.3	41	78.8	35.675	<0.001
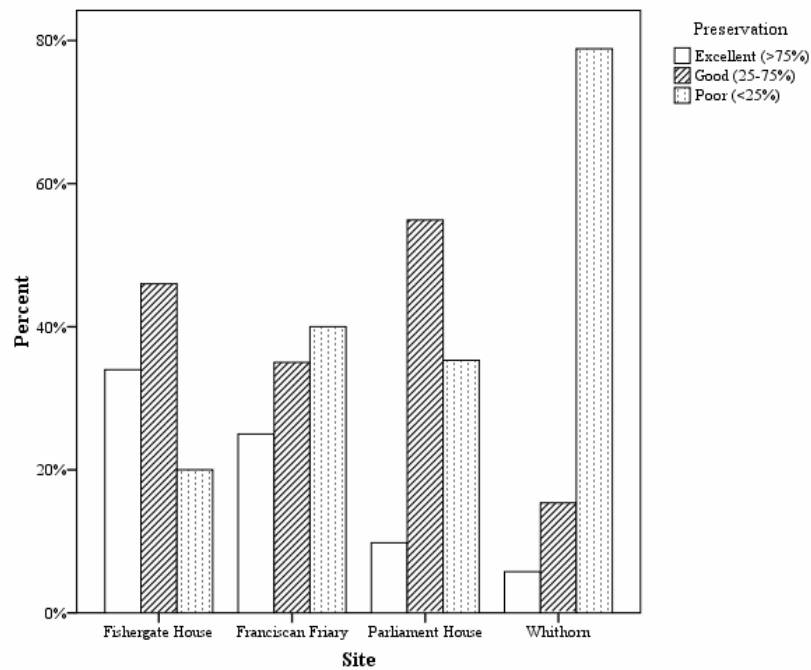
Figure 4.11: Neighbours preservation by site.

4.2.2 Demographic Profile

The overall poor preservation of the NP skeletons did not allow for skeletal analysis of the indicators of sex, age, and body shape at the same level as in the CZP. However, all sex and age categories were observed within the 173 NP skeletons. It was also possible to apply body shape estimation methods to both adult and non-adult individuals from this population. The following section summarises the results of the demographic analysis of the NP.

4.2.2.1 Sex

A total of 132 adults were analyzed from the NP, of which 40 were identified as male or possible male, 48 were identified female or possible female and 44 were of indeterminate sex (Table 4.82, Figure 4.12). There was a significant difference in the distribution of the adult individuals within the five categories of sex estimation ($X^2_{(4)}$ = 16.788, p = 0.002). When the male/possible male and female/possible female categories were combined into simple male and female categories, the sex distribution produced a ratio of 1.20:1 in favour of females. There was no significant difference observed between the number of males and females in the NP ($X^2_{(1)}$ = 0.727, p = 0.394). However, when the sex distribution of the adults included the indeterminate

adults, with an expected ratio of 2:1:2 for males to indeterminate adults to females, there was a significant difference in the sex distribution from the expectation ($X^2_{(2)}$ = 15.273, p < 0.001). There were significantly more adults of indeterminate sex than expected compared to both the males ($X^2_{(1)}$ = 13.714, p < 0.001) and females ($X^2_{(1)}$ = 8.696, p = 0.003).

Table 4.82: Neighbours adult sex distribution.

Type	Sex	No.	%
Sex	Male	24	18.2
	Possible Male	16	12.1
	Indeterminate	44	33.3
	Possible Female	22	16.7
	Female	26	19.7
Simplified Sex	Male	40	30.3
	Female	48	36.4
	Indeterminate	44	33.3
Total		132	100
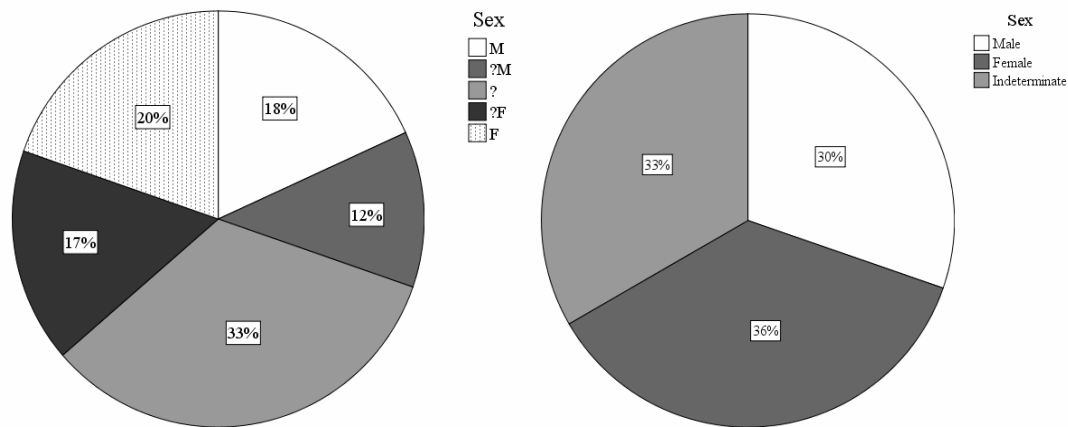
Figure 4.12: Neighbours adult sex distribution.

A significant difference was observed in the overall distribution of individuals through the simplified sex categories between the four NP sites ($X^2_{(6)}$ = 27.235, p < 0.001). There were significantly more individuals of indeterminate sex in the Whithorn population than in the three other NP sites (Table 4.83).

Table 4.83: Neighbours sex distribution by site.

Sex	Fishergate House No.	%	Franciscan Friary No.	%	Parliament House No.	%	Whithorn No.	%	Comparison $X^2_{(3)}$	p
Male	14	38.9	5	26.3	11	34.4	10	22.2	4.200	0.241
Female	12	33.3	11	57.9	17	53.1	8	17.8	3.500	0.321
Indeterminate	10	27.8	3	15.8	4	12.5	27	60.0	33.636	<0.001

4.2.2.2 Age at Death

Of the 173 skeletons examined from the NP, 132 (76.3%) were identified as adults and 41 (23.7%) were non-adults under the age of 15 years (Table 4.85). The age at death rates for the population remained consistent throughout the early non-adult age ranges, then slightly increased in the non-adults between five and nine years old (Figure 4.84). The adult mortality rates increased sharply in the early years of adulthood and peaked in the 25 to 34 year age range at 27% with a decline observed in the older adult age ranges.

Table 4.84: Neighbours age-at-death distribution by age and sex.

		Total		Male		Female		Indeterminate	
Type	*Age*	*No.*	*%*	*No.*	*%*	*No*	*%*	*No.*	*%*
Age Category	Non-adult	41	23.7	-	-	-	-	-	-
	Young Adult	37	21.4	8	20.0	11	22.9	18	48.6
	Adult	76	43.9	27	67.5	27	56.3	22	28.9
	Older Adult	19	11.0	5	12.5	10	20.8	4	21.1
Age (years)	0 – 2	11	6.4	-	-	-	-	-	-
	2 – 5	10	5.8	-	-	-	-	-	-
	5 – 9	14	8.1	-	-	-	-	-	-
	10 – 14	6	3.5	-	-	-	-	-	-
	15 – 24	37	21.4	8	20.0	11	22.9	18	40.9
	25 – 34	46	26.6	18	45.0	15	31.3	13	29.5
	35 – 44	30	17.3	9	22.5	12	25.0	9	20.5
	45+	19	11.0	5	12.5	10	20.8	4	9.1
Total		173	100	40	23.1	48	27.7	44	25.4
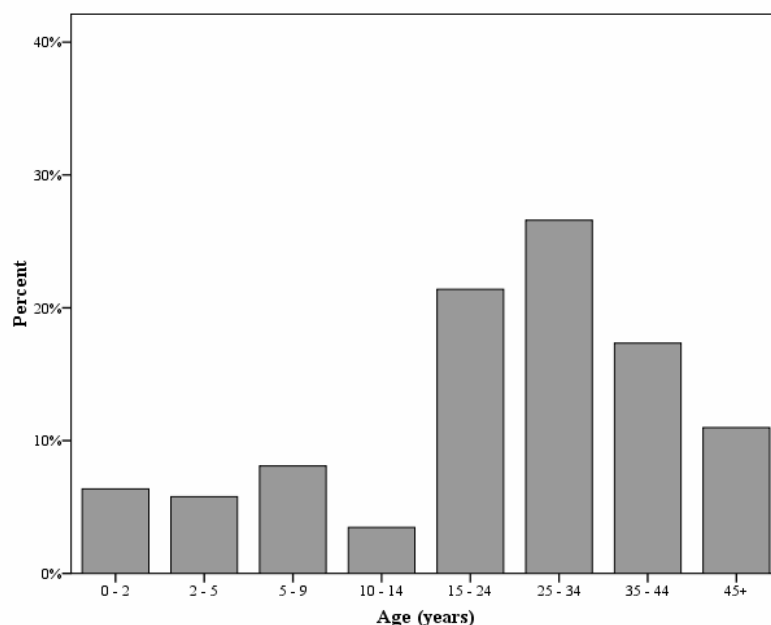
Figure 4.13: Neighbours age-at-death by range.

The life expectancy at birth (e_0) for the NP was 26.60 years (Table 4.85). The mean age at death was 25.26 years and the maximum estimated age was 63 years.

Table 4.85: Neighbours life table.

x	l_x	d_x	q_x	L_x	T_x	e_x
0	1.00	0.11	0.11	4.73	26.60	26.60
5	0.89	0.09	0.10	4.23	21.88	24.58
10	0.80	0.03	0.04	3.90	17.65	22.06
15	0.76	0.08	0.11	3.60	13.75	18.09
20	0.68	0.13	0.19	3.08	10.15	14.93
25	0.55	0.07	0.13	2.58	7.08	12.86
30	0.48	0.20	0.41	1.90	4.50	9.38
35	0.28	0.08	0.27	1.23	2.60	9.29
40	0.21	0.11	0.50	0.78	1.38	6.55
45	0.10	0.07	0.72	0.33	0.60	6.00
50	0.03	0.01	0.40	0.13	0.28	9.17
55	0.02	0.00	0.00	0.10	0.15	7.50
60	0.02	0.02	1.00	0.05	0.05	2.50
65	0.00	0.00	0.00	0.00	0.00	0.00

The male and female adults from the combined NP demonstrated different mortality profiles (Table 4.86, Figure 4.14). The life expectancy for males (N = 40) that reached puberty (e_{15}) was 33.45 years and for females (N = 48) was 34.80 years. The difference in life expectancy between the sexes was not statistically significant (p = 0.705).

Table 4.86: Neighbours life table for adults by sex.

Sex	x	l_x	d_x	q_x	L_x	T_x	e_x
Males	15	1.00	0.10	0.10	4.75	18.45	18.45
	20	0.90	0.10	0.11	4.25	13.70	15.22
	25	0.80	0.13	0.16	3.70	9.45	11.81
	30	0.68	0.33	0.48	2.58	5.75	8.46
	35	0.35	0.07	0.21	1.58	3.18	9.07
	40	0.28	0.15	0.55	1.03	1.60	5.71
	45	0.13	0.08	0.60	0.45	0.58	4.42
	50	0.05	0.05	1.00	0.13	0.13	2.50
	55	0.00	0.00	0.00	0.00	0.00	0.00
Females	15	1.00	0.08	0.08	4.80	19.80	19.80
	20	0.92	0.15	0.16	4.23	15.00	16.30
	25	0.77	0.15	0.19	3.50	10.78	13.99
	30	0.63	0.17	0.27	2.73	7.28	11.55
	35	0.46	0.11	0.23	2.03	4.55	9.89
	40	0.35	0.14	0.41	1.40	2.53	7.21
	45	0.21	0.17	0.80	0.63	1.13	5.36
	50	0.04	0.00	0.00	0.20	0.50	12.50
	55	0.04	0.00	0.00	0.20	0.30	7.50
	60	0.04	0.04	1.00	0.10	0.10	2.50
	65	0.00	0.00	0.00	0.00	0.00	0.00
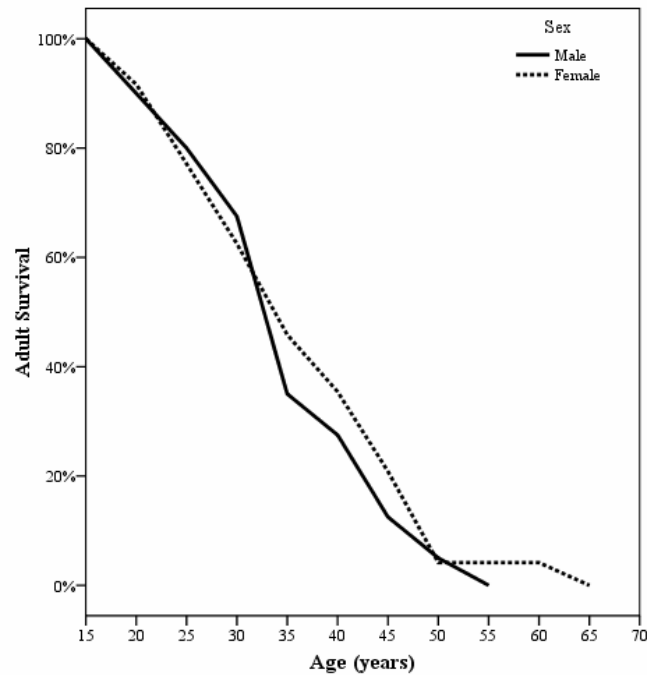
Figure 4.14: Neighbours adult mortality as a percentage of survival by sex.

4.2.2.3 Body Shape

Despite the poor preservation of the NP skeletons, body shape estimations were possible for the majority of individuals observed. The following section summarises the estimated stature, body mass, and platymeric and platycnemic indices for the combined population.

4.2.2.3.a Stature

It was possible to estimate stature for 77 adults from the NP. Sex estimation was possible for 62 individuals which allowed mean stature to be determined for each sex (Table 4.87). The average male stature was significantly taller than the average female stature in the NP ($t = -6.704$, $p < 0.001$).

Table 4.87: Neighbours adult stature estimates.

Sex	No.	Mean (cm)	S.D. (cm)	Min. (cm)	Max. (cm)
Males	31	169.14	5.02	160.66	178.66
Females	31	159.43	6.31	145.01	170.11
Indeterminate	15	164.85	9.22	145.48	183.45

A total of 22 non-adults in the NP were preserved well enough to allow stature estimations to be calculated (Table 4.88). Stature gradually increased with age, although there was a noticeable decrease in the mean during the seven to eight year

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age category (Figure 4.15). Non-adult stature in this population could be estimated by mean age at death with the equation: Stature = 6.804(Age) + 65.774

Table 4.88: Neighbours non-adult stature estimates by mean estimated age-at-death.

Age (years)	No.	Mean (cm)	S.D. (cm)	Min. (cm)	Max. (cm)
0.00	2	55.95	0.37	55.69	56.21
2.50	2	83.25	4.14	80.32	86.17
3.00	2	92.23	4.83	88.81	95.64
3.50	1	87.10	-	-	-
5.00	2	107.41	18.16	94.57	120.25
5.50	1	100.31	-	-	-
6.00	1	122.87	-	-	-
7.00	2	121.28	5.41	117.45	125.10
7.50	2	105.28	1.91	103.93	106.63
8.00	1	108.40	-	-	-
9.00	2	120.74	1.05	119.99	121.48
10.00	3	144.43	5.19	138.56	148.42
12.00	1	127.72	-	-	-
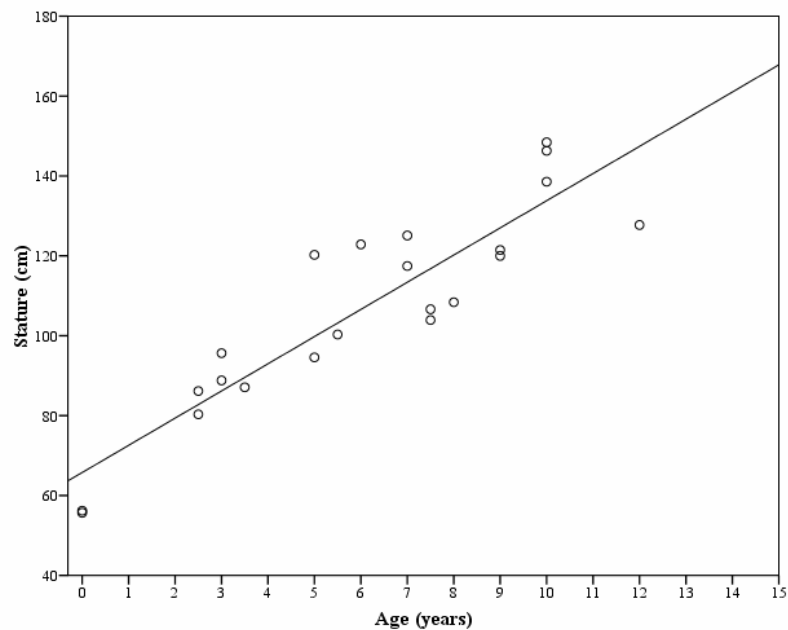
Figure 4.15: Neighbours non-adult stature by mean age-at-death.

4.2.2.3.b Body Mass

It was possible to estimate body mass for a total of 57 adults from the NP (Table 4.89). The male mean body mass was significantly higher than the females when estimated from the femoral head diameter method (t = -4.608, p < 0.001). However, there was no significant difference observed between the sexes via the bi-iliac breadth estimation method (t = -0.986, p = 0.342).

Table 4.89: Neighbours adult body mass by sex and estimation method.

Estimation Method	Sex	No.	Mean (kg)	S.D.	Min.	Max.
Femoral Head Diameter Method	Male	27	66.93	5.75	54.82	84.25
	Female	25	59.42	6.00	51.42	77.12
	Indeterminate	5	55.77	6.89	44.83	62.07
Bi-iliac Breadth Method	Male	8	66.82	5.32	55.00	71.46
	Female	7	63.55	7.46	49.99	71.34
	Indeterminate	-	-	-	-	-

There were 15 adults in the NP that were in a state of preservation which allowed both body mass estimation methods to be applied to the same individual. There was no significant difference observed between the estimation methods in the NP adults (Table 4.90).

Table 4.90: Comparison of neighbours adults with both body mass estimation methods applied.

Sex	No.	Femoral Head Diameter Method Mean (kg)	S.D.	Bi-iliac Breadth Method Mean (kg)	S.D	Comparison t	p
Male	8	65.71	3.74	66.82	5.32	-1.055	0.326
Female	7	60.57	7.28	63.55	7.46	-1.035	0.341
Indeterminate	-	-	-	-	-	-	-

It was possible to estimate body mass for five non-adults in the NP (Table 4.91, Figure 4.16). Non-adult body mass in this population could be estimated by mean age at death by the equation: Body Mass = 2.227*(Age) + 7.709

Table 4.91: Neighbours non-adult body mass estimates by mean age-at-death.

Age (years)	No.	Mean (kg)
8.00	1	22.50
9.00	1	26.62
10.00	1	36.40
12.00	1	34.78
13.00	1	34.03
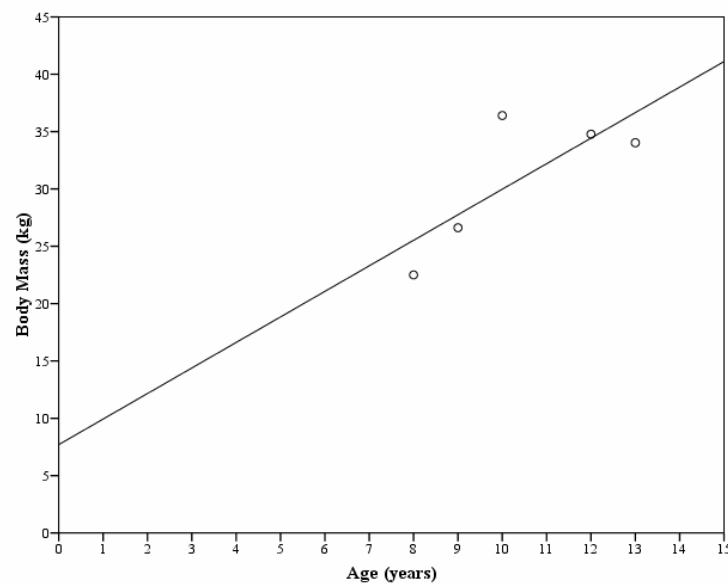
Figure 4.16: Neighbours non-adult body mass estimates by mean age-at-death.

4.2.2.3.c Platymeric Index

It was possible to calculate the platymeric index for 66 adult individuals in the combined NP (Table 4.92). The mean index for the females in the NP was significantly higher than the mean index in the males ($t = 2.450$, $p = 0.019$).

Table 4.92: Neighbours platymeric index summary by sex.

Sex	No.	Mean	S.D.	Minimum	Maximum
Male	30	83.70	8.78	69.13	104.37
Female	29	93.00	18.52	71.75	137.63
Indeterminate	7	88.46	7.58	80.75	101.53
Total	66	88.29	14.39	69.13	137.63

The majority of the males were classified as platymeric in contrast to the females and the adults of indeterminate sex, who were more even distributed throughout the indices (Table 4.93). There was no significant difference observed in the distribution of the indices in the sex categories ($X^2_{(4)} = 6.701$, $p = 0.153$).

Table 4.93: Neighbours platymeric index by type and sex.

Sex	No.	Platymeric No.	Platymeric %	Eurymeric No.	Eurymeric %	Stenomeric No.	Stenomeric %
Male	30	21	70.0	7	23.3	2	6.7
Female	29	13	44.8	8	27.6	8	27.6
Indeterminate	7	3	42.9	3	42.9	1	14.2
Total	66	37	56.1	18	27.3	11	16.6

4.2.2.3.d Platycnemic Index

It was possible to calculate the platycnemic index for 66 adult individuals in the combined NP (Table 4.94). There was no significant difference in the mean indices between the males and females ($t = 1.489$, $p = 0.143$).

Table 4.94: Neighbours platycnemic index summary by sex.

Sex	No.	Mean	S.D.	Minimum	Maximum
Male	25	70.82	4.29	64.61	82.30
Female	27	72.72	4.86	63.91	83.80
Indeterminate	14	74.08	6.75	66.38	90.95
Total	66	72.29	5.19	63.91	90.95

The majority of all the NP adults were classified as eurycnemic (Table 4.95). There was no significant difference between the distribution of the indices through the three adult sex categories ($X^2_{(2)} = 1.723$, $p = 0.423$).

Table 4.95: Neighbours platycnemic index by type and sex.

Sex	No.	Hypoplatycnemic No.	Hypoplatycnemic %	Platycnemic No.	Platycnemic %	Mesocnemic No.	Mesocnemic %	Eurycnemic No.	Eurycnemic %
Male	23	-	-	-	-	11	47.8	12	52.2
Female	27	-	-	-	-	9	33.3	18	66.7
Indeterminate	14	-	-	-	-	4	28.6	10	71.4
Total	64	-	-	-	-	24	37.5	40	62.5

4.2.3 Palaeopathological Profile

Palaeopathological data were recorded for all 173 NP skeletons included in this population survey. However, poor preservation restricted the counts available for each observation location. The following section tabulates the rates of pathological indicators of stress, metabolic bone diseases, and non-specific infection lesions recorded for the NP.

4.2.3.1 Cribra Orbitalia and Porotic Hyperostosis

There were 69 individuals in the NP with orbits present and 28 of those individuals had cribra orbitalia lesions. A total of 42 lesions were observed in the 123 orbits available for observation. The prevalence rates generally decreased with age (Table 4.96). There was no significant difference in the number of individuals with cribra orbitalia ($X^2_{(3)}$ = 4.201, p = 0.215), or in the count of orbits affected ($X^2_{(3)}$ = 3.433, p = 0.297), across the four age categories. However, there was a significant difference in the count of individuals ($X^2_{(7)}$ = 15.087, p = 0.016), and the count of orbits affected ($X^2_{(7)}$ = 13.955, p = 0.046), between the eight age ranges.

Table 4.96: Neighbours cribra orbitalia prevalence rates by age.

Type	Age	Individuals Affected			Orbits Affected		
		No.	CO	TPR %	No.	CO	TPR %
Age Category	Non-adults	16	9	56.3	30	12	40.0
	Young Adults	15	7	46.7	26	11	42.3
	Adults	31	11	35.5	54	17	31.5
	Older Adults	7	1	14.3	13	2	15.4
Age (years)	0 – 2	7	1	14.3	14	2	14.3
	2 – 5	2	2	100.0	4	3	75.0
	5 – 9	5	4	80.0	8	4	50.0
	10 – 14	2	2	100.0	4	3	75.0
	15 – 24	15	7	46.7	26	11	42.3
	25 – 34	18	8	44.4	31	12	38.7
	35 – 44	13	3	23.1	23	5	21.7
	45+	7	1	14.3	13	2	15.4
Total		69	28	29.4	123	42	34.1

Comparison between the age ranges of individuals affected revealed the rates in the five to nine year non-adults were significantly higher than in the 35 to 44 years adults (Table 4.97).

Comparison of rates of the orbits affected also revealed significant differences within the non-adult age ranges (Table 4.98). The prevalence rate in the birth to two year age range was significantly lower than the two to five year and the 10 to 14 year non-adult age ranges.

Table 4.97: Comparison of neighbours cribra orbitalia prevalence rates as individuals affected by age.

Age (years)	0 – 2 $X^2_{(1)}$	0 – 2 F	2 – 5 $X^2_{(1)}$	2 – 5 F	5 – 9 $X^2_{(1)}$	5 – 9 F	10 – 14 $X^2_{(1)}$	10 – 14 F	15 – 24 $X^2_{(1)}$	15 – 24 F	25 – 34 $X^2_{(1)}$	25 – 34 F	35 – 44 $X^2_{(1)}$	35 – 44 F
0 – 2	-	-	5.143	0.083	5.182	0.072	5.143	0.083	2.163	0.193	1.990	0.355	0.220	1.000
2 – 5	5.143	0.083	-	-	0.467	1.000	-	-	2.015	0.471	2.222	0.474	4.615	0.095
5 – 9	5.182	0.072	0.467	1.000	-	-	0.467	1.000	1.684	0.319	1.982	0.317	4.923	0.047
10–14	5.143	0.083	-	-	0.467	1.000	-	-	2.015	0.471	2.222	0.474	4.615	0.095
15–24	2.163	0.193	2.015	0.471	1.684	0.319	2.015	0.471	-	-	0.016	1.000	1.688	0.254
25–34	1.990	0.355	2.222	0.474	1.982	0.317	2.222	0.474	0.016	1.000	-	-	1.505	0.275
35–44	0.220	1.000	4.615	0.095	4.923	0.047	4.615	0.095	1.688	0.254	1.505	0.275	-	-
45+	0.000	1.000	5.143	0.083	5.182	0.072	5.143	0.083	2.163	0.193	1.990	0.355	0.220	1.000

Table 4.98: Comparison of neighbours cribra orbitalia prevalence rates as orbits affected by age.

Age (years)	0 – 2 $X^2_{(1)}$	0 – 2 F/p	2 – 5 $X^2_{(1)}$	2 – 5 F/p	5 – 9 $X^2_{(1)}$	5 – 9 F/p	10 – 14 $X^2_{(1)}$	10 – 14 F/p	15 – 24 $X^2_{(1)}$	15 – 24 F/p	25 – 34 $X^2_{(1)}$	25 – 34 F/p	35 – 44 $X^2_{(1)}$	35 – 44 F/p
0 – 2	-	-	5.716	0.044	3.274	0.137	5.716	0.044	3.257	0.090	2.684	0.165	0.315	0.687
2 – 5	5.716	0.044	-	-	0.686	0.576	0.000	1.000	1.489	0.315	1.905	0.292	4.636	0.065
5 – 9	3.274	0.137	0.686	0.576	-	-	0.686	0.576	0.147	1.000	0.335	0.694	2.301	0.185
10–14	5.716	0.044	0.000	1.000	0.686	0.576	-	-	1.489	0.315	1.905	0.292	4.634	0.065
15–24	3.257	0.090	1.489	0.315	0.147	1.000	1.489	0.315	-	-	0.076	0.794	2.348	0.125
25–34	2.684	0.165	1.905	0.292	0.335	0.694	1.905	0.292	0.076	0.794	-	-	1.763	0.184
35–44	0.315	0.687	4.636	0.065	2.301	0.185	4.634	0.065	2.348	0.125	1.763	0.184	-	-
45+	0.006	1.000	5.236	0.055	2.908	0.146	5.236	0.053	2.827	0.151	2.297	0.170	0.214	1.000

Within the NP adults, there were 18 males and 27 females observable for cribra orbitalia lesions (Table 4.99). There was no significant difference in the rates observed between the sexes overall or within specific adult age ranges when calculated as either a percentage of individuals or orbits affected.

Table 4.99: Neighbours adult cribra orbitalia prevalence rates by sex.

Calculation Method	Age (years)	Males No.	Males CO	Males TPR %	Females No.	Females CO	Females TPR%	Comparison $X^2_{(1)}$	Comparison F/p
Individuals Affected		18	6	33.3	27	9	33.3	0.000	1.000
	15 – 24	5	2	40.0	8	3	37.5	0.008	1.000
	25 – 34	5	3	60.0	10	3	30.0	1.250	0.329
	35 – 44	5	1	20.0	6	2	33.3	0.244	1.000
	45+	3	-	-	3	1	33.3	1.200	1.000
Orbits Affected		31	9	29.0	49	15	30.6	0.023	0.881
	15 – 24	9	3	33.3	14	5	35.7	0.014	1.000
	25 – 34	8	5	62.5	18	4	22.2	3.970	0.078
	35 – 44	8	1	12.5	11	4	36.4	1.360	0.338
	45+	6	-	-	6	2	33.3	2.400	0.455

The Whithorn prevalence rate, when calculated as individuals affected, was the highest rate observed between the four sites within the NP (Table 4.100). However, Fishergate House demonstrated the highest prevalence rate when calculated as orbits affected. Prevalence rates between the four NP sites were not significantly different when calculated either as individuals ($X^2_{(3)} = 0.907$, p = 0.825), or as orbits affected ($X^2_{(3)} = 0.782$, p = 0.854).

Table 4.100: Neighbours cribra orbitalia prevalence rates by site.

Site	Individuals Affected			Orbits Affected		
	No.	CO	TPR %	No.	CO	TPR %
Fishergate House	21	8	38.1	38	13	34.2
Franciscan Friary	12	4	33.3	22	7	31.8
Parliament House	20	8	40.0	36	11	30.6
Whithorn	16	8	50.0	27	11	30.6

A total of 85 skeletons of the 173 from the NP had parietal bones available for observation. A minimum of 145 parietal bones were examined for porotic hyperostosis lesions, but no lesions were observed on these NP individuals.

4.2.3.2 Enamel Hypoplasia

A total of 96 individuals in the NP had teeth present. However, four of those individuals did not have tooth enamel present due to dental attrition and post-mortem damage. Therefore, 92 individuals were observed for enamel hypoplasia and a total of 61 of those individuals had visible lesions. A total of 345 lesions were observed in the 1759 teeth available for observation.

The highest prevalence rate of individuals affected was in the young adult broad age category, in contrast to the highest prevalence rate of teeth affected which was in the non-adult age category (Table 4.101). There was no significant difference in the number of individuals with enamel hypoplasia ($X^2_{(3)}$ = 7.448, p = 0.052). However, there was a significant difference in the count of teeth affected across the four age categories ($X^2_{(3)}$ = 13.355, p = 0.004). The highest prevalence rate was specifically observed in the 10 to 14 year age range. There was a significant difference in the count of individuals ($X^2_{(7)}$ = 21.327, p = 0.003), and the count of teeth affected ($X^2_{(7)}$ = 75.434, p < 0.001), between the eight age ranges.

Table 4.101: Neighbours enamel hypoplasia prevalence rates by age.

Type	Age	Individuals Affected			Teeth Affected		
		No.	EH	TPR %	No.	EH	TPR %
Age Category	Non-adults	19	10	52.6	281	66	23.5
	Young Adults	30	25	83.3	630	143	22.7
	Adults	34	22	64.7	705	113	16.0
	Older Adults	9	4	44.4	143	23	16.1
Age (years)	0 – 2	4	-	-	24	-	-
	2 – 5	5	1	20.0	66	1	1.5
	5 – 9	7	6	85.7	127	32	25.2
	10 – 14	3	3	100.0	64	33	51.6
	15 – 24	30	25	83.3	630	143	22.7
	25 – 34	21	14	66.7	441	65	14.7
	35 – 44	13	8	61.5	264	48	18.2
	45+	9	4	44.4	143	23	16.1
Total		92	61	66.3	1759	345	19.6

When calculated as teeth affected, the rates in the non-adult and young adult age categories were significantly higher than the rate in the adults (Table 4.102).

Table 4.102: Comparison of neighbours enamel hypoplasia prevalence rates as individuals affected by age category.

Age Category	Non-adults $X^2_{(1)}$	p	Young Adults $X^2_{(1)}$	p	Adults $X^2_{(1)}$	p	Older Adults $X^2_{(1)}$	p
Non-adults	-	-	0.068	0.794	7.524	0.006	3.132	0.077
Young Adults	0.068	0.794	-	-	9.550	0.002	3.024	0.082
Adults	7.524	0.006	9.550	0.002	-	-	0.000	0.987
Older Adults	3.132	0.077	3.024	0.082	0.000	0.987	-	-

Specifically, the infants between birth and two years had a prevalence rate of enamel hypoplasia that was significantly lower than the rates observed in the five to nine, 10 to 14, 15 to 24 and 25 to 34 year age ranges (Table 4.103). The two to five year olds also had a significantly lower prevalence rate than in the 15 to 24 year age range. Within the adults, the 15 to 24 year old had a significantly higher prevalence rate than in the 45+ adults from the NP.

Table 4.103: Comparison of neighbours enamel hypoplasia prevalence rates as individuals affected by age.

Age (years)	0 – 2 $X^2_{(1)}$	F	2 – 5 $X^2_{(1)}$	F	5 – 9 $X^2_{(1)}$	F	10 – 14 $X^2_{(1)}$	F	15 – 24 $X^2_{(1)}$	F	25 – 34 $X^2_{(1)}$	F	35 – 44 $X^2_{(1)}$	F
0 – 2	-	-	0.900	1.000	7.543	0.015	7.000	0.029	12.593	0.003	6.061	0.026	4.650	0.082
2 – 5	0.900	1.000	-	-	5.182	0.072	4.800	0.143	8.999	0.010	3.603	0.128	2.492	0.294
5 – 9	7.543	0.015	5.182	0.072	-	-	0.476	1.000	0.024	1.000	0.933	0.633	1.266	0.354
10–14	7.000	0.029	4.800	0.143	0.476	1.000	-	-	0.589	1.000	1.412	0.530	1.678	0.509
15–24	12.593	0.003	8.999	0.010	0.024	1.000	0.589	1.000	-	-	1.907	0.196	2.414	0.140
25–34	6.061	0.026	3.603	0.128	0.933	0.633	1.412	0.530	1.907	0.196	-	-	0.09	1.000
35–44	4.650	0.082	2.492	0.294	1.266	0.354	1.678	0.509	2.414	0.140	0.092	1.000	-	-
45+	2.568	0.228	0.837	0.580	2.861	0.145	2.857	0.205	5.491	0.032	1.296	0.418	0.627	0.666

The TPR rates of the teeth affected also revealed significant differences across all age ranges (Table 4.104). The non-adult individuals between birth and five years had a significantly lower prevalence rate of enamel hypoplasia than all of the other age ranges in the NP. In contrast, the prevalence rate in the 10 to 14 year age range was significantly higher than all of the other age ranges. The prevalence rates in the five to nine year and 15 to 24 year age ranges were significantly higher than the rate observed in the 25 to 34 year age range.

Table 4.104: Comparison of neighbours enamel hypoplasia prevalence rates as teeth affected by age.

Age (years)	0 – 2 $X^2_{(1)}$	F/p	2 – 5 $X^2_{(1)}$	F/p	5 – 9 $X^2_{(1)}$	F/p	10 – 14 $X^2_{(1)}$	F/p	15 – 24 $X^2_{(1)}$	F/p	25 – 34 $X^2_{(1)}$	F/p	35 – 44 $X^2_{(1)}$	F/p
0 – 2	-	-	0.368	1.000	7.673	0.006	19.800	<0.001	6.972	0.008	4.112	0.035	5.236	0.018
2 – 5	0.368	1.000	-	-	17.183	<0.001	42.139	<0.001	16.337	<0.001	8.866	0.003	11.600	0.001
5 – 9	7.673	0.006	17.183	<0.001	-	-	13.177	<0.001	0.371	0.542	7.615	0.006	2.593	0.107
10–14	19.800	<0.001	42.139	<0.001	13.177	<0.001	-	-	25.571	<0.001	48.455	<0.001	30.865	<0.001
15–24	6.972	0.008	16.337	<0.001	0.371	0.542	25.571	<0.001	-	-	10.501	0.001	2.259	0.133
25–34	4.112	0.035	8.866	0.003	7.615	0.006	48.455	<0.001	10.501	0.001	-	-	1.454	0.228
35–44	5.236	0.018	11.600	0.001	2.593	0.107	30.865	<0.001	2.259	0.133	1.454	0.228	-	-
45+	4.477	0.048	9.430	0.002	3.444	0.063	28.200	<0.001	3.024	0.082	0.153	0.696	0.283	0.594

Table 4.105: Neighbours adult enamel hypoplasia prevalence rates by sex and age.

Calculation Method	Age (years)	Males			Females			Comparison	
		No.	EH	TPR%	No.	EH	TPR%	$X^2_{(1)}$	F/p
Individuals Affected	Total	17	11	64.7	32	22	68.8	0.083	0.774
	15 – 24	5	4	80.0	8	6	75.0	0.043	1.000
	25 – 34	7	6	85.7	11	7	63.6	1.039	0.596
	35 – 44	3	1	33.3	8	5	62.5	0.749	0.545
	45+	2	-	-	5	4	80.0	3.733	0.143
Teeth Affected		352	50	14.2	694	144	20.7	6.622	0.010
	15 – 24	90	24	26.7	191	51	26.7	0.000	0.995
	25 – 34	155	24	15.5	255	40	15.7	0.003	0.956
	35 – 44	70	2	2.9	160	30	18.8	10.269	0.001
	45+	37	-	-	88	23	26.1	11.851	0.001

Within the NP adults, there were 17 males and 32 females observable for enamel hypoplasia lesions (Table 4.105). There was no significant difference in the enamel hypoplasia prevalence rates between the sexes in the NP when calculated as individuals affected ($X^2_{(1)} = 0.083$, p = 0.774). However, the female prevalence rate was significantly higher than the male rate when calculated as teeth affected. This trend was specifically observed in the 35 to 44 and 45+ age ranges.

The rate in the Parliament House sample was the highest observed between the four sites within the NP (Table 4.106). This difference was not significant when prevalence was calculated as individuals affected ($X^2_{(3)} = 6.447$, p = 0.092). However, there was a significant difference between the sites when prevalence was calculated as teeth affected ($X^2_{(3)} = 27.370$, p < 0.001).

Table 4.106: Neighbours enamel hypoplasia prevalence rates by site.

Site	Individuals Affected			Teeth Affected		
	No.	CL	TPR %	No.	CL	TPR %
Fishergate House	25	13	52.0	496	83	16.7
Franciscan Friary	10	5	50.0	168	26	15.5
Parliament House	27	22	81.5	540	146	27.0
Whithorn	30	21	70.0	555	90	16.2

When calculated as teeth affected, the prevalence rate in the Parliament House population was significantly higher than the rates observed in the other three NP sites (Table 4.107).

Table 4.107: Comparison of nieghbours enamel hypoplasia prevalence rates as teeth affected by site.

Site	Fishergate House		Franciscan Friary		Parliament House		Whithorn	
	$X^2_{(1)}$	p	$X^2_{(1)}$	p	$X^2_{(1)}$	p	$X^2_{(1)}$	p
Fishergate House	-	-	0.145	0.704	15.939	<0.001	0.051	0.821
Franciscan Friary	0.145	0.704	-	-	9.312	0.002	0.052	0.819
Parliament House	15.939	<0.001	9.312	0.002	-	-	18.955	<0.001
Whithorn	0.051	0.821	0.052	0.819	18.955	<0.001	-	-

4.2.3.3 Non-Specific Infections

A total of 107 individuals of 169 available, from the NP demonstrated similar bone changes (63.3%). The highest prevalence rate within the disease category was observed in the maxillary sinuses and the lowest rate was in rib lesions (Table 4.108).

Table 4.108: Neighbours non-specific infection rates by type.

Category	No.	Cases	TPR %
Non-Specific Infections	169	107	63.3
Endocranial Lesions	82	19	23.2
Maxillary Sinusitis	72	59	81.9
Rib Lesions	102	12	11.8
Periosteal Lesions	139	56	40.3

The highest prevalence rate for the non-specific infection disease category overall was observed in the older adults (Table 4.109). The prevalence rates gradually increased throughout the age categories and a significant difference was observed between the four available categories ($X^2_{(3)}$ = 14.450, p = 0.002). The same trend was observed in the more specific age ranges, with the exception of the 10 to 14 year age range. A decrease in non-specific infection lesions was recorded in this age bracket in contrast to the general trend of an increase in prevalence associated with age. Again, there was a significant difference observed between the eight age ranges overall ($X^2_{(7)}$ = 16.612, p = 0.020).

Table 4.109: Neighbours non-specific infection prevalence rates by age.

Type	Age	No.	Cases	TPR %
Age Category	Non-adults	41	16	39.0
	Young Adults	35	23	65.7
	Adults	76	55	72.4
	Older Adults	17	13	76.5
Age (years)	0 – 2	11	3	27.3
	2 – 5	10	4	40.0
	5 – 9	14	7	50.0
	10 – 14	6	2	33.3
	15 – 24	35	23	65.7
	25 – 34	46	35	76.1
	35 – 44	30	20	66.7
	45+	17	13	76.5
Total		169	107	63.3

When directly compared, the prevalence rate in the non-adults was significantly lower than the rates in the three adult age categories (Table 4.110).

Table 4.110: Comparison of neighbours non-specific infection prevalence rates by age categories.

Age Category	Non-adults $X^2_{(1)}$	Non-adults F/p	Young Adults $X^2_{(1)}$	Young Adults F/p	Adults $X^2_{(1)}$	Adults F/p	Older Adults $X^2_{(1)}$	Older Adults F/p
Non-adults	-	-	5.384	0.020	12.411	<0.001	6.740	0.020
Young Adults	5.384	0.020	-	-	0.508	0.476	0.621	0.532
Adults	12.411	<0.001	0.508	0.476	-	-	0.119	1.000
Older Adults	6.740	0.020	0.621	0.532	0.119	1.000	-	-

Specifically, the prevalence rate in the infant age range was significantly lower than the rates observed in the four adult age ranges (Table 4.111).

Table 4.111: Comparison of neighbours non-specific infection prevalence rates by age range.

Age (years)	0 – 2 $X^2_{(1)}$	F/p	2 – 5 $X^2_{(1)}$	F/p	5 – 9 $X^2_{(1)}$	F/p	10 – 14 $X^2_{(1)}$	F/p	15 – 24 $X^2_{(1)}$	F/p	25 – 34 $X^2_{(1)}$	F/p	35 – 44 $X^2_{(1)}$	F/p
0 – 2	-	-	0.382	0.659	1.326	0.414	0.069	1.000	5.033	0.038	9.519	0.004	5.072	0.036
2 – 5	0.382	0.659	-	-	0.235	0.697	0.071	1.000	2.143	0.166	5.060	0.052	2.222	0.159
5 – 9	1.326	0.414	0.235	0.697	-	-	0.471	0.642	1.040	0.346	3.478	0.062	1.118	0.290
10–14	0.069	1.000	0.071	1.000	0.471	0.642	-	-	2.257	0.187	4.727	0.050	2.338	0.181
15–24	5.033	0.038	2.143	0.166	1.040	0.346	2.257	0.187	-	-	1.052	0.305	0.007	0.936
25–34	9.519	0.004	5.060	0.052	3.478	0.062	4.727	0.050	1.052	0.305	-	-	0.806	0.369
35–44	5.072	0.036	2.222	0.159	1.118	0.290	2.338	0.181	0.007	0.936	0.806	0.369	-	-
45+	6.601	0.019	3.591	0.101	2.350	0.125	3.638	0.131	0.621	0.532	0.001	1.000	0.499	0.529

Within the 128 adults, a total of 40 males and 47 females were observed for indications of non-specific infections. All the rates observed in both sexes were above 45%. There were no significant differences observed between the sexes overall, or within the more specific age ranges (Table 4.112).

Table 4.112: Neighbours adult non-specific infection prevalence rates by sex and age range.

Age (years)	Males No.	Cases	TPR %	Females No.	Cases	TPR %	Comparison $X^2_{(1)}$	F/p
15 – 24	8	5	62.5	11	5	45.5	0.540	0.650
25 – 34	18	14	77.8	15	12	80.0	0.024	1.000
35 – 44	9	6	66.7	12	9	75.0	0.175	1.000
45+	5	5	100.0	9	6	66.7	2.121	0.258
Total	40	30	75.0	47	32	68.1	0.505	0.478

There was variation within the NP in the non-specific infection prevalence rates, with the highest rate recorded in the Whithorn population and the lowest recorded in the Parliament House population (Table 4.113). The differences were statistically significant ($X^2_{(3)} = 13.815$, p = 0.003).

Table 4.113: Neighbours non-specific infection prevalence rates by site.

Site	No.	Cases	TPR %
Fishergate House	50	37	74.0
Franciscan Friary	19	10	52.6
Parliament House	51	23	45.1
Whithorn	49	37	75.5

Specifically, the prevalence rates recorded in the Fishergate House and Whithorn populations were significantly higher than the rate in the Parliament House population (Table 4.114).

Table 4.114: Comparison of neighbours non-specific infection prevalence rates by site.

Site	Fishergate House $X^2_{(1)}$	p	Franciscan Friary $X^2_{(1)}$	p	Parliament House $X^2_{(1)}$	p	Whithorn $X^2_{(1)}$	p
Fishergate House	-	-	2.895	0.089	8.745	0.003	0.030	0.863
Franciscan Friary	2.895	0.089	-	-	0.315	0.574	3.357	0.067
Parliament House	8.745	0.003	0.315	0.574	-	-	9.631	0.002
Whithorn	0.030	0.863	3.357	0.067	9.631	0.002	-	-

4.2.3.3.a Endocranial Lesions

A total of 19 individuals of 82 available from the NP, had endocranial surfaces affected by non-specific infectious lesions (23.2%). The highest prevalence rate was observed in the adults with the lowest rates reported in the individuals between five and 25 years old (Table 4.115). The variability between the age categories was statistically significant ($X^2_{(3)}$ = 9.385, p = 0.025); but, this difference was not observed in the more specific age ranges ($X^2_{(7)}$ = 12.667, p = 0.081).

Table 4.115: Neighbours endocranial lesions prevalence rates by age.

Type	Age	No.	Cases	TPR %
Age Category	Non-adults	29	4	13.8
	Young Adults	13	1	7.7
	Adults	36	14	38.9
	Older Adults	4	-	-
Age (years)	0 – 2	10	3	30.0
	2 – 5	5	1	20.0
	5 – 9	12	-	-
	10 – 14	2	-	-
	15 – 24	13	1	7.7
	25 – 34	22	8	36.4
	35 – 44	14	6	42.9
	45+	4	-	-
Total		82	19	23.2

The prevalence rate in the adult age category was significantly higher than the rates in the non-adult and young adult age categories (Table 4.116).

Table 4.116: Comparison of neighbours endocranial lesions prevalence rates by age categories.

Age Category	Non-adults $X^2_{(1)}$	Non-adults F/p	Young Adults $X^2_{(1)}$	Young Adults F/p	Adults $X^2_{(1)}$	Adults F/p	Older Adults $X^2_{(1)}$	Older Adults F/p
Non-adults	-	-	0.319	1.000	5.052	0.029	0.628	1.000
Young Adults	0.319	1.000	-	-	4.376	0.043	0.327	1.000
Adults	5.052	0.029	4.376	0.043	-	-	2.393	0.278
Older Adults	0.628	1.000	0.327	1.000	2.393	0.278	-	-

Within the 176 adult individuals, a total of 62 males and 80 females were observed for indications of non-specific infections on their endocranial surfaces. Although the counts of individuals affected were the same, a higher prevalence rate was recorded in the male individuals (Table 4.117). There were no significant differences observed between the sexes overall or within the more specific age ranges.

Table 4.117: Neighbours adult endocranial lesions prevalence rates by sex and age range.

Age (years)	Males No.	Males Cases	Males TPR %	Females No.	Females Cases	Females TPR %	Comparison $X^2_{(1)}$	Comparison F/p
15 – 24	4	1	25.0	7	-	-	1.95	0.364
25 – 34	8	3	37.5	10	2	20.0	0.678	0.608
35 – 44	4	2	50.0	8	4	50.0	0.000	1.000
45+	1	-	-	2	-	-	-	-
Total	17	6	35.3	27	6	22.2	0.899	0.343

There was variation within the NP with the highest rate recorded in the Whithorn population and the lowest recorded in the Parliament House population (Table 4.118). However, the differences observed between the four populations were not statistically significant ($X^2_{(3)}$ = 4.154, p = 0.245).

Table 4.118: Neighbours endocranial lesions prevalence rates by site.

Site	No.	Cases	TPR %
Fishergate House	29	8	27.6
Franciscan Friary	8	1	12.5
Parliament House	25	3	12.0
Whithorn	20	7	35.0

4.2.3.3.b Maxillary Sinusitis

A total of 59 individuals of 72 available from the NP had bone changes in the maxillary sinuses indicative of non-specific infection (81.9%). The highest prevalence rate was observed in the young adult age category and the lowest in the non-adults (Table 4.119). However, there were no statistically significant differences between the four age categories ($X^2_{(3)}$ = 5.770, p = 0.123), or the eight age ranges ($X^2_{(7)}$ = 11.451, p = 0.120).

Table 4.119: Neighbours maxillary sinusitis prevalence rates by age.

Type	Age	No.	Cases	TPR %
Age Category	Non-adults	12	7	58.3
	Young Adults	20	18	90.0
	Adults	31	26	83.9
	Older Adults	9	8	88.9
Age (years)	0 – 2	2	-	-
	2 – 5	3	2	66.7
	5 – 9	4	3	75.0
	10 – 14	3	2	66.7
	15 – 24	20	18	90.0
	25 – 34	20	17	85.0
	35 – 44	11	9	81.8
	45+	9	8	88.9
Total		72	59	81.9

Within the 60 adult individuals available, a total of 18 males and 23 females were observed for indications of maxillary sinusitis. There were no significant differences observed in the prevalence rates between the sexes (Table 4.120).

Table 4.120: Neighbours adult maxillary sinusitis prevalence rates by sex and age range.

| Age (years) | Males | | | Females | | | Comparison | |
	No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F/p
15 – 24	2	1	50.0	5	4	80.0	0.630	1.000
25 – 34	8	7	87.5	10	8	80.0	0.180	1.000
35 – 44	5	4	80.0	4	3	75.0	0.032	1.000
45+	3	3	100.0	4	3	75.0	0.875	1.000
Total	18	15	83.3	23	18	78.3	0.165	0.684

There was variation within the population, with the highest rate recorded in the Franciscan Friary population and the lowest in the Parliament House population (Table 4.121). The differences observed between the four populations were statistically significant ($X^2_{(3)} = 9.863$, p = 0.020).

Table 4.121: Neighbours maxillary sinusitis prevalence rates by site.

Site	No.	Cases	TPR %
Fishergate House	21	16	76.2
Franciscan Friary	5	5	100.0
Parliament House	19	12	63.2
Whithorn	27	26	96.3

Specifically, the prevalence rate recorded in the Whithorn population was significantly higher than the rate in the Parliament House population (Table 4.122).

Table 4.122: Comparison of neighbours maxillary sinusitis prevalence rates by site.

Site	Fishergate House $X^2_{(1)}$	F/p	Franciscan Friary $X^2_{(1)}$	F/p	Parliament House $X^2_{(1)}$	F/p	Whithorn $X^2_{(1)}$	F/p
Fishergate House	-	-	1.474	0.545	0.807	0.369	4.366	0.073
Franciscan Friary	1.474	0.545	-	-	2.601	0.272	0.191	1.000
Parliament House	0.807	0.369	2.601	0.272	-	-	8.524	0.006
Whithorn	4.366	0.073	0.191	1.000	8.524	0.006	-	-

4.2.3.3.c Rib Lesions

A total of 12 individuals of 102 available, from the NP had observable signs of non-specific infection in the ribs (11.8%). The highest prevalence was observed in the older children and the older adults (Table 4.123). There were no significant differences between the the four age categories ($X^2_{(3)} = 1.110$, p = 0.775), or within the eight age ranges ($X^2_{(7)} = 2.998$, p = 0.885).

Table 4.123: Neighbours rib lesions prevalence rates by age.

Type	Age	No.	Cases	TPR %
Age Category	Non-adults	35	5	14.3
	Young Adults	13	1	7.7
	Adults	43	4	9.3
	Older Adults	11	2	18.2
Age (years)	0 – 2	11	1	9.1
	2 – 5	7	1	14.3
	5 – 9	12	2	16.7
	10 – 14	5	1	20.0
	15 – 24	13	1	7.7
	25 – 34	24	1	4.2
	35 – 44	19	3	15.8
	45+	11	2	18.2
Total		102	12	11.8

Within the 67 adults, a total of 27 males and 32 females were observed for indications of non-specific infections on the ribs. The only lesions observed occurred in the individuals estimated to have been male (Table 4.124). There was a

significantly higher rate overall in the males when compared to the rate in the females. However, this significant difference was not observed in the specific age ranges.

Table 4.124: Neighbours adult rib lesions prevalence rates by sex and age range.

Age (years)	Males No.	Cases	TPR %	Females No.	Cases	TPR %	Comparison $X^2_{(1)}$	F
15 – 24	6	-	-	4	-	-	-	-
25 – 34	11	1	9.1	12	-	-	1.140	0.478
35 – 44	7	3	42.9	10	-	-	5.204	0.051
45+	3	2	66.7	6	-	-	5.143	0.083
Total	27	6	22.2	32	-	-	7.916	0.007

There was variation within the population in the rib lesions prevalence rates, with the highest rate recorded in the Fishergate House population and no cases recorded in the Franciscan Friary population (Table 4.125). These differences were statistically significant ($X^2_{(3)} = 11.569$, p = 0.009).

Table 4.125: Neighbours rib lesions prevalence rates by site.

Site	No.	Cases	TPR %
Fishergate House	40	10	25.0
Franciscan Friary	16	-	-
Parliament House	34	1	2.9
Whithorn	12	1	8.3

Specifically, the rate in the Fishergate House population was significantly higher than the rate in the Franciscan Friary population (Table 4.126).

Table 4.126: Comparison of neighbours rib lesions prevalence rates by site.

Site	Fishergate House $X^2_{(1)}$	F/p	Franciscan Friary $X^2_{(1)}$	F/p	Parliament House $X^2_{(1)}$	F/p	Whithorn $X^2_{(1)}$	F/p
Fishergate House	-	-	4.870	0.048	7.066	0.009	1.537	0.421
Franciscan Friary	4.870	0.048	-	-	0.480	1.000	1.383	0.429
Parliament House	7.066	0.009	0.480	1.000	-	-	0.620	0.458
Whithorn	1.537	0.421	1.383	0.429	0.620	0.458	-	-

4.2.3.3.d Periosteal Lesions

A total of 59 individuals of 140 available in the NP had observable signs of periosteal lesions (42.1%). There was an overall increase in prevalence rates with age, and the highest rate was observed in the older adults (Table 4.127). There was a significant differences observed between the broad age ranges ($X^2_{(3)} = 14.994$, p = 0.002), and the specific age ranges ($X^2_{(7)} = 16.279$, p = 0.023). The prevalence rates in the adults and older adults were significantly higher than the rate in the non-adults (Table 4.128).

Table 4.127: Neighbours periosteal lesion prevalence rates by age.

Type	Age	No.	Cases	TPR %
Age Category	Non-adults	40	8	20.0
	Young Adults	21	7	33.3
	Adults	68	37	54.4
	Older Adults	11	7	63.6
Age (years)	0 – 2	11	3	27.3
	2 – 5	10	2	20.0
	5 – 9	13	3	23.1
	10 – 14	6	-	-
	15 – 24	21	7	33.3
	25 – 34	39	21	53.8
	35 – 44	29	16	55.2
	45+	11	7	63.6
Total		140	59	42.1

Table 4.128: Comparison of neighbours periosteal lesion prevalence rates by age categories.

	Non-adults		Young Adults		Adults		Older Adults	
Age Category	$X^2_{(1)}$	F/p	$X^2_{(1)}$	F/p	$X^2_{(1)}$	F/p	$X^2_{(1)}$	F
Non-adults	-	-	1.320	0.251	12.270	<0.001	7.913	0.009
Young Adults	1.320	0.251	-	-	2.852	0.091	2.694	0.142
Adults	12.270	<0.001	2.852	0.091	-	-	0.327	0.746
Older Adults	7.913	0.009	2.694	0.142	0.327	0.746	-	-

Specifically, the adults over 25 years had significantly higher periosteal lesion prevalence rates than the non-adults between 10 and 14 years (Table 4.129).

Table 4.129: Statistical comparison of neighbours periosteal lesion prevalence rates by age range.

Age (years)	0 – 2		2 – 5		5 – 9		10 – 14		15 – 24		25 – 34		35 – 44	
	$X^2_{(1)}$	F	$X^2_{(1)}$	F	$X^2_{(1)}$	F	$X^2_{(1)}$	F	$X^2_{(1)}$	F/p	$X^2_{(1)}$	F/p	$X^2_{(1)}$	F/p
0 – 2	-	-	0.153	1.000	0.056	1.000	1.987	0.515	0.123	1.000	2.427	0.175	2.489	0.163
2 – 5	0.153	1.000	-	-	0.031	1.000	1.371	0.500	0.585	0.677	3.661	0.080	3.701	0.074
5 – 9	0.056	1.000	0.031	1.000	-	-	1.644	0.517	0.407	0.704	3.714	0.064	3.732	0.093
10–14	1.987	0.515	1.371	0.500	1.644	0.517	-	-	2.700	0.155	6.058	0.023	6.098	0.022
15–24	0.123	1.000	0.585	0.677	0.407	0.704	2.700	0.155	-	-	2.308	0.129	2.339	0.126
25–34	2.427	0.175	3.661	0.080	3.714	0.064	6.058	0.023	2.308	0.129	-	-	0.012	0.914
35–44	2.489	0.163	3.701	0.074	3.732	0.093	6.098	0.022	2.339	0.126	0.012	0.914	-	-
45+	2.933	0.198	4.073	0.080	4.033	0.095	6.491	0.035	2.694	0.142	0.334	0.734	0.234	0.730

Within the 77 adult individuals, a total of 35 males and 42 females were observed. There were no significant differences observed in the periosteal lesion prevalence rates between the sexes overall or within the more specific adult age ranges (Table 4.130).

Table 4.130: Neighbours adult periosteal lesion prevalence rates by sex and age range.

	Males			Females			Comparison	
Age (years)	No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F/p
15 – 24	7	4	57.1	9	1	11.1	3.883	0.106
25 – 34	15	9	60.0	15	7	46.7	0.536	0.464
35 – 44	9	4	44.4	12	8	66.7	1.037	0.309
45+	4	4	100.0	6	3	50.0	2.857	0.200
Total	35	21	60.0	42	19	45.2	1.667	0.197

When divided by region of the skeleton affected by periosteal lesions the lower leg, consisting of the tibia and fibula was the most affected region of the body (Table 4.131). Periosteal lesions observed on the cranium were the second most common lesions recorded in the NP. Of the 12 individuals with cranial lesions, nine were described as ectocranial porosity, indicative of a minor scalp infection (12.3%).

Table 4.131: Neighbours periosteal lesion prevalence rates by elements.

Elements Affected	No.	Cases	TPR %
Cranium	73	12	16.4
Arm	93	2	2.2
Upper and Lower Leg	101	16	15.8
Lower Leg	91	20	22.0
Throughout the skeleton	140	9	6.4
Total Individuals	140	59	42.1

There was significant variability within the NP ($X^2_{(3)}$ = 23.208, p < 0.001), with the highest rate recorded in the Fishergate House population and the lowest recorded in the Parliament House population (Table 4.132).

Table 4.132: Neighbours periosteal lesion prevalence rates by site.

Site	No.	Cases	TPR %
Fishergate House	50	33	66.0
Franciscan Friary	16	6	37.5
Parliament House	49	9	18.4
Whithorn	25	11	44.0

The prevalence rate in the Fishergate House population was significantly higher than the rates in the Franciscan Friary and Parliament House populations (Table 4.133). The rate in the Whithorn population was also significantly higher than the rate observed in the Parliament House sample.

Table 4.133: Comparison of neighbours periosteal lesion prevalence rates by site.

Site	Fishergate House $X^2_{(1)}$	p	Franciscan Friary $X^2_{(1)}$	p	Parliament House $X^2_{(1)}$	p	Whithorn $X^2_{(1)}$	p
Fishergate House	-	-	4.073	0.044	22.987	<0.001	3.327	0.068
Franciscan Friary	4.073	0.044	-	-	2.487	0.115	0.170	0.680
Parliament House	22.987	<0.001	2.487	0.115	-	-	5.515	0.019
Whithorn	3.327	0.068	0.170	0.680	5.515	0.019	-	-

4.2.3.4 Metabolic Bone Disease

A total of 21 individuals of 166 available for observation, from the NP skeletal samples demonstrated bone changes indicative of metabolic bone disease (12.7%). Pathological lesions indicative of vitamin C, vitamin D, and osteoporosis were observed in all the age ranges and in both sexes. The following section summarises

the rates observed in the NP for this disease category as well as by type of metabolic bone disease (Table 4.134).

Table 4.134: Neighbours metabolic bone disease prevalence rates by disease type and category.

Type	No.	Cases	TPR %
Metabolic bone diseases	166	21	12.7
Vitamin C Deficiency	155	7	4.5
Vitamin D Deficiency	129	11	8.5
Osteoporosis	148	4	2.7

The highest prevalence rate of the disease category was observed in the older adult individuals (Table 4.135). The next highest rates were observed in the non-adult age ranges. There was no significant difference identified in the prevalence rates between the broad age categories ($X^2_{(3)}$ = 7.048, p = 0.098) or within the eight age ranges ($X^2_{(7)}$ = 10.991, p = 0.140).

Table 4.135: Neighbours metabolic bone disease prevalence rates by age.

Type	Age	No.	Cases	TPR %
Age Category	Non-adults	41	7	17.1
	Young Adults	32	2	6.3
	Adults	76	7	9.2
	Older Adults	17	5	29.4
Age (years)	0 – 2	11	3	27.3
	2 – 5	10	-	-
	5 – 9	14	3	21.4
	10 – 14	6	1	16.7
	15 – 24	32	2	6.3
	25 – 34	46	4	8.7
	35 – 44	30	3	10.0
	45+	17	5	29.4
Total		166	21	12.7

Within the 125 adults available for sex estimation, there were 40 males and 46 females observed for lesions indicative of metabolic bone disease. Although there was a higher prevalence rate consistently observed in the females across the adult age ranges, this difference was not significant in comparison to the rates observed in the males (Table 4.136).

Table 4.136: Neighbours adult metabolic bone disease prevalence rates by sex and age range.

Age (years)	Males			Females			Comparison	
	No.	Cases	TPR%	No.	Cases	TPR%	X^2	F/p
15 – 24	8	-	-	11	1	9.1	0.768	1.000
25 – 34	18	2	11.1	15	2	13.3	0.038	1.000
35 – 44	9	1	11.1	12	2	16.7	0.130	1.000
45+	5	1	20.0	8	4	50.0	1.170	0.565
Total	40	4	10.0	46	9	19.6	1.526	0.217

There was significant variability in the metabolic bone disease prevalence rates observed between the four sites within the NP ($X^2_{(3)}$ = 9.957, p = 0.022). The

highest prevalence rate was observed in the Franciscan Friary population and the lowest was recorded in the Parliament House population (Table 4.137).

Table 4.137: Neighbours metabolic bone disease prevalence rates by site.

Site	N	Cases	TPR %
Fishergate House	50	10	20.0
Franciscan Friary	18	5	27.8
Parliament House	51	3	5.9
Whithorn	47	3	6.4

The two neighbouring populations in England, specifically Fishergate House in York and the Franciscan Friary in Hartlepool, demonstrated significantly higher prevalence rates than the two Scottish neighbouring populations, Parliament House and Whithorn (Table 4.138).

Table 4.138: Comparison of metabolic bone disease prevalence rates between the neighbours sites.

Site	Fishergate House $X^2_{(1)}$	F/p	Franciscan Friary $X^2_{(1)}$	F/p	Parliament House $X^2_{(1)}$	F/p	Whithorn $X^2_{(1)}$	F/p
Fishergate House	-	-	0.466	0.519	4.487	0.041	3.871	0.049
Franciscan Friary	0.466	0.519	-	-	6.223	0.024	5.520	0.032
Parliament House	4.487	0.041	6.223	0.024	-	-	0.011	1.000
Whithorn	3.871	0.049	5.520	0.032	0.011	1.000	-	-

4.2.3.4.a Vitamin C Deficiency

A total of seven individuals of 155 available from the NP had observable signs of vitamin C deficiency (4.5%). All the pathological lesions observed were determined to be indicative of scurvy. No lesions indicative of osteopenia were observed in any of the individuals in the NP.

The highest prevalence rate of scurvy was observed in the non-adult individuals, specifically the infants (Table 4.139). There was no significant difference in the prevalence rates between the broad age categories ($X^2_{(3)} = 2.642$, p = 0.450), or between the eight age ranges ($X^2_{(7)} = 16.764$, p = 0.082).

Table 4.139: Neighbours vitamin C deficiency prevalence rates by age.

Type	Age	No.	Cases	TPR %
Age Category	Non-adults	41	3	7.3
	Young Adults	30	2	6.7
	Adults	68	1	1.5
	Older Adults	16	1	6.3
Age (years)	0 – 2	11	3	27.3
	2 – 5	10	-	-
	5 – 9	14	-	-
	10 – 14	6	-	-
	15 – 24	30	2	6.7
	25 – 34	40	1	2.5
	35 – 44	28	-	-
	45+	16	1	6.3
Total		155	7	4.5

Within the adults available for sex estimation, there were 40 males and 44 females observed for lesions indicative of vitamin C deficiency. There were no significant differences observed in the prevalence rates between males and females either in the overall sex categories or within the adult age ranges (Table 4.140).

Table 4.140: Neighbours adult vitamin C deficiency prevalence rates by sex and age range.

	Males			Females			Comparison	
Age (years)	No.	Cases	TPR%	No.	Cases	TPR%	X^2	F
15 – 24	8	-	-	11	1	9.1	0.768	1.000
25 – 34	18	1	5.6	14	-	-	0.803	1.000
35 – 44	9	-	-	11	-	-	-	-
45+	5	1	20.0	8	-	-	1.733	0.385
Total	40	2	5.0	44	1	2.3	0.453	0.603

Little variability was observed in the scurvy prevalence rates between the four sites within the NP (Table 4.141). The highest rate was observed in the Whithorn population and no cases were recorded in the Parliament House population. These differences were not significant ($X^2_{(3)}$ = 3.532, p = 0.317).

Table 4.141: Neighbours vitamin C deficiency prevalence rates by site.

Site	No.	Cases	TPR %
Fishergate House	48	3	6.3
Franciscan Friary	15	1	6.7
Parliament House	50	-	-
Whithorn	42	3	7.1

4.2.3.4.b Vitamin D Deficiency

A total of 11 individuals of 129 available from the NP had observable signs of vitamin D deficiency (8.5%). Within this disease category, two individuals (1.6%) possess lesions indicative of rickets, nine individuals (7.0%) had lesions indicative of healed or residual rickets, and no individuals from the NP had lesions indicative of osteomalacia.

The highest prevalence rate of the disease category was observed in the older adult individuals (Table 4.142). There was no significant difference identified in the overall prevalence rates ($X^2_{(3)}$ = 2.546, p = 0.467), in the rickets prevalence rates ($X^2_{(3)}$ = 4.520, p = 0.211), or in the healed rickets prevalence rates ($X^2_{(3)}$ = 3.215, p = 0.360), between the broad age categories. The highest rate in the age ranges was observed in the children between five and nine years old. Again, there were no significant differences observed in the overall vitamin D deficiency prevalence rates ($X^2_{(7)}$ = 8.438, p = 0.296), the rates of rickets ($X^2_{(7)}$ = 18.127, p = 0.220), or the rates of healed rickets ($X^2_{(7)}$ = 8.438, p = 0.296), in the eight age ranges.

Table 4.142: Neighbours vitamin D deficiency prevalence rates by age category.

Type	Age	Vitamin D Deficiency			Rickets			Healed Rickets		
		No.	Cases	TPR %	No.	Cases	TPR %	No.	Cases	TPR %
Age	Non-adults	40	4	10.0	40	2	5.0	40	2	5.0
Category	Young Adults	15	-	-	15	-	-	15	-	-
	Adults	62	5	8.1	62	-	-	62	5	8.1
	Older Adults	12	2	16.7	12	-	-	12	2	16.7
Age (years)	0 – 2	11	-	-	11	-	-	11	-	-
	2 – 5	10	-	-	10	-	-	10	-	-
	5 – 9	13	3	23.1	13	2	15.4	13	1	7.7
	10 – 14	6	1	16.7	6	-	-	6	1	16.7
	15 – 24	15	-	-	15	-	-	15	-	-
	25 – 34	36	3	8.3	36	-	-	36	3	8.3
	35 – 44	26	2	7.7	26	-	-	26	2	7.7
	45+	12	2	16.7	12	-	-	12	2	16.7
Total		129	11	8.5	129	2	1.6	129	9	7.0

Within the adults, there were 35 males and 35 females observed for lesions indicative of healed or residual rickets. There were no significant differences observed in the healed rickets prevalence rates between the sexes, either overall or within the specific adult age ranges (Table 4.143).

Table 4.143: Neighbours adult healed rickets prevalence rates by sex and age range.

Age	Males			Females			Comparison	
(years)	No.	Cases	TPR%	No.	Cases	TPR%	$X^2_{(1)}$	F/p
15 – 24	7	-	-	5	-	-	-	-
25 – 34	15	1	6.7	14	2	14.3	0.453	0.598
35 – 44	9	1	11.1	10	1	10.0	0.006	1.000
45+	4	-	-	6	2	33.3	1.667	0.467
Total	35	2	5.7	35	5	14.3	1.429	0.428

There was variability in the vitamin D deficiency prevalence rates observed between the four sites within the NP. The highest prevalence rate was observed in the Franciscan Friary population and no cases were recorded in the Whithorn population (Table 4.144). However, these differences between the four populations were not statistically significant for the overall disease category ($X^2_{(3)} = 3.627$, p = 0.305), for rickets prevalence rates ($X^2_{(3)} = 0.673$, p = 0.880), or for healed rickets prevalence rates ($X^2_{(3)} = 4.724$, p = 0.193).

Table 4.144: Neighbours vitamin D deficiency prevalence rates by site.

Site	Vitamin D Deficiency			Rickets			Healed Rickets		
	No.	Cases	TPR %	No.	Cases	TPR %	No.	Cases	TPR %
Fishergate House	50	5	10.0	50	1	2.0	50	4	8.0
Franciscan Friary	17	3	17.6	17	-	-	17	3	17.6
Parliament House	47	3	6.4	47	1	2.1	47	2	4.3
Whithorn	15	-	-	15	-	-	15	-	-

4.2.3.4.c Osteoporosis

A total of four individuals of 148 available from the NP had observable signs of osteoporosis (2.7%). When only adult individuals were tabulated, the prevalence rate of osteoporosis in the NP increased to 3.2%, or four out of 124 individuals.

The highest prevalence rate of the disease was observed in the older adult age category (Table 4.145). There was a significant difference observed in the prevalence rates both between the age categories ($X^2_{(3)}$ = 16.522, p = 0.001), and the more specific age ranges ($X^2_{(7)}$ = 17.289, p = 0.016).

Table 4.145: Neighbours osteoporosis prevalence rates by age category.

Type	Age	No.	Cases	TPR %
Age Category	Non-adults	24	-	-
	Young Adults	31	-	-
	Adults	76	1	1.3
	Older Adults	17	3	17.6
Age (years)	0 – 2	7	-	-
	2 – 5	7	-	-
	5 – 9	5	-	-
	10 – 14	5	-	-
	15 – 24	31	-	-
	25 – 34	46	-	-
	35 – 44	30	1	3.3
	45+	17	3	17.6
Total		148	4	2.7

The osteoporosis rate in the older adult age category was significantly higher than the rates observed in the young adult and adult age categories (Table 4.146).

Table 4.146: Comparison of neighbours osteoporosis prevalence rates by age.

Age Category	Non-adults $X^2_{(1)}$	F	Young Adults $X^2_{(1)}$	F	Adults $X^2_{(1)}$	F	Older Adults $X^2_{(1)}$	F
Non-adults	-	-	-	-	0.319	1.000	4.570	0.064
Young Adults	-	-	-	-	0.412	1.000	5.835	0.039
Adults	0.319	1.000	0.412	1.000	-	-	9.002	0.019
Older Adults	4.570	0.064	5.835	0.039	9.002	0.019	-	-

The prevalence rate observed in the adults over 45 years was significantly higher than the rates observed in the adults between 15 and 34 years (Table 4.147).

Table 4.147: Comparison of neighbours osteoporosis prevalence rates between available age ranges.

Age (years)	35 – 44 $X^2_{(1)}$	F	45+ $X^2_{(1)}$	F
0 – 2	0.240	1.000	1.412	0.530
2 – 5	0.240	1.000	1.412	0.530
5 – 9	0.172	1.000	1.022	1.000
10–14	0.172	1.000	1.022	1.000
15–24	1.051	0.492	5.835	0.039
25–34	1.554	0.395	8.524	0.017
35–44	-	-	2.855	0.128
45+	2.855	0.128	-	-

There were 40 males and 46 females observed for lesions indicative of osteoporosis. Although no males were observed with lesions indicative of osteoporosis, in contrast to four females observed with associated bone changes, there was no significant difference in the prevalence rates between the sexes (Table 4.148).

Table 4.148: Neighbours osteoporosis prevalence rates by sex and age range.

| Age (years) | Males | | | Females | | | Comparison | |
	No.	Cases	TPR%	No.	Cases	TPR%	$X^2_{(1)}$	F
15 – 24	8	-	-	11	-	-	-	-
25 – 34	18	-	-	15	-	-	-	-
35 – 44	9	-	-	12	1	8.3	0.788	1.000
45+	5	-	-	8	3	37.5	2.438	0.231
Total	40	-	-	46	4	8.7	3.648	0.120

Within the NP, the highest prevalence rate was observed in the Franciscan Friary population and no cases were observed in the Parliament House and Whithorn populations (Table 4.149). These differences between the four populations was significant ($X^2_{(3)}$ = 8.458, p = 0.037).

Table 4.149: Neighbours osteoporosis prevalence rates by site.

Site	No.	Cases	TPR %
Fishergate House	42	2	4.8
Franciscan Friary	17	2	11.8
Parliament House	49	-	-
Whithorn	40	-	-

However, there were no significant differences observed between the NP sites when directly compared to each other individually (Table 4.150).

Table 4.150: Comparison of neighbours osteoporosis prevalence rates by site.

| Site | Fishergate House | | Franciscan Friary | | Parliament House | | Whithorn | |
	$X^2_{(1)}$	F	$X^2_{(1)}$	F	$X^2_{(1)}$	F	$X^2_{(1)}$	F
Fishergate House	-	-	0.939	0.571	2.386	0.210	1.952	0.494
Franciscan Friary	0.939	0.571	-	-	5.945	0.063	4.877	0.085
Parliament House	2.386	0.210	5.945	0.063	-	-	-	-
Whithorn	1.952	0.494	4.877	0.085	-	-	-	-

4.2.3.5 Caries Lesions

Of the 96 individuals in the NP with teeth present, caries lesions were observed in 51 of those individuals. A total of 113 lesions were observed affecting 94 teeth out of the 1777 teeth present. There was an average of 2.22 caries lesions per individual with caries lesions observed in this population.

The highest prevalence rate of both individuals and teeth affected was in the older adults (Table 4.151). There was a significant difference in the number of individuals ($X^2_{(3)}$ = 15.721, p = 0.001) and the count of teeth affected ($X^2_{(3)}$ = 11.654, p = 0.009) with caries lesions between age categories. There was also a significant

difference in both the count of individuals affected ($X^2_{(7)}$ = 19.050, p = 0.002), and the total teeth affected ($X^2_{(7)}$ = 17.431, p = 0.012), between the eight age ranges.

Table 4.151: Neighbours caries lesions prevalence rates by age.

Type	Age	Individuals Affected			Teeth Affected		
		No.	CL	TPR %	No.	CL	TPR %
Age Category	Non-adults	20	4	20.0	282	7	2.5
	Young Adults	30	14	46.7	630	26	4.1
	Adults	35	25	71.4	709	49	6.9
	Older Adults	11	8	72.7	156	12	7.7
Age (years)	0 – 2	5	-	-	25	-	-
	2 – 5	5	-	-	66	-	-
	5 – 9	7	3	42.9	127	5	3.9
	10 – 14	3	1	33.3	64	2	3.1
	15 – 24	30	14	46.7	630	26	4.1
	25 – 34	22	16	72.7	445	30	6.7
	35 – 44	13	9	69.2	264	19	7.2
	45+	11	8	72.7	156	12	7.7
Total		96	51	53.1	1777	94	5.3

When prevalence was calculated as a percentage of individuals affected, the rate in the adult age category was significantly higher than the rates in the non-adult and the young adult categories (Table 4.152). Additionally, the rate observed in the older adults was significantly higher than the rate in the non-adults. When the prevalence rate was calculated as a percentage of teeth affected compared to the total number of teeth observed, the same significant relationships were observed as in the previous prevalence calculation method.

Table 4.152: Comparison of neighbours caries lesions prevalence rates by age category.

Calculation Method	Age Category	Non-adults		Young Adults		Adults		Older Adults	
		$X^2_{(1)}$	F	$X^2_{(1)}$	F/p	$X^2_{(1)}$	F/p	$X^2_{(1)}$	F
Individuals	Non-adults	-	-	3.704	0.074	13.505	0.000	8.316	0.007
Affected	Young Adults	3.704	0.074	-	-	4.127	0.042	2.198	0.138
	Adults	13.505	0.000	4.127	0.042	-	-	0.007	1.000
	Older Adults	8.316	0.007	2.198	0.138	0.007	1.000	-	-
Teeth	Non-adults	-	-	1.511	0.219	7.423	0.006	6.570	0.010
Affected	Young Adults	1.511	0.219	-	-	4.890	0.027	3.455	0.063
	Adults	7.423	0.006	4.890	0.027	-	-	0.119	0.730
	Older Adults	6.570	0.010	3.455	0.063	0.119	0.730	-	-

The prevalence rates of individuals affected in the adult age ranges were significantly higher than the rates in the non-adult individuals between birth and five years of age (Table 4.153).

Table 4.153: Comparison of neighbours caries lesions prevalence rates as individuals affected by age.

Age (years)	0 – 2		2 – 5		5 – 9		10 – 14		15 – 24		25 – 34		35 – 44	
	$X^2_{(1)}$	F	$X^2_{(1)}$	F	$X^2_{(1)}$	F	$X^2_{(1)}$	F	$X^2_{(1)}$	F/p	$X^2_{(1)}$	F/p	$X^2_{(1)}$	F/p
0 – 2	-	-	-	-	2.857	0.205	1.905	0.375	3.889	0.069	8.926	0.006	6.923	0.029
2 – 5	-	-	-	-	2.857	0.205	1.905	0.375	3.889	0.069	8.926	0.006	6.923	0.029
5 – 9	2.857	0.205	2.857	0.205	-	-	0.079	1.000	0.033	1.000	2.097	0.193	1.319	0.356
10–14	1.905	0.375	1.905	0.375	0.079	1.000	-	-	0.196	1.000	1.883	0.231	1.340	0.518
15–24	3.889	0.069	3.889	0.069	0.033	1.000	0.196	1.000	-	-	3.532	0.060	1.856	0.173
25–34	8.926	0.006	8.926	0.006	2.097	0.193	1.883	0.231	3.532	0.060	-	-	0.049	1.000
35–44	6.923	0.029	6.923	0.029	1.319	0.356	1.340	0.518	1.856	0.173	0.049	1.000	-	-
45+	7.273	0.026	7.273	0.026	1.606	0.332	1.593	0.505	2.198	0.138	0.000	1.000	0.035	1.000

The prevalence rate when calculated as teeth affected in the two to five year age range was significantly lower than the rates observed in the 25 to 34, 35 to 44, and 45+ year adult age ranges (Table 4.154).

Table 4.154: Comparison of neighbours caries lesions prevalence rates as teeth affected by age.

Age (years)	0 – 2		2 – 5		5 – 9		10 – 14		15 – 24		25 – 34		35 – 44	
	$X^2_{(1)}$	F	$X^2_{(1)}$	F	$X^2_{(1)}$	F/p	$X^2_{(1)}$	F	$X^2_{(1)}$	F/p	$X^2_{(1)}$	F/p	$X^2_{(1)}$	F/p
0 – 2	-	-	-	-	1.018	0.592	0.799	1.000	1.074	0.617	1.800	0.392	1.926	0.388
2 – 5	-	-	-	-	2.668	0.167	2.095	0.240	2.830	0.161	4.727	0.023	5.040	0.018
5 – 9	1.018	0.592	2.668	0.167	-	-	0.079	1.000	0.010	0.921	1.353	0.245	1.582	0.209
10–14	0.799	1.000	2.095	0.240	0.079	1.000	-	-	0.151	1.000	1.242	0.408	1.425	0.391
15–24	1.074	0.617	2.830	0.161	0.010	0.921	0.151	1.000	-	-	3.610	0.070	3.668	0.055
25–34	1.800	0.392	4.727	0.023	1.353	0.245	1.242	0.408	3.610	0.070	-	-	0.053	0.817
35–44	1.926	0.388	5.040	0.018	1.582	0.209	1.425	0.391	3.668	0.055	0.053	0.817	-	-
45+	2.060	0.377	5.367	0.020	1.749	0.186	1.589	0.361	3.455	0.063	0.161	0.689	0.035	0.851

Within the adults, there were 20 males and 32 females observable for caries lesions (Table 4.155). There was no significant difference in the overall prevalence rates between the sexes in the NP when calculated as individuals or as teeth affected. However, there were significantly more male teeth affected in the specific 15 to 24 year age range than in the females.

Table 4.155: Neighbours adult caries lesions prevalence rates by sex and calculation method.

Calculation Method	Age (years)	Males			Females			Comparison	
		No.	CL	TPR%	No.	CL	TPR%	$X^2_{(1)}$	F/p
Individuals Affected		20	12	60.0	32	21	65.6	0.168	0.682
	15 – 24	5	3	60.0	8	2	25.0	1.593	0.293
	25 – 34	8	4	50.0	11	10	90.9	3.997	0.111
	35 – 44	3	2	66.7	8	6	75.0	0.076	1.000
	45+	4	3	75.0	5	3	60.0	0.225	1.000
Teeth Affected		369	22	6.0	694	44	6.3	0.059	0.808
	15 – 24	90	9	10.0	191	4	2.1	8.665	0.005
	25 – 34	159	5	3.1	255	20	7.8	3.810	0.051
	35 – 44	70	4	5.7	160	14	8.8	0.622	0.596
	45+	50	4	8.0	88	6	6.8	0.066	1.000

The highest prevalence rate was observed in the Parliament House population between the four sites within the NP (Table 4.156). There was no significant difference observed in the prevalence rates within the four NP sites when calculated

either as individuals ($X^2_{(3)}$ = 1.383, p = 0.710) or as teeth affected ($X^2_{(3)}$ = 1.189, p = 0.756).

Table 4.156: Neighbours caries lesions prevalence rates by site.

Site	Individuals Affected			Teeth Affected		
	No.	CL	TPR %	No.	CL	TPR %
Fishergate House	26	13	50.0	508	27	5.3
Franciscan Friary	12	7	58.3	173	10	5.8
Parliament House	28	17	60.7	541	32	5.9
Whithorn	30	14	46.7	555	25	4.5

4.3 Conflict-zone and Neighbours Comparison

The demographic and palaeopathological data from the 215 CZP and 173 NP skeletons were directly compared to test the hypothesis that CZP demonstrated more skeletal indicators of nutritional stress and general poor health as a result of the impact of socio-political conflict. The results of these comparisons are presented in the following section.

The total count of individuals analysed overall (388; 299 adults and 89 non-adults) favoured the CZP (Table 4.157). The significant difference in count was specifically observed in the adult skeletons.

Table 4.157: Comparison of the count of skeletons.

Category	Conflict-zone		Neighbours		Comparison	
	No.	%	No.	%	$X^2_{(1)}$	p
Non-adults	48	22.3	41	23.7	0.551	0.458
Adults	167	77.7	132	76.3	4.097	0.043
Total	215	55.4	173	44.6	4.546	0.033

4.3.1 Preservation Comparison

The majority of CZP skeletons were described as in a good state of preservation with between 25% and 75% of their skeletal elements present and observable (Table 4.158). In contrast, the largest proportion of skeletons from the NP was described as poorly preserved. The CZP skeletons were in a significantly better state of preservation than the skeletons analysed from neighbouring populations ($X^2_{(2)}$ = 28.151, p < 0.001).

Table 4.158: Skeletal preservation by region.

Preservation	Conflict-Zone		Neighbours		Total	
	No.	%	No.	%	No.	%
Excellent	56	26.0	30	17.3	86	22.2
Good	117	54.4	66	38.2	183	47.2
Poor	42	19.5	77	44.5	119	30.6

This difference in preservation, however, did not apply to all ages. The significant differences in preservation were observed in the young adult and adult age categories, specifically in the adults between 15 and 24 and 35 and 44 years of age, where the CZP was in a markedly better state of preservation (Table 4.159). When the more specific age ranges were examined, a significant preservation difference was also identified within the non-adult age range. The CZP children from two to five years of age were significantly better preserved than the NP children of the same age.

Table 4.159: Comparison of preservation by age.

Age	Preservation	Conflict-zone No.	%	Neighbours No.	%	Comparison $X^2_{(2)}$	p
Non-adult						1.406	0.495
	Excellent	13	27.1	7	17.1		
	Good	29	60.4	27	65.8		
	Poor	6	12.5	7	17.1		
Young Adult						13.763	0.001
	Excellent	12	28.6	6	16.2		
	Good	20	47.6	7	18.9		
	Poor	10	23.8	24	64.9		
Adult						15.440	<0.001
	Excellent	24	25.5	13	17.1		
	Good	51	54.3	26	34.2		
	Poor	19	20.2	37	48.7		
Older Adult						3.660	0.160
	Excellent	7	22.6	4	21.1		
	Good	17	54.8	6	31.6		
	Poor	7	22.6	9	47.3		
0 – 2						3.759	0.153
	Excellent	2	12.5	4	36.4		
	Good	11	68.8	7	63.6		
	Poor	3	18.8	-	-		
2 – 5						6.567	0.012
	Excellent	2	18.2	-	-		
	Good	9	81.8	6	60.0		
	Poor	-	-	4	40.0		
5 – 9						4.905	0.075
	Excellent	8	53.3	2	14.3		
	Good	6	40.0	10	71.4		
	Poor	1	6.7	2	14.3		
10 – 14						0.476	0.785
	Excellent	1	16.7	1	16.7		
	Good	3	50.0	4	66.7		
	Poor	2	33.3	1	16.7		
15 – 24						13.763	0.001
	Excellent	12	28.6	6	16.2		
	Good	20	47.6	7	18.9		
	Poor	10	23.8	24	64.9		
25 – 34						5.593	0.061
	Excellent	9	22.0	5	10.9		
	Good	22	53.7	19	41.3		
	Poor	10	24.4	22	47.8		
35 – 44						11.591	0.003
	Excellent	15	28.3	8	26.7		
	Good	29	54.7	7	23.3		
	Poor	9	17.0	15	50.0		
45+						3.660	0.160
	Excellent	7	22.6	4	21.1		
	Good	17	54.8	6	31.6		
	Poor	7	22.6	9	47.3		

Within the adults, the CZP females were significantly better preserved than the NP females (Table 4.160). Similarly, the sexually indeterminate individuals in the CZP were significantly better preserved than those in the NP. The same trend was observed in the skeletal completeness of the males between the two populations with the CZP in an overall better state than the NP. However, this difference was not statistically significant.

Table 4.160: Comparison of preservation by sex.

Sex	Preservation	Conflict-zone No.	%	Neighbours No.	%	Comparison $X^2_{(2)}$	p
Males						4.291	0.117
	Excellent	22	31	11	28		
	Good	37	53	16	40		
	Poor	11	16	13	32		
Females						6.948	0.031
	Excellent	15	22	9	19		
	Good	42	62	21	44		
	Poor	11	16	18	37		
Indeterminate						14.789	0.001
	Excellent	6	21	3	7		
	Good	9	31	2	4		
	Poor	14	48	39	89		

Table 4.161: Comparison of female and sexually indeterminate adult preservation by age.

Sex	Age (years)	Preservation	Conflict-zone No.	%	Neighbours No.	%	Comparison $X^2_{(2)}$	F/p
Females	15 – 24						5.051	0.071
		Excellent	1	9.1	1	9.1		
		Good	8	72.7	3	27.3		
		Poor	2	18.2	7	63.6		
	25 – 34						0.759	0.682
		Excellent	2	13.3	3	20.0		
		Good	8	53.3	9	60.0		
		Poor	5	33.3	3	20.0		
	35 – 44						3.348	0.198
		Excellent	8	36.4	4	33.3		
		Good	12	54.5	4	33.3		
		Poor	2	9.1	4	33.3		
	45+						3.821	0.161
		Excellent	4	20.0	1	10.0		
		Good	14	70.0	5	50.0		
		Poor	2	10.0	4	40.0		
Indeterminate	15 – 24						3.363	0.190
		Excellent	2	18.2	2	11.1		
		Good	3	27.3	1	5.6		
		Poor	6	54.5	15	83.3		
	25 – 34						9.534	0.005
		Excellent	3	42.9	-	-		
		Good	2	28.6	1	7.7		
		Poor	2	28.6	12	92.3		
	35 – 44						4.289	0.065
		Excellent	1	12.5	1	11.1		
		Good	3	37.5	-	-		
		Poor	4	50.0	8	88.9		
	45+						$X^2_{(1)}$=1.556	0.429
		Excellent	-	-	-	-		
		Good	1	33.3	-	-		
		Poor	2	66.7	4	100.0		

When the preservation state of the females and adults of indeterminate sex were compared between the two populations by age, no significant differences were identified in the female individuals (Table 4.161). However, the indeterminate individuals between 25 and 34 years were significantly better preserved in the CZP than in the NP.

4.3.2 Demographic Comparison

Despite the differential preservation, comparisons of sex, age-at-death, and body shape distributions were possible between the two regional populations. The results of these comparisons are descibed in the following section.

4.3.2.1 Sex Comparison

The highest count of CZP adults were estimated to have been either male or female, while the highest count of NP adults was in the indeterminate sex category (Table 4.162, Figure 4.17). This difference in the sex distributions through the five possible estimation categories was statistically significant between the CZP and NP ($X^2_{(4)}$ = 12.484, p = 0.014). There were significantly more males and females in the CZP than in the NP.

When the sex categories were simplified into male, female, and indeterminate, the distribution of the adults through the three sex categories also differed significantly between the two populations ($X^2_{(2)}$ = 10.763, p = 0.005). There were significantly more males in the CZP than in the NP. In contrast, there was no significant difference in the number of females or in the number of adults of indeterminate sex between the two sites.

Table 4.162: Comparison of adult sex distribution.

Category	Sex	Conflict-zone No.	%	Neighbours No.	%	Comparison $X^2_{(1)}$	p
Sex	Males	48	28.7	24	18.2	8.000	0.005
	Possible Males	22	13.2	16	12.1	0.947	0.330
	Indeterminate	29	17.4	44	33.3	3.082	0.079
	Possible Females	25	15.0	22	16.7	0.191	0.662
	Females	43	25.7	26	19.7	4.188	0.041
Simplified Sex	Males	70	41.9	40	30.3	8.182	0.004
	Females	68	40.7	48	36.4	3.448	0.063
	Indeterminate	29	17.4	44	33.3	3.082	0.079
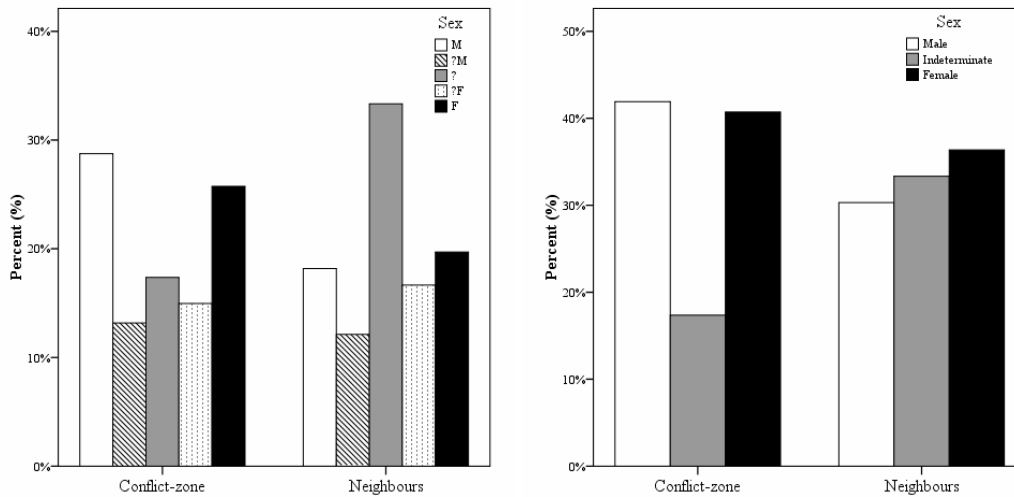
Figure 4.17: Comparison of adult sex distributions by sex category (left) and simplified sex (right).

4.3.2.2 Age at Death Comparison

The highest percentage of both the CZP and NP individuals was estimated to have died during adulthood (Table 4.163, Figure 4.18). The largest percent of the CZP was estimated to have died between the ages of 35 and 44 years, similar to the NP where the largest percentage died between the ages of 25 and 34 years. There were significantly more CZP individuals in the 35 to 44 year age range than in the NP. Despite these differences in count, there were no significant differences in the age distributions of individuals through the age categories ($X^2_{(3)} = 1.120$, p = 0.772), or the age ranges ($X^2_{(7)} = 6.394$, p = 0.495), between the regional populations.

Table 4.163: Comparison of age distribution.

Type	Age	Conflict-zone No.	Conflict-zone %	Neighbours No.	Neighbours %	Comparison $X^2_{(1)}$	Comparison p
Age Category	Non-adult	48	22.3	41	23.7	0.551	0.458
	Young Adult	42	19.5	37	21.4	0.316	0.574
	Adult	94	43.7	76	43.9	1.906	0.167
	Older Adult	31	14.4	19	11.0	2.880	0.090
Age (years)	0 – 2	16	7.4	11	6.4	0.926	0.336
	2 – 5	11	5.1	10	5.8	0.048	0.827
	5 – 9	15	7.0	14	8.1	0.034	0.853
	10 – 14	6	2.8	6	3.4	0.000	1.000
	15 – 24	42	19.5	37	21.4	0.316	0.574
	25 – 34	41	19.1	46	26.6	0.287	0.592
	35 – 44	53	24.7	30	17.3	6.373	0.012
	45+	31	14.4	19	11.0	2.880	0.090
Total		215	100	173	100	4.546	0.033

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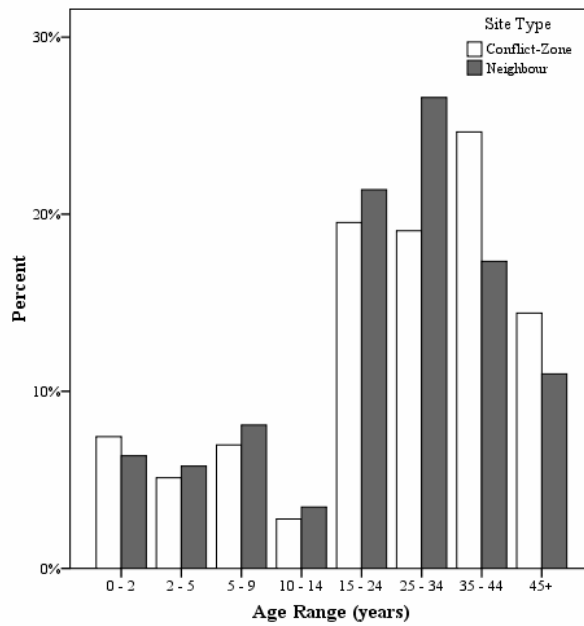
Figure 4.18: Age at death distribution by region.

The mortality profiles of both populations were similar (Figure 4.19). Life expectancy at birth (e_0) for the CZP was 28.80 years and for the NP was 26.60 years. This difference in life expectancy between the populations was not significant (p = 0.136).
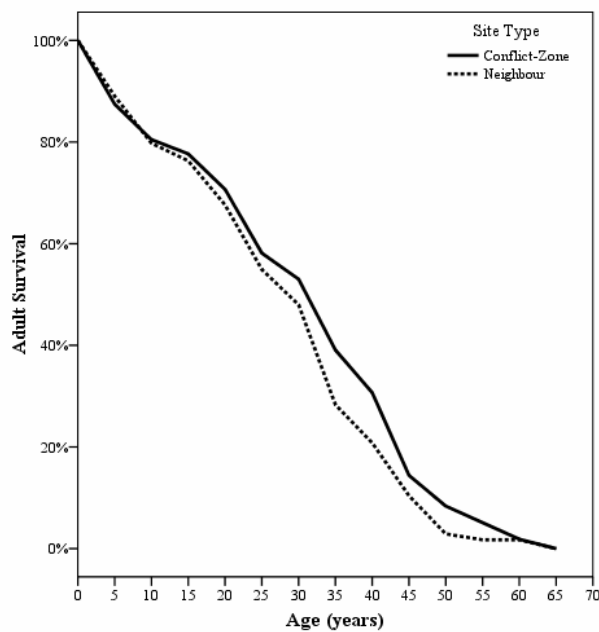
Figure 4.19: Mortality as a percentage of survival.

The mortality rates for the male and female adults who survived to the young adult age range (e_{15}) were compared between both regional populations (Figure 4.20).

Life expectancy for males who reached 15 years of age in the CZP was 33.00 years and was 33.45 years for the males in the NP. There was no significant difference observed between the male mortality profiles in the CZP and NP (p = 0.876).
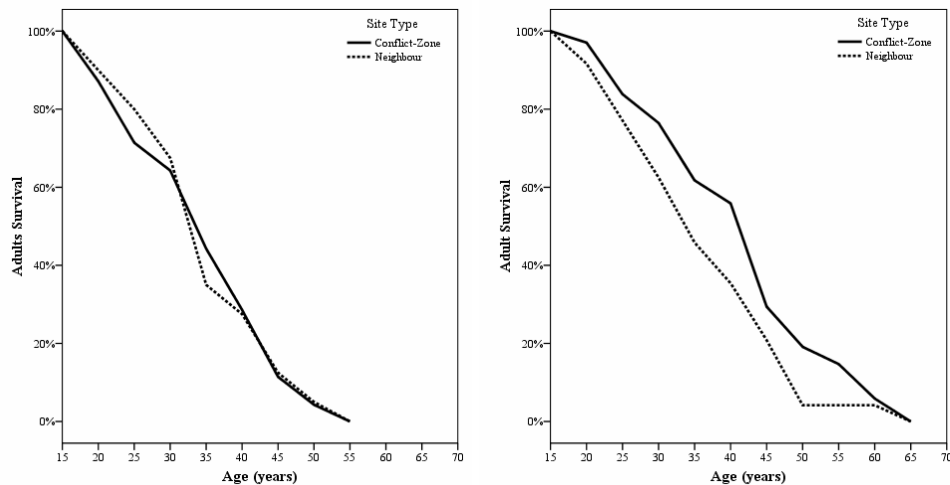
Figure 4.20: Male (left) and female (right) mortality as a percentage of survival.

The life expectancy of the females in the CZP who survived to 15 years (e_{15}) was 39.70 years and was 34.80 years for the same females in the NP. The female mortality rate in the NP was higher than in the CZP, which reduced the overall survivorship of female adults in the NP at a faster rate than in the CZP. This difference between the two populations was statistically significant (p = 0.048).

4.3.2.3 Body Shape Comparison

The following section summarises the comparison of estimated stature, body mass, platymeric and platycnemic indices for the two regional populations.

4.3.2.3.a Stature Comparison

Stature was estimated for a total of 210 adults in this study, 133 adults from the conflict zone population and 77 adults from the NP (Table 4.164, Figure 4.21). There were no significant differences observed in the mean statures either of the sexes or the individuals of indeterminate sex between populations.

Table 4.164: Adult stature estimates.

	Conflict-zone			*Neighbours*			*Comparison*	
Sex	*No.*	*Mean (cm)*	*S.D. (cm)*	*No.*	*Mean (cm)*	*S.D. (cm)*	*t*	*p*
Males	60	168.85	5.72	31	169.14	5.02	0.239	0.812
Females	58	159.68	6.33	31	159.43	6.31	-0.178	0.859
Indeterminate	15	163.73	8.47	15	164.85	9.22	0.347	0.731
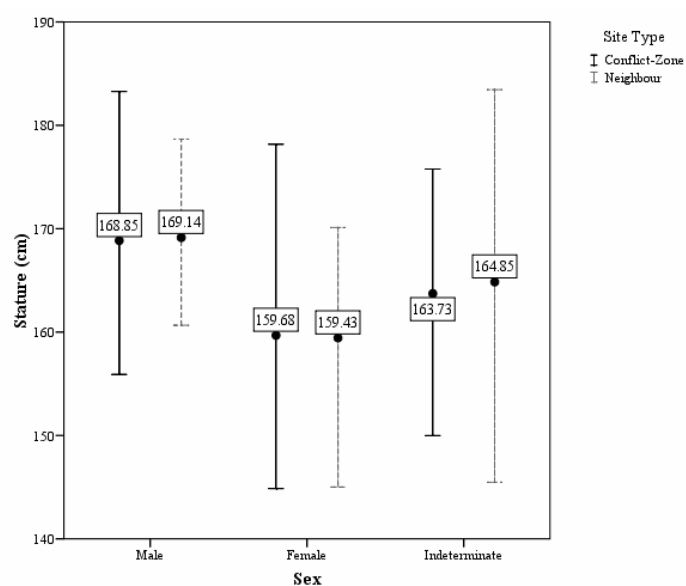
Figure 4.21: Adult stature means and ranges by region.

A total of 56 non-adults were preserved well enough to allow stature estimations to be calculated. When directly compared by age, the CZP mean stature was only significantly shorter than the NP for the children estimated around six years of age (Table 4.165). The overall growth patterns in both populations, based on the non-adult stature estimations, were remarkably similar (Figure 4.22).

Table 4.165: Non-adult stature by mean estimated age-at-death.

Age (years)	No.	Conflict-zone Mean (cm)	S.D. (cm)	No.	Neighbours Min. (cm)	Max. (cm)	Comparison t	p
0.00	2	50.86	2.43	2	55.95	0.37	-2.926	0.201
0.20	1	86.39	-	-	-	-	-	-
0.25	1	65.11	-	-	-	-	-	-
0.50	1	63.89	-	-	-	-	-	-
0.75	3	65.01	3.51	-	-	-	-	-
1.00	1	70.17	-	-	-	-	-	-
1.50	2	77.16	1.68	-	-	-	-	-
2.00	1	83.53	-	-	-	-	-	-
2.50	1	86.59	-	2	83.25	4.14	0.660	0.629
3.00	2	99.57	1.61	2	92.23	4.83	2.040	0.254
3.50	1	75.73	-	1	87.10	-	-	-
4.00	2	95.64	3.29	-	-	-	-	-
5.00	1	101.34	-	2	107.41	18.16	-0.273	0.830
5.50	-	-	-	1	100.31	-	-	-
6.00	5	105.14	5.36	1	122.87	-	-3.019	0.039
7.00	4	115.55	11.64	2	121.28	5.41	-0.634	0.561
7.50	-	-	-	2	105.28	1.91	-	-
8.00	-	-	-	1	108.40	-	-	-
9.00	3	117.85	3.58	2	120.74	1.05	-1.061	0.367
10.00	-	-	-	3	144.43	5.19	-	-
11.00	1	134.48	-	-	-	-	-	-
12.00	1	146.89	-	1	127.72	-	-	-
12.50	1	153.32	-	-	-	-	-	-
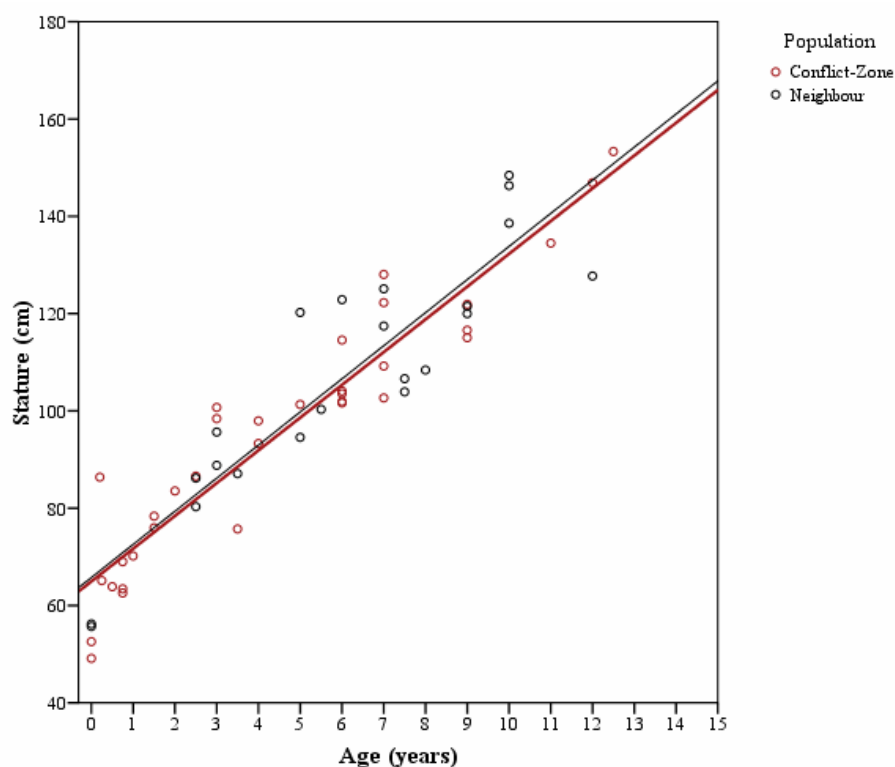
Figure 4.22: Comparison of stature estimation equations for the non-adults.

4.3.2.3.b Body Mass Comparison

Body mass was estimated for a total of 174 adults in this study. Overall, there were 117 adults in the CZP available for body mass estimation and 57 individuals from the NP. There was no significant difference in the mean body mass between the CZP and NP for males, females, or adults of indeterminate sex (Table 4.166, Figure 4.23). This result was consistent across both methods of body mass estimation for these two populations.

Table 4.166: Adult body mass by sex and estimation method.

Calculation Method	Sex	*Conflict-Zone* No.	Mean (kg)	S.D.	*Neighbours* No.	Mean (kg)	S.D.	*Comparison* t	p
Femoral Head	Male	59	68.61	6.21	27	66.93	5.75	-1.187	0.238
Diameter	Female	49	61.93	5.52	25	59.42	6.00	-1.793	0.077
	Indeterminate	9	62.20	7.54	5	55.77	6.89	-1.573	0.142
Bi-iliac Breadth	Male	18	68.68	7.08	8	66.82	5.32	-0.661	0.515
	Female	9	58.53	6.92	7	63.55	7.46	1.392	0.186
	Indeterminate	4	64.84	9.28	-	-	-	-	-
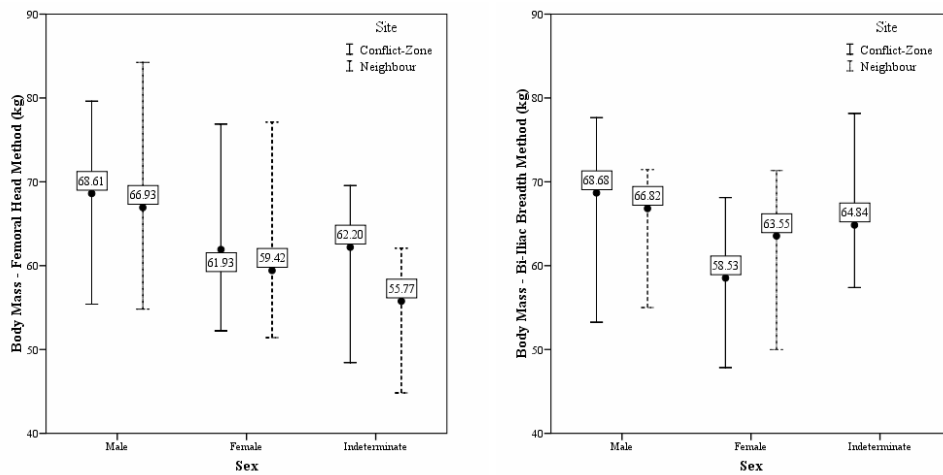
Figure 4.23: Comparison of adult body mass by femoral head diameter method (left) and by bi-iliac breadth method (right) by population.

It was only possible to estimate body mass for five non-adult individuals, all of whom were from the NP. The lack of non-adults available in the CZP for body mass estimation prevented the direct comparison of non-adult body mass estimates between the two regional populations.

4.3.2.3.c Platymeric Index Comparison

It was possible to calculate the platymeric index for 133 adult individuals in this study (Table 4.167). There was no significant difference in the mean indices between the CZP and the NP overall, for the males or for the females. However, the mean index for the adults of indeterminate sex in the CZP was significantly lower than that in the NP.

Table 4.167: Platymeric index summaries by sex.

| | Conflict-zone | | | Neighbours | | | Comparison | |
Sex	No.	Mean	S.D.	No.	Mean	S.D.	t	p
Male	63	83.43	10.01	30	83.70	8.78	0.126	0.900
Female	56	87.76	14.61	29	93.00	18.52	1.427	0.157
Indeterminate	14	79.64	9.62	7	88.46	7.58	2.111	0.048
Total	133	84.86	12.35	66	88.29	14.39	1.747	0.082

This difference in the means did not affect the distribution of the indices throughout the three possible platymeric categories (Table 4.168). There was no significant difference in the distribution of the indices through the platymeric categories between the CZP and the NP ($X^2_{(2)} = 2.734$, p = 0.255). There was also no significant difference in the distribution of the individual indices observed between the males ($X^2_{(2)} = 0.382$, p = 0.826), the females ($X^2_{(2)} = 3.252$, p = 0.197), or the adults of indeterminate sex ($X^2_{(2)} = 2.901$, p = 0.234).

Table 4.168: Platymeric index by type and sex.

Sex	Site	No.	Platymeric No.	Platymeric %	Eurymeric No.	Eurymeric %	Stenomeric No.	Stenomeric %
Male	Conflict-zone	63	40	63.5	18	28.6	5	7.9
	Neighbours	30	21	70.0	7	23.3	2	6.7
Female	Conflict-zone	56	27	48.2	22	39.3	7	12.5
	Neighbours	29	13	44.8	8	27.6	8	27.6
Indeterminate	Conflict-zone	14	10	71.4	4	28.6	-	-
	Neighbours	7	3	42.9	3	42.9	1	14.2
Total	Conflict-zone	133	77	57.9	44	33.1	12	9.0
	Neighbours	66	37	56.1	18	27.3	11	16.6

4.3.2.3.d Platycnemic Index Comparison

It was possible to calculate the platycnemic index for 185 adult individuals; 119 individuals from the CZP and 66 from the NP were observed (Table 4.169). The overall mean index was significantly higher in the NP than in the CZP. This difference, however, did not translate to the mean indices observed by sex. There was no significant difference in the mean indices between the two populations for the males, the females, or the adults of indeterminate sex.

Table 4.169: Platycnemic index summaries by sex.

Sex	Conflict-zone No.	Conflict-zone Mean	Conflict-zone S.D.	Neighbours No.	Neighbours Mean	Neighbours S.D.	Comparison t	Comparison p
Male	59	69.21	6.14	25	70.82	4.29	1.195	0.236
Female	47	70.50	6.63	27	72.72	4.86	1.521	0.133
Indeterminate	13	70.42	6.89	14	74.08	6.75	1.396	0.175
Total	119	69.85	6.40	66	72.29	5.19	2.653	0.009

The CZP individuals were more evenly distributed between the mesocnemic and eurycnemic index classifications while the majority of the NP individuals were classified as eurycnemic (Table 4.170). The CZP also included individuals with platycnemic and hypoplatycnemic indices. The difference in distribution of individuals through the platycnemic categories between the CZP and the NP was statistically significant ($X^2_{(3)} = 11.049$, p = 0.011).

There was no significant difference observed between the males ($X^2_{(3)} = 4.889$, p = 0.180), but there was a significant difference between the females ($X^2_{(2)} = 7.353$, p = 0.025); the CZP females were more evenly distributed between the mesocnemic and eurycnemic index categories in contrast to the NP females who were eurycnemic. Similarly, there was a significant difference in the distribution patterns within the adults of indeterminate sex ($X^2_{(2)} = 11.106$, p = 0.004); there were more CZP adults of indeterminate sex categorised as platycnemic than in the NP adults which were categorised as mesocnemic.

Table 4.170: Platycnemic index by type and sex.

Sex	Site	No.	Hypoplatycnemic No.	Hypoplatycnemic %	Platycnemic No.	Platycnemic %	Mesocnemic No.	Mesocnemic %	Eurycnemic No.	Eurycnemic %
Male	Conflict-zone	59	1	1.7	6	10.2	26	44.1	26	44.1
	Neighbours	23	-	-	-	-	11	47.8	12	52.2
Female	Conflict-zone	47	-	-	6	12.8	20	42.6	21	44.7
	Neighbours	27	-	-	-	-	9	33.3	18	66.7
Indeterminate	Conflict-zone	13	-	-	4	30.8	-	-	9	69.2
	Neighbours	14	-	-	-	-	4	28.6	10	71.4
Total	Conflict-zone	119	1	0.8	16	13.4	46	38.7	56	47.1
	Neighbours	64	-	-	-	-	24	37.5	40	62.5

4.3.3 Palaeopathological Comparison

The prevalence rates of non-specific indicators of stress, metabolic bone disease and non-specific infections were directly compared between the CZP and NP to test the hypothesis that the CZP was less healthy than their contemporary neighbours. The results of this comparison are summarised in the following section.

4.3.3.1 Cribra Orbitalia Comparison

There were a total of 206 individuals with orbits present and, of those individuals, 77 had cribra orbitalia lesions. A total of 124 lesions were observed in the 376 orbits available for analysis.

The highest prevalence rate based on individuals affected was in the non-adult age category for both populations (Table 4.171). The highest rate of orbits affected in the CZP was also in the non-adults. However, the highest prevalence rate of orbits affected was in the young adult age category in the NP. There were no significant differences observed in the overall number of individuals or orbits affected between the CZP and NP. However, there was a significantly higher prevalence rate in the CZP infants between birth and two years old than in the NP infants. In contrast, there was a significantly higher rate of orbits affected in the NP non-adults between the ages of 10 and 14 than in the CZP.

There were 54 males and 73 females in this study observable for cribra orbitalia lesions (Table 4.172). There were no significant differences observed in the prevalence rates between the populations for either the males or the females.

Table 4.171: Comparison of cribra orbitalia prevalence rates by age.

Calculation Method	Type	Age	Conflict-zone No.	CO	TPR %	Neighbours No.	CO	TPR %	Comparison $X^2_{(1)}$	F/p
Individuals			137	49	35.8	69	28	40.6	0.454	0.500
Affected	Age	Non-adults	37	23	62.2	16	9	56.3	0.163	0.686
	Category	Young Adults	29	8	27.6	15	7	46.7	1.602	0.206
		Adults	52	12	23.1	31	11	35.5	1.492	0.222
		Older Adults	19	6	31.6	7	1	14.3	0.778	0.378
	Age	0 – 2	12	7	58.3	7	1	14.3	3.519	0.147
	(years)	2 – 5	9	6	66.7	2	2	100.0	0.917	1.000
		5 – 9	12	10	83.3	5	4	80.0	0.027	1.000
		10 – 14	4	-	-	2	2	100.0	6.000	0.067
		15 – 24	29	8	27.6	15	7	46.7	1.602	0.206
		25 – 34	22	5	22.7	18	8	44.4	2.128	0.145
		35 – 44	30	7	23.3	13	3	23.1	0.000	1.000
		45+	19	6	31.6	7	1	14.3	0.778	0.629
Orbits Affected			253	82	32.4	123	42	34.1	0.113	0.737
	Age	Non-adults	66	37	56.1	30	12	40.0	1.219	0.145
	Category	Young Adults	53	13	24.5	26	11	42.3	2.607	0.106
		Adults	99	22	22.2	54	17	31.5	1.577	0.209
		Older Adults	35	10	28.6	13	2	15.4	0.879	0.469
	Age	0 – 2	21	12	57.1	14	2	14.3	6.429	0.011
	(years)	2 – 5	16	8	50.0	4	3	75.0	0.808	0.591
		5 – 9	21	17	81.0	8	4	50.0	2.778	0.164
		10 – 14	8	-	-	4	3	75.0	8.000	0.018
		15 – 24	53	13	24.5	26	11	42.3	2.607	0.106
		25 – 34	40	9	22.5	31	12	38.7	2.203	0.138
		35 – 44	59	13	22.0	23	5	21.7	0.001	0.977
		45+	35	10	28.6	13	2	15.4	0.879	0.469

Table 4.172: Comparison of adult cribra orbitalia prevalence rates by sex.

Calculation Method	Sex	Conflict-zone No.	CO	TPR %	Neighbours No.	CO	TPR%	Comparison $X^2_{(1)}$	p
Individuals Affected	Males	36	12	33.3	18	6	33.3	0.000	1.000
	Females	46	12	26.1	27	9	33.3	0.436	0.509
Orbits Affected	Males	67	22	32.8	31	9	29.0	0.142	0.707
	Females	85	19	22.4	49	15	30.6	1.120	0.290

No porotic hyperostosis lesions were observed in the 248 individuals with parietal bones. A total of 163 individuals from the CZP and 85 individuals from the NP were observed. No statistical comparisons between the CZP and NP could be undertaken for this lesion.

4.3.3.2 Enamel Hypoplasia Comparison

There were a total of 250 individuals with dentitions present and observable. A total of 169 of those individuals had enamel hypoplastic lesions, and a total of 1202 lesions were observed in the 4752 teeth available for analysis.

The highest prevalence rates based on individuals affected were in the young adult age category for both populations (Table 4.173). There was no significant difference in the count of individuals affected by enamel hypoplastic lesions between

the CZP and NP. However, there were significantly more teeth affected by enamel hypoplasia lesions in the CZP than in the NP. This difference was specifically in the young adults and adults between the ages of 15 and 44 years.

Table 4.173: Comparison of enamel hypoplasia prevalence rates by age.

Calculation Method	Type	Age	Conflict-zone No.	EH	TPR %	Neighbours No.	EH	TPR %	Comparison $X^2_{(1)}$	p
Individuals Affected			158	108	68.4	92	61	66.3	0.112	0.738
	Age Category	Non-adults	41	19	46.3	19	10	52.6	0.206	0.650
		Young Adults	36	32	88.9	30	25	83.3	0.429	0.721
		Adults	60	46	76.7	34	22	64.7	1.552	0.213
		Older Adults	21	11	52.4	9	4	44.4	0.159	1.000
	Age (years)	0 – 2	12	-	-	4	-	-	-	-
		2 – 5	11	4	36.4	5	1	20.0	0.428	1.000
		5 – 9	14	11	78.6	7	6	85.7	0.154	1.000
		10 – 14	4	4	100.0	3	3	100.0	-	-
		15 – 24	36	32	88.9	30	25	83.3	0.429	0.721
		25 – 34	29	21	72.4	21	14	66.7	0.192	0.662
		35 – 44	31	25	80.6	13	8	61.5	1.783	0.182
		45+	21	11	52.4	9	4	44.4	0.159	1.000
Teeth Affected			2993	857	28.6	1759	345	19.6	47.702	<0.001
	Age Category	Non-adults	573	129	22.5	281	66	23.5	0.102	0.750
		Young Adults	786	337	42.9	630	143	22.7	63.536	<0.001
		Adults	1294	357	27.6	705	113	16.0	33.914	<0.001
		Older Adults	340	34	10.0	143	23	16.1	3.580	0.058
	Age (years)	0 – 2	66	-	-	24	-	-	-	-
		2 – 5	157	6	3.8	66	1	1.5	0.813	0.677
		5 – 9	267	82	30.7	127	32	25.2	1.273	0.259
		10 – 14	83	41	49.4	64	33	51.6	0.068	0.795
		15 – 24	786	337	42.9	630	143	22.7	63.536	<0.001
		25 – 34	607	174	28.7	441	65	14.7	28.139	<0.001
		35 – 44	687	183	26.6	264	48	18.2	7.415	0.006
		45+	340	34	10.0	143	23	16.1	3.580	0.058

There were 63 males and 81 females observable for enamel hypoplasia lesions (Table 4.174). There were no significant differences observed in the prevalence rates of individuals affected between the populations for either the males or the females. However, the CZP had a significantly higher prevalence rate of teeth affected in both the male and female adults. The CZP prevalence rate was significantly higher in the males from the ages of 15 to 44 years. The prevalence rate in the CZP females was significantly higher than the NP in only the 15 to 24 year age range. In contrast, the rate of enamel hypoplasia in the 45+ females was significantly higher in the NP compared to the CZP.

Table 4.174: Comparison of adult enamel hypoplasia prevalence rates by sex and age.

Calculation Method	Sex	Age (years)	Conflict-zone No.	EH	TPR %	Neighbours No.	EH	TPR %	Comparison $X^2_{(1)}$	p
Individuals Affected	Males		46	35	76.1	17	11	64.7	0.816	0.366
	Females		49	40	81.6	32	22	68.8	1.789	0.181
Teeth Affected	Males		1001	309	30.9	352	50	14.2	37.101	<0.001
		15 – 24	375	151	40.3	90	24	26.7	5.720	0.017
		25 – 34	232	63	27.2	155	24	15.5	7.263	0.007
		35 – 44	318	90	28.3	70	2	2.9	20.534	<0.001
		45+	76	5	6.6	37	-	-	2.547	0.170
	Females		979	272	27.8	694	144	20.7	10.756	0.001
		15 – 24	233	122	52.4	191	51	26.7	28.610	<0.001
		25 – 34	258	49	19.0	255	40	15.7	0.978	0.323
		35 – 44	275	72	26.2	160	30	18.8	3.122	0.078
		45+	213	29	13.6	88	23	26.1	6.832	0.009

4.3.3.3 Non-Specific Infections Comparison

A total of 384 individuals were well preserved enough to observe for pathological lesions indicative of non-specific infections, and a total of 243 individuals had observable signs. There were no significant differences observed between the CZP and their contemporary neighbours in the overall prevalence rate of non-specific infections, or in the majority of rates observed in specific skeletal locations (Table 4.175, Figure 4.24). However, the maxillary sinusitis prevalence rate in the NP was significantly higher than the rate observed in the CZP.

Table 4.175: Comparison of non-specific infection rates by type.

Category	Conflict-Zone No.	Affected	TPR %	Neighbours No.	Affected	TPR %	Comparison $X^2_{(1)}$	p
Non-Specific Infections	215	136	63.3	169	107	63.3	0.000	0.991
Endocranial Lesions	167	28	16.8	82	19	23.2	1.473	0.225
Maxillary Sinusitis	118	67	56.8	72	59	81.9	12.677	<0.001
Rib Lesions	186	13	7.0	102	12	11.8	1.895	0.169
Periosteal Lesions	204	95	46.6	140	59	42.1	0.658	0.417
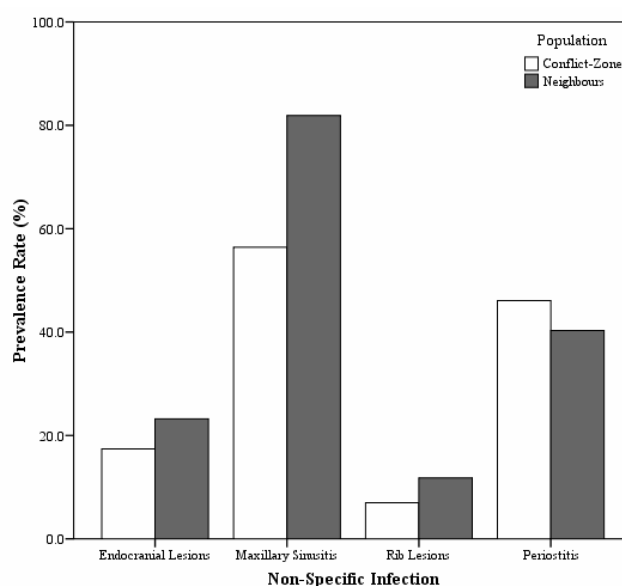
Figure 4.24: Comparison of non-specific infection rates by type.

The highest prevalence rate for non-specific infections was observed in the older adult broad age category for both regional populations (Table 4.176). The prevalence rates in the CZP stayed consistently above 50% throughout the age categories, in contrast to the rates in the NP which increased with age. The CZP prevalence rate for the non-adults was significantly higher than the rate observed in the NP non-adults. The rate in the CZP was significantly higher for the non-adults between five and nine years old than the rate in the NP for the same age range.

Table 4.176: Comparison of non-specific infection prevalence rates by age.

Type	Age	Conflict-zone			Neighbours			Comparison	
		No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F/p
Age Category	Non-adults	48	32	66.7	41	16	39.0	6.800	0.009
	Young Adults	42	27	64.3	35	23	65.7	0.017	0.896
	Adults	94	55	58.5	76	55	72.4	3.534	0.060
	Older Adults	31	22	71.0	17	13	76.5	0.168	0.747
Age (years)	0 – 2	16	9	56.3	11	3	27.3	2.217	0.239
	2 – 5	11	9	81.8	10	4	40.0	3.884	0.080
	5 – 9	15	13	86.7	14	7	50.0	4.549	0.050
	10 – 14	6	1	16.7	6	2	33.3	0.444	1.000
	15 – 24	42	27	64.3	35	23	65.7	0.017	0.896
	25 – 34	41	24	58.5	46	35	76.1	3.059	0.108
	35 – 44	53	31	58.5	30	20	66.7	0.541	0.462
	45+	31	22	71.0	17	13	76.5	0.168	0.747
Total		215	136	63.3	169	107	63.3	0.000	0.991

Within the 295 adult individuals, a total of 110 males and 115 females were observed for indications of non-specific infections. All the prevalence rates observed in both sexes within each population were above 45%. There were no significant

differences observed between the populations in prevalence rates in the sex categories overall, or within the more specific age ranges (Table 4.177).

Table 4.177: Comparison of adult non-specific infection prevalence rates by sex and age.

| Sex | Age (years) | Conflict-zone | | | Neighbours | | | Comparison | |
		No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F/p
Males		70	47	67.1	40	30	75.0	0.748	0.387
	15 – 24	20	15	75.0	8	5	62.5	0.438	0.651
	25 – 34	19	13	68.4	18	14	77.8	0.410	0.714
	35 – 44	23	14	60.9	9	6	66.7	0.093	1.000
	45+	8	5	62.5	5	5	100.0	2.438	0.231
Females		68	41	60.3	47	32	68.1	0.728	0.435
	15 – 24	11	7	63.6	11	5	45.5	0.733	0.670
	25 – 34	15	8	53.3	15	12	80.0	2.400	0.245
	35 – 44	22	12	54.5	12	9	75.0	1.376	0.292
	45+	20	14	70.0	9	6	66.7	0.032	1.000

4.3.3.3.a Endocranial Lesions Comparison

A total of 249 individuals were well preserved enough to observe for pathological lesions on the endocranial surfaces of the skull. A total of 47 individuals had visible non-specific infectious lesions on their endocranial surfaces. There were no significant differences observed between the CZP and their contemporary neighbours in the overall prevalence rate of endocranial lesions (Table 4.178).

Table 4.178: Comparison of endocranial lesions prevalence rates by age.

| Type | Age | Conflict-zone | | | Neighbours | | | Comparison | |
		No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F/p
Age Category	Non-adults	44	10	22.7	29	4	13.8	0.900	0.383
	Young Adults	34	7	20.6	13	1	7.7	1.107	0.413
	Adults	65	7	10.8	36	14	38.9	11.124	0.001
	Older Adults	24	4	16.7	4	-	-	0.778	1.000
Age (years)	0 – 2	14	5	35.7	10	3	30.0	0.086	1.000
	2 – 5	11	2	18.2	5	1	20.0	0.007	1.000
	5 – 9	15	3	20.0	12	-	-	2.700	0.231
	10 – 14	4	-	-	2	-	-	-	-
	15 – 24	34	7	20.6	13	1	7.7	1.107	0.413
	25 – 34	27	3	11.1	22	8	36.4	4.440	0.046
	35 – 44	38	4	10.5	14	6	42.9	6.885	0.016
	45+	24	4	16.7	4	-	-	0.778	1.000
Total		167	28	16.8	82	19	23.2	1.473	0.225

The highest prevalence rate was observed in the non-adults in the CZP and in the adults in the NP. Although the overall rate between the two populations was not significantly different, the NP rate in the adult age category was significantly higher than the rate in the CZP adults. The same trends in both populations were observed in the more specific age ranges. The significant difference between the populations was specifically observed in the adult individuals between 25 and 44 years old.

Within the 176 adult individuals, a total of 62 males and 80 females were observed for indications of endocranial lesions. The overall prevalence rate for all of the adults in the NP was significantly higher than the rate in the CZP (Table 4.179). However, there were no significant differences observed between the regional populations in the prevalence rates observed in either the male or female sex categories overall, or within the more specific age ranges.

Table 4.179: Comparison of adult endocranial lesions prevalence rates by sex and age.

Sex	Age (years)	Conflict-zone			Neighbours			Comparison	
		No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F/p
Males		45	7	15.6	17	6	35.3	2.901	0.089
	15 – 24	14	5	35.7	4	1	25.0	0.161	1.000
	25 – 34	10	1	10.0	8	3	37.5	1.945	0.275
	35 – 44	15	1	6.7	4	2	50.0	4.460	0.097
	45+	6	-	-	1	-	-	-	-
Females		53	7	13.2	27	6	22.2	1.068	0.301
	15 – 24	10	-	-	7	-	-	-	-
	25 – 34	12	1	8.3	10	2	20.0	0.630	0.571
	35 – 44	16	3	18.8	8	4	50.0	2.521	0.167
	45+	15	3	20.0	2	-	-	0.486	1.000

4.3.3.3.b Maxillary Sinusitis Comparison

A total of 189 individuals were well preserved enough to observe for pathological lesions indicative of maxillary sinusitis. A total of 126 individuals had observable signs of maxillary sinusitis. The maxillary sinusitis prevalence rate in the NP was significantly higher than the rate observed in the CZP (Table 4.180).

Table 4.180: Comparison of maxillary sinusitis prevalence rates by age.

Type	Age	Conflict-zone			Neighbours			Comparison	
		No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F/p
Age Category	Non-adults	22	12	54.5	12	7	58.3	0.045	0.832
	Young Adults	29	16	55.2	20	18	90.0	6.759	0.012
	Adults	48	28	58.3	31	26	83.9	5.679	0.017
	Older Adults	19	11	57.9	9	8	88.9	2.690	0.195
Age (years)	0 – 2	2	1	50.0	2	-	-	1.333	1.000
	2 – 5	6	5	83.3	3	2	66.7	0.321	1.000
	5 – 9	10	6	60.0	4	3	75.0	0.280	1.000
	10 – 14	4	-	-	3	2	66.7	3.733	0.143
	15 – 24	29	16	55.2	20	18	90.0	6.759	0.012
	25 – 34	19	9	47.4	20	17	85.0	6.209	0.019
	35 – 44	29	19	65.5	11	9	81.8	1.009	0.451
	45+	19	11	57.9	9	8	88.9	2.690	0.195
Total		118	67	56.8	72	59	81.9	12.677	<0.001

The highest prevalence rate for maxillary sinusitis was observed in the CZP adults and in the young adults in the NP. The differences in prevalence rates between the populations were significant in both the young adult and adult age categories, and specifically in the 15 to 34 year old individuals.

Within the 156 adult individuals available, a total of 51 males and 66 females were observed for indications of maxillary sinusitis. The prevalence rate in the 25 to 34 year old NP males was significantly higher than the rate in the CZP males of the same age (Table 4.181).

Table 4.181: Comparison of adult maxillary sinusitis prevalence rates by sex and age.

Sex	Age (years)	Conflict-zone			Neighbours			Comparison	
		No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F/p
Males		33	18	54.5	18	15	83.3	4.227	0.065
	15 – 24	13	8	61.5	2	1	50.0	0.096	1.000
	25 – 34	6	1	16.7	8	7	87.5	7.024	0.026
	35 – 44	11	7	63.6	5	4	80.0	0.428	1.000
	45+	3	2	66.7	3	3	100.0	1.200	1.000
Females		43	27	62.8	23	18	78.3	1.653	0.270
	15 – 24	8	5	62.5	5	4	80.0	0.442	1.000
	25 – 34	9	6	66.7	10	8	80.0	0.434	0.628
	35 – 44	13	9	69.2	4	3	75.0	0.049	1.000
	45+	13	7	53.8	4	3	75.0	0.565	0.603

4.3.3.3.c Rib Lesions Comparison

A total of 288 individuals in this study had ribs present for observation of non-specific infectious lesions. A total of 25 individuals had observable signs of non-specific infections. There were no significant differences observed between the CZP and NP in the overall prevalence rate of rib lesions. The highest prevalence rate was observed in the non-adults in the CZP and in the older adults in the NP (Table 4.182). The CZP rates gradually decreased with age, in contrast to the NP where the rates were higher in the non-adults and then increased through the adult age categories. However, these differences in prevalence rates between the populations were not significant.

Table 4.182: Comparison of rib lesions prevalence rates by age.

Type	Age	Conflict-zone			Neighbours			Comparison	
		No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F/p
Age Category	Non-adults	47	4	8.5	35	5	14.3	0.685	0.486
	Young Adults	38	3	7.9	13	1	7.7	0.001	1.000
	Adults	74	5	6.8	43	4	9.3	0.248	0.723
	Older Adults	27	1	3.7	11	2	18.2	2.532	0.196
Age (years)	0 – 2	16	2	12.5	11	1	9.1	0.077	1.000
	2 – 5	11	1	9.1	7	1	14.3	0.117	1.000
	5 – 9	14	1	7.1	12	2	16.7	0.574	0.580
	10 – 14	6	-	-	5	1	20.0	1.320	0.455
	15 – 24	38	3	7.9	13	1	7.7	0.001	1.000
	25 – 34	31	2	6.5	24	1	4.2	0.137	1.000
	35 – 44	43	3	7.0	19	3	15.8	1.171	0.359
	45+	27	1	3.7	11	2	18.2	2.532	0.196
Total		186	13	7.0	102	12	11.8	1.895	0.169

Within the 206 adult individuals with ribs available for observation, a total of 87 males and 91 females were observed for indications of non-specific infections on

the ribs. The highest prevalence rates in both populations were observed in the males. There were no significant differences observed between the populations in the prevalence rates by sex overall or within the more specific age ranges (Table 4.183).

Table 4.183: Comparison of adult rib lesions prevalence rates by sex and age range.

Sex	Age (years)	No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F/p
			Conflict-zone			*Neighbours*		*Comparison*	
Males		60	5	8.3	27	6	22.2	3.252	0.088
	15 – 24	19	2	10.5	6	-	-	0.686	1.000
	25 – 34	15	1	6.7	11	1	9.1	0.053	1.000
	35 – 44	19	2	10.5	7	3	42.9	3.442	0.101
	45+	7	-	-	3	2	66.7	5.833	0.067
Females		59	3	5.1	32	-	-	1.683	0.549
	15 – 24	10	-	-	4	-	-	-	-
	25 – 34	12	1	8.3	12	-	-	1.043	1.000
	35 – 44	19	1	5.3	10	-	-	0.545	1.000
	45+	18	1	5.6	6	-	-	0.348	1.000

4.3.3.3.d Periosteal Lesion Comparison

A total of 384 individuals were well preserved enough to observe for pathological lesions indicative of non-specific infectious diseases. A total of 154 individuals had observable periosteal lesions. There were no significant differences observed between the CZP and their contemporary neighbours in the overall prevalence rates (Table 4.184, Figure 4.25). The rates in the CZP were highest in the non-adults and decreased with age, in contrast to the rates in the NP which increased with age. Significant differences were observed at both extremes of this trend. The CZP non-adults prevalence rate was higher than the rate in the NP non-adults and the rate in the NP adults between 35 and 44 years old was also higher than the rate in the CZP.

Table 4.184: Comparison of periosteal lesion prevalence rates by age.

Type	Age	No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F/p
			Conflict-zone			*Neighbours*		*Comparison*	
Age Category	Non-adults	46	25	54.3	40	8	20.0	10.674	0.001
	Young Adults	39	21	53.8	21	7	33.3	2.308	0.129
	Adults	91	36	39.6	68	37	54.4	3.457	0.063
	Older Adults	28	13	46.4	11	7	63.6	0.936	0.333
Age (years)	0 – 2	16	10	62.5	11	3	27.3	3.240	0.120
	2 – 5	11	7	63.6	10	2	20.0	4.073	0.080
	5 – 9	14	7	50.0	13	3	23.1	2.095	0.236
	10 – 14	5	1	20.0	6	-	-	1.320	0.455
	15 – 24	39	21	53.8	21	7	33.3	2.308	0.129
	25 – 34	39	19	48.7	39	21	53.8	0.205	0.651
	35 – 44	52	17	32.7	29	16	55.2	3.897	0.048
	45+	28	13	46.4	11	7	63.6	0.936	0.333
Total		204	95	46.6	140	59	42.1	0.658	0.417
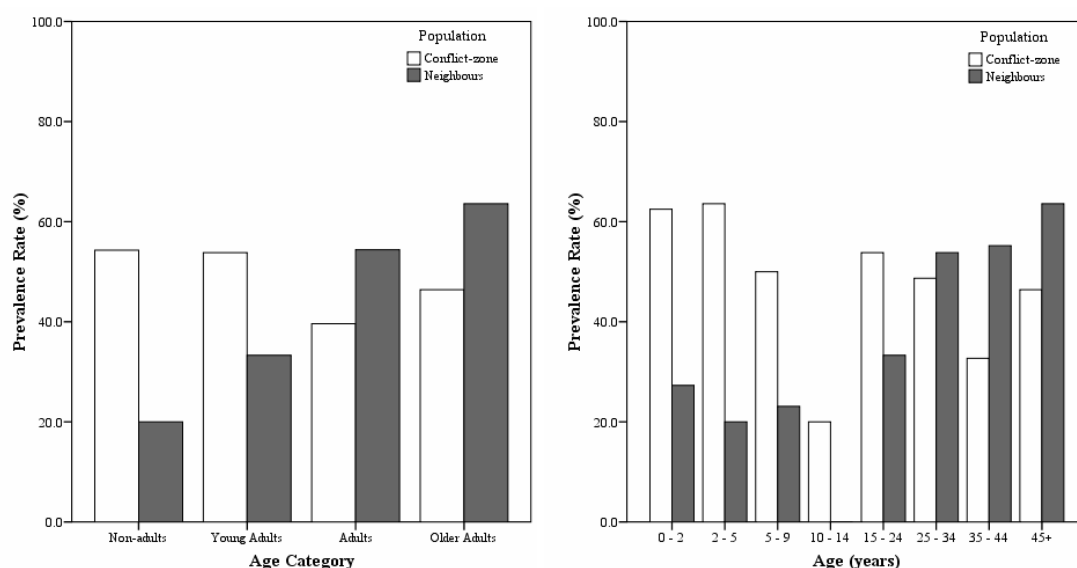
Figure 4.25: Comparison of periosteal lesion prevalence rates by age.

Within the 209 adult individuals available, a total of 104 males and 107 females were observed. There were no significant differences observed between the regional populations in the prevalence rates of either sex category overall (Table 4.185). However, the rate observed in the NP 35 to 44 year old females was significantly higher than the same rate in the CZP.

Table 4.185: Comparison of adult periosteal lesion prevalence rates by sex and age.

Sex	Age (years)	Conflict-zone			Neighbours			Comparison	
		No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F/p
Males		69	43	62.3	35	21	60.0	0.053	0.818
	15 – 24	20	15	75.0	7	4	57.1	0.793	0.633
	25 – 34	19	12	63.2	15	9	60.0	0.035	0.851
	35 – 44	23	11	47.8	9	4	44.4	0.030	1.000
	45+	7	5	71.4	4	4	100.0	1.397	0.491
Females		65	19	29.2	42	19	45.2	2.855	0.091
	15 – 24	10	3	30.0	9	1	11.1	1.017	0.582
	25 – 34	14	5	35.7	15	7	46.7	0.358	0.550
	35 – 44	22	4	18.2	12	8	66.7	7.993	0.008
	45+	19	7	36.8	6	3	50.0	0.329	0.653

When divided by region of the skeleton affected by periosteal lesions, the lower leg (tibia and fibula) was the most affected region of the body in both populations (Table 4.186). There were no significant differences observed between the populations in the distribution of periosteal lesions through the skeletal elements.

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Table 4.186: Comparison of periosteal lesion prevalence rates by element affected.

Elements Affected	Conflict-Zone			Neighbours			Comparison	
	No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F/p
Cranium	148	19	12.8	73	12	16.4	0.526	0.468
Arm	180	7	3.9	93	2	2.2	0.581	0.723
Upper and Lower Leg	174	18	10.3	101	16	15.8	1.782	0.182
Lower Leg	145	35	24.1	91	20	22.0	0.146	0.702
Throughout the skeleton	204	16	7.8	140	9	6.4	0.247	0.620
Total Individuals	204	95	46.6	140	59	42.1	0.658	0.417

4.3.3.4 Metabolic Bone Disease Comparison

A total of 374 individuals were observed for pathological lesions indicative of metabolic bone disease in both populations. A total of 56 individuals had observable signs of metabolic bone disease. There were no differences observed between the CZP and their contemporary neighbours in either the prevalence rates for individual metabolic bone disease or for the entire disease category (Table 4.187, Figure 4.26).

Table 4.187: Comparison of metabolic bone disease prevalence rates by disease type and category.

Category	Conflict-Zone			Neighbours			Comparison	
	No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F/p
Metabolic Bone Diseases	208	35	16.8	166	21	12.7	1.265	0.261
Vitamin C Deficiency	207	13	6.3	155	7	4.5	0.528	0.467
Vitamin D Deficiency	205	16	7.8	129	11	8.5	0.056	0.814
Osteoporosis	205	5	2.4	148	4	2.7	0.877	1.000
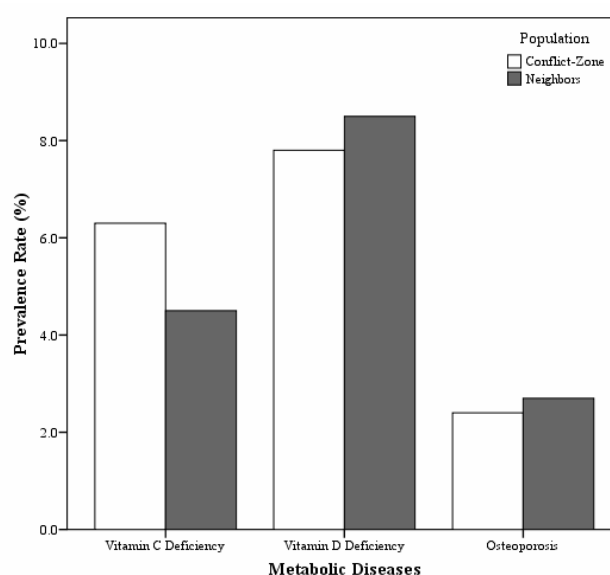
Figure 4.26: Metabolic bone disease prevalence rates by disease type and site.

When both regional populations were divided into the four broad age categories and directly compared, the highest prevalence rate of metabolic bone disease in the CZP was observed in the non-adults. In contrast, the highest prevalence

rate in the NP was observed in the older adults. These differences were not significant between the populations (Table 4.188).

Table 4.188: Comparison of metabolic bone disease prevalence rates by age.

Type	Age	Conflict-zone			Neighbours			Comparison	
		No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F/p
Age Category	Non-adults	46	16	34.8	41	7	17.1	3.496	0.062
	Young Adults	40	5	12.5	32	2	6.3	0.791	0.451
	Adults	91	10	11.0	76	7	9.2	0.143	0.705
	Older Adults	31	4	12.9	17	5	29.4	1.964	0.247
Age (years)	0 – 2	15	7	46.7	11	3	27.3	1.008	0.428
	2 – 5	11	4	36.4	10	-	-	4.492	0.090
	5 – 9	14	5	35.7	14	3	21.4	0.700	0.678
	10 – 14	6	-	-	6	1	16.7	1.091	1.000
	15 – 24	40	5	12.5	32	2	6.3	0.791	0.451
	25 – 34	39	4	10.3	46	4	8.7	0.060	1.000
	35 – 44	52	6	11.5	30	3	10.0	0.046	1.000
	45+	31	4	12.9	17	5	29.4	1.964	0.247
Total		208	35	16.8	166	21	12.7	1.265	0.261

Within the adult age ranges, there were a total of 110 males and 112 females observed for metabolic bone diseases. There was no significant difference observed in the overall prevalence rates in the males, females, or the total number of adults between the CZP and NP (Table 4.189).

Table 4.189: Comparison of adult metabolic bone disease prevalence rates by sex and age.

Sex	Age (years)	Conflict-zone			Neighbours			Comparison	
		No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F/p
Males		70	3	4.3	40	4	10.0	1.395	0.254
	15 – 24	20	-	-	8	-	-	-	-
	25 – 34	19	3	15.8	18	2	11.1	0.173	1.000
	35 – 44	23	-	-	9	1	11.1	2.638	0.281
	45+	8	-	-	5	1	20.0	1.733	0.385
Females		66	13	19.7	46	9	19.6	0.000	0.986
	15 – 24	10	4	40.0	11	1	9.1	2.759	0.149
	25 – 34	14	-	-	15	2	13.3	2.005	0.157
	35 – 44	22	5	22.7	12	2	16.7	0.174	1.000
	45+	20	4	20.0	8	4	50.0	2.520	0.172

4.3.3.4.a Vitamin C Deficiency Comparison

A total of 362 individuals were available for observation of bone lesions indicative of vitamin C deficiency, and a total of 20 individuals had lesions indicative of scurvy. There was no significant difference observed in the overall prevalence rates between these populations ($X^2_{(1)}$ = 0.528, p = 0.467). However, there were significantly more non-adults in the CZP with scurvy lesions than in the NP (Table 4.190). When the non-adult broad age category was broken down into more specific ages, there were no significant differences observed in the prevalence rates between the two regional

populations. However, the rates observed in the CZP infants and children between five and nine years old were markedly higher than the rates observed in the NP.

Table 4.190: Comparison of vitamin C deficiency prevalence rates by age category.

Type	Age	Conflict-zone			Neighbours			Comparison	
		No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F/p
Age Category	Non-adults	46	12	26.1	41	3	7.3	5.353	0.025
	Young Adults	41	1	2.4	30	2	6.7	0.765	0.570
	Adults	90	-	-	68	1	1.5	1.332	0.430
	Older Adults	30	-	-	16	1	6.3	1.917	0.348
Age (years)	0 – 2	15	7	46.7	11	3	27.3	1.008	0.428
	2 – 5	11	1	9.1	10	-	-	0.955	1.000
	5 – 9	14	4	28.6	14	-	-	4.667	0.098
	10 – 14	6	-	-	6	-	-	-	-
	15 – 24	41	1	2.4	30	2	6.7	0.765	0.570
	25 – 34	39	-	-	40	1	2.5	0.988	1.000
	35 – 44	51	-	-	28	-	-	-	-
	45+	30	-	-	16	1	6.3	1.917	0.348
Total		207	13	6.3	155	7	4.5	0.528	0.467

Within the 275 adult individuals, a total of 108 males and 111 females were observed for lesions indicative of vitamin C deficiency. There were no significant differences observed between the two populations between the male and female prevalence rates (Table 4.191).

Table 4.191: Comparison of adult vitamin C deficiency prevalence rates by sex and age.

Sex	Age (years)	Conflict-zone			Neighbours			Comparison	
		No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F/p
Males		68	-	-	40	2	5.0	3.464	0.135
	15 – 24	20	-	-	8	-	-	-	-
	25 – 34	19	-	-	18	1	5.6	1.085	0.486
	35 – 44	22	-	-	9	-	-	-	-
	45+	7	-	-	5	1	20.0	1.527	0.417
Females		67	1	1.5	44	1	2.3	0.091	1.000
	15 – 24	11	1	9.1	11	1	9.1	0.000	1.000
	25 – 34	14	-	-	14	-	-	-	-
	35 – 44	22	-	-	11	-	-	-	-
	45+	20	-	-	8	-	-	-	-

4.3.3.4.b Vitamin D Deficiency Comparison

A total of 334 individuals were observed for bone changes associated with vitamin D deficiency, and there were 27 individuals. There was no significant difference in overall prevalence rates between the two populations (Table 4.192).

Table 4.192: Comparison of vitamin D deficiency prevalence rates by diagnosis.

Type	Conflict-zone			Neighbours			Comparison	
	No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F/p
Rickets	205	3	1.5	129	2	1.6	0.004	1.000
Healed Rickets	205	13	6.3	129	9	7.0	0.052	0.820
Osteomalacia	205	-	-	129	-	-	-	-
Vitamin D Deficiency	205	16	7.8	129	11	8.5	0.056	0.814

Of the individuals with lesions, rickets and healed or residual rickets were observed in both populations, while no cases of osteomalacia were recorded in either population. There was no significant difference between the populations in the distribution of the overall prevalence rate between rickets and healed rickets ($X^2_{(2)}$ = 0.057, p = 0.972).

Differences were observed in prevalence trends between the two regional populations within the broad age categories; the highest prevalence rate in the CZP was observed in the young adult age range in contrast to the highest rate in the NP which was observed in the older adults. These differences, however, were not statistically significant (Table 4.193).

Table 4.193: Comparison of vitamin D deficiency prevalence rates by age.

Type	Age	Conflict-zone			Neighbours			Comparison	
		No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F/p
Age Category	Non-adults	46	4	8.7	40	4	10.0	0.043	1.000
	Young Adults	39	4	10.3	15	-	-	1.662	0.567
	Adults	91	6	6.6	62	5	8.1	0.120	0.758
	Older Adults	29	2	6.9	12	2	16.7	0.920	0.567
Age (years)	0 – 2	15	-	-	11	-	-	-	-
	2 – 5	11	3	27.3	10	-	-	3.182	0.214
	5 – 9	14	1	7.1	13	3	23.1	1.356	0.326
	10 – 14	6	-	-	6	1	16.7	1.091	1.000
	15 – 24	39	4	10.3	15	-	-	1.662	0.567
	25 – 34	39	3	7.7	36	3	8.3	0.010	1.000
	35 – 44	52	3	5.8	26	2	7.7	0.107	1.000
	45+	29	2	6.9	12	2	16.7	0.920	0.567
Total		205	16	7.8	129	11	8.5	0.056	0.814

Within the non-adult age category, cases of both active rickets and healed rickets were observed in the CZP and NPand in contrast to the vitamin D deficiency cases observed in the three adult age categories which were all described as healed or residual rickets. There were no significant differences observed in the prevalence rates of rickets and healed rickets between the non-adults in these two regional populations (Table 4.194).

Table 4.194: Comparison of non-adult vitamin D deficiency prevalence rates by diagnosis.

Type	Conflict-zone			Neighbours			Comparison	
	No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F
Rickets	46	3	6.5	40	2	5.0	0.090	1.000
Healed Rickets	46	1	2.2	40	2	5.0	0.508	0.595
Total	46	4	8.7	40	4	10.0	0.043	1.000

Within the adult age ranges, there were 248 individuals analysed for vitamin D deficiency. There were no significant differences observed between the two populations between the sexes for healed rickets (Table 4.195).

Table 4.195: Comparison of adult healed rickets prevalence rates by sex and age.

Sex	Age (years)	Conflict-zone No.	Cases	TPR %	Neighbours No.	Cases	TPR %	Comparison $X^2_{(1)}$	F/p
Males		69	2	2.9	35	2	5.7	0.498	0.601
	15 – 24	20	-	-	7	-	-	-	-
	25 – 34	19	2	10.5	15	1	6.7	0.155	1.000
	35 – 44	23	-	-	9	1	11.1	2.638	0.281
	45+	7	-	-	4	-	-	-	-
Females		65	7	10.8	35	5	14.3	0.266	0.606
	15 – 24	10	3	30.0	5	-	-	1.875	0.505
	25 – 34	14	-	-	14	2	14.3	2.154	0.481
	35 – 44	22	2	9.1	10	1	10.0	0.007	1.000
	45+	19	2	10.5	6	2	33.3	1.765	0.234

4.3.3.4.c Osteoporosis Comparison

A total of 353 individuals were available for observation of bone lesions indicative of osteoporosis. A total of nine individuals had bone changes consistent with osteoporosis. There was no significance observed in the prevalence rate differences between these populations (Table 4.196). All the individuals identified with probable osteoporosis at the time of their death were from the adult and older adult ages, and there were no significant differences observed between the regional populations in the prevalence rates specific to these age categories.

Table 4.196: Comparison of osteoporosis prevalence rates by age.

Type	Age	Conflict-zone No.	Cases	TPR %	Neighbours No.	Cases	TPR %	Comparison $X^2_{(1)}$	F
Age Category	Non-adults	46	-	-	24	-	-	-	-
	Young Adults	39	-	-	31	-	-	-	-
	Adults	91	3	3.3	76	1	1.3	0.695	0.627
	Older Adults	29	2	6.9	17	3	17.6	1.279	0.343
Age (years)	15 – 24	39	-	-	31	-	-	-	-
	25 – 34	39	1	2.6	46	-	-	1.194	0.459
	35 – 44	52	2	3.8	30	1	3.3	0.014	1.000
	45+	29	2	6.9	17	3	17.6	1.279	0.343
Total		205	5	2.4	148	4	2.7	0.024	1.000

A total of 109 males and 111 female adults were observed for indications of osteoporosis. There were no significant differences observed in the rates recorded for either sex in both their overall and age-specific prevalence rates (Table 4.197).

Table 4.197: Comparison of adult osteoporosis prevalence rates by sex and age.

Sex	Age (years)	Conflict-zone No.	Cases	TPR %	Neighbours No.	Cases	TPR %	Comparison $X^2_{(1)}$	F
Males		69	1	1.4	40	-	-	0.585	1.000
	15 – 24	20	-	-	8	-	-	-	-
	25 – 34	19	1	5.3	18	-	-	0.974	1.000
	35 – 44	23	-	-	9	-	-	-	-
	45+	7	-	-	5	-	-	-	-
Females		65	4	6.2	46	4	8.7	0.260	0.716
	15 – 24	10	-	-	11	-	-	-	-
	25 – 34	14	-	-	15	-	-	-	-
	35 – 44	22	2	9.1	12	1	8.3	0.006	1.000
	45+	19	2	10.5	8	3	37.5	2.715	0.136

4.3.3.5 Caries Lesions Comparison

Of the 250 individuals with dentitions, a total of 113 had caries lesions, a total of 288 lesions were observed affecting 249 teeth in the 4794 teeth available for analysis. The overall prevalence rate based on individuals affected was significantly higher in the NP than in the CZP (Table 4.198).

Prevalence rates based on counts of teeth affected demonstrated no significant difference between the two populations either in the overall counts or within the ages. The highest overall prevalence rates in the CZP were observed in the 25 to 34 year age range, whereas the prevalence rates increased with age in the NP. There was also a notable increase in the count of both individuals and teeth affected in the five to nine year non-adult age range for both populations.

Table 4.198: Comparison of caries lesions prevalence rates by age.

Calculation Method	Type	Age	Conflict-zone No.	CL	TPR%	Neighbours No.	CL	TPR%	Comparison $X^2_{(1)}$	F/p
Individuals Affected			162	62	38.3	96	51	53.1	5.403	0.020
	Age Category	Non-adults	43	6	14.0	20	4	20.0	0.374	0.713
		Young Adults	36	14	38.9	30	14	46.7	0.405	0.524
		Adults	61	33	54.1	35	25	71.4	2.793	0.095
		Older Adults	22	9	40.9	11	8	72.7	2.972	0.085
	Age (years)	0 – 2	14	-	-	5	-	-	-	-
		2 – 5	11	1	9.1	5	-	-	0.485	1.000
		5 – 9	14	4	28.6	7	3	42.9	0.429	0.638
		10 – 14	4	1	25.0	3	1	33.3	0.058	1.000
		15 – 24	36	14	38.9	30	14	46.7	0.405	0.524
		25 – 34	29	16	55.2	22	16	72.7	1.649	0.199
		35 – 44	32	17	53.1	13	9	69.2	0.983	0.321
		45+	22	9	40.9	11	8	72.7	2.972	0.085
Teeth Affected			3017	155	5.1	1777	94	5.3	0.053	0.819
	Age Category	Non-adults	587	19	3.2	282	7	2.5	0.374	0.541
		Young Adults	786	37	4.7	630	26	4.1	0.277	0.599
		Adults	1303	80	6.1	709	49	6.9	0.455	0.500
		Older Adults	341	19	5.6	156	12	7.7	0.823	0.364
	Age (years)	0 – 2	80	-	-	25	-	-	-	-
		2 – 5	157	2	1.3	66	-	-	0.848	1.000
		5 – 9	267	15	5.6	127	5	3.9	0.505	0.477
		10 – 14	83	2	2.4	64	2	3.1	0.070	1.000
		15 – 24	786	37	4.7	630	26	4.1	0.277	0.599
		25 – 34	607	38	6.3	445	30	6.7	0.098	0.754
		35 – 44	696	42	6.0	245	19	7.2	0.435	0.510
		45+	341	19	5.6	156	12	7.7	0.823	0.364

There were 66 males and 83 females observable for caries lesions (Table 4.199). There were no significant differences observed in the prevalence rates between the males or the females in the two populations when calculated as either the percent of individuals or teeth affected.

Table 4.199: Comparison of adult caries lesions prevalence rates by sex.

Calculation Method	Sex	Conflict-zone			Neighbours			Comparison	
		No.	CL	TPR %	No.	CL	TPR%	$X^2_{(1)}$	p
Individuals Affected	Males	46	19	41.3	20	12	60.0	1.956	0.162
	Females	51	27	52.9	32	21	65.6	1.297	0.255
Teeth Affected	Males	1001	45	4.5	369	22	6.0	1.247	0.264
	Females	989	66	6.7	694	44	6.3	0.074	0.785

4.4 Summary

Preservation differed between the populations in the opposite direction from expectation; the conflict-zone skeletons were better preserved and more complete than the skeletons from the neighbours population.

The mortality trends observed in the medieval conflict-zone and neighbours populations were remarkably similar. The sex distributions indicated there were more males in the conflict-zone cemeteries, and the age distributions suggested more people in the conflict-zone died between 35 and 44 years of age than in the nieghbours population. However, life expectancy did not differ between the populations for the males and was significantly lower for the females in the neighbours population.

Contrary to expectations, the population morbidity trends did not indicate a difference in metabolic bone disease between the two regional populations. There were also no indications of stunting in the conflict-zone. However, the rates for non-specific indicators of stress and infections were higher and malnutrition directly affected children in the conflict zone populations. Adult indicators of chronic infections and poorer diets were occasionally higher in the neighbours population, indicating factors other than war-related events affected the expression of these indicators of health in medieval Britain.

5 Discussion: The bioarchaeology of a conflict-zone

The aim of this study was to bridge the gap in the literature between biological anthropological population studies of the health consequences of living in a conflict-zone and bioarchaeological population studies of demographic and palaeopathological indicators of stress. This aim was achieved by conducting a bioarchaeological survey of people living in a medieval British conflict-zone to describe mortality rates and the rates of non-specific skeletal indicators of stress and metabolic bone diseases in a socio-politically 'stressed' population. The results of this bioarchaeological survey of health and disease patterns in the medieval Anglo-Scottish conflict-zone indicated that the relationship between causal factors of 'conflict-zone' mortality as observed in living populations was not present. There were no differences observed in the mortality trends between the conflict-zone and neighbours populations. This result indicated that the higher mortality rates in modern conflict-zone populations might not have been present in the past. In general, the trends of poor health, malnutrition, and chronic infectious diseases in the conflict-zone were also not observed in the growth rates, non-specific indicators of stress, and metabolic bone disease rates. However, the conflict-zone non-adults did demonstrate higher prevalence rates of the non-specific indicators of stress and vitamin C deficiencies. Therefore, the hypothesis that 'stressed' medieval populations living along the contested Anglo-Scottish border, from the 10th through the 16th century, had significantly higher mortality rates and more skeletal indicators of stress than contemporary 'unstressed' populations living in other regions of Britain was rejected overall, yet interesting differences were identified when describing childhood health trends. In addition, this study described higher chronic maxillary sinusitis and dental caries prevalence rates in the neighbours adults which was contrary to the expected result. Overall it is suggested that factors other than conflict-related events were causal factors behind regional differences in adult health in northern England and southern Scotland.

5.1 Preservation Differences

The underlying assumption regarding skeletal preservation in the Medieval Anglo-Scottish conflict-zone population was that the soil in the burial environment was too damp and acidic to preserving bone to the extent that skeletons would not yield any useful demographic or palaeopathological data (Henderson, 1990; Boulter and Rega, 1993; Anderson, 1994). Therefore, the conflict-zone skeletal collections were expected to be in an overall poorer state of completeness in comparison to the neighbours skeletons. The results of a direct comparison of the preservation states and completeness observed in each regional population contradicted the assumption. The assumption therefore must be rejected.

The conflict-zone skeletal collections were overall in a good state of preservation with skeletons described as both excellently and poorly preserved. The Blackfriars Street population was the most poorly preserved population in the border region based on skeletal completeness. In contrast, The Hirsel population was listed as overall in a good to excellent state of preservation due to the overall completeness of the individuals examined. However, many of the individuals in The Hirsel population had eroding and flaking cortical surfaces because the skeletal elements were wrapped in damp newspaper before storage. This storage practice has most likely aggravated the fragile condition the skeletal elements were in when they were initially excavated.

The trend of good skeletal completeness was consistently observed throughout the age categories in the conflict-zone; indicating no individual subgroup of infants, children, or adults was significantly biased by poor or excellent preservation. The same preservation trends were observed in the sexed adults with the majority of estimated males and females described as in a good state of preservation, and more described as excellently than poorly preserved. Adults of indeterminate sex were observed in all preservation states, with most described as poor. This indicated that sex estimation in the poorly preserved skeletons was biased by adverse preservation conditions. However, since the same number of individuals of indeterminate sex was also observed in good and excellent preservation categories, this suggested that this sample of border adults was not disproportionately affected by poor preservation biasing the natural distribution of sex-based identifying traits across the male-indeterminate-female spectrum. These data indicated the conflict-zone population

was indeed a cross-section sample of the cemetery populations that were archaeologically recovered in the Anglo-Scottish border region. This population experienced the diagenetic processes of the burial environment, excavation and post-excavation processes, and curatorial environments to more or less the same degree. That is to say that the environmental factors and selective processes that created the cemetery populations of the conflict-zone acted more or less consistently across the populations surveyed in this study. The conflict-zone population was as accurate a representation of the medieval Anglo-Scottish border populations sampled as it could have been for an archaeological sample (Kelley, 1979; Meindl et al., 1985a; Walker et al., 1988; Walker, 1995).

In contrast, preservation trends observed in the neighbours population were greatly affected by diagenetic, excavation, post-excavation and curatorial factors. The majority of skeletons were less than 25% complete and these individuals were predominately adults between 15 and 44 years at the time of their death. The non-adults, in contrast, were in a significantly better state of preservation than the adults in this population. This alone suggests that the 'normal' cemetery populations in the neighbours region have been exposed to various processes at a disproportionate rate to their contemporary counterparts in the conflict-zone populations. Previous studies of these skeletal collections described them as normally distributed through the age and sex categories (Birkett, 1986; Daniels, 1986; Cardy, 1997). These alterations to population profiles in this study must have been as a result of factors occurring after the initial excavation and preliminary analyses.

Communications with curatorial staff at the collection storage facilities revealed these populations were largely reburied in response to various public and storage pressures associated with these excavations (Daniels, per comm.; Pickin, per comm.). The Whithorn population was in a significantly poorer state of preservation overall due to reburial of the majority of the collection, which consisted of reburying the skeletal elements at one storage location while the other portions of the collection in other storage facilities and out on loan remained above ground (Pickin, per comm.). Parliament House was in a poorer state of preservation due to the nature of the soil and the restrictions of the excavation which was conducted by a commercial redevelopment construction company (Toolis, per comm.). Many of the individual graves were bisected and truncated by later burials as well as truncated by the size and shape of the small excavation area due to the parameters of the recovery excavation

and permission granted by the St. Giles parish church (Melikian, 2005; Toolis, 2005). These differences in skeletal preservation highlighted sample biases which cautioned the assumption that the data collected from the neighbours skeletal collections represented a cross-section of the health and disease trends present in these medieval populations.

The majority of the poorly preserved skeletons were observed in the adults with the worst preservation rates recorded for individuals between the ages of 15 and 24 years. In contrast, the preservation observed in the non-adults, specifically the infants between birth and two years old, was significantly better than the preservation of the adult skeletons. This suggested that mortality rates might be biased by preservation problems. However, the fact that age-at-death estimates were still possible for these poorly preserved skeletons indicated that the mortality profile for the neighbours population might not be as adversely biased by poor preservation as other demographic and palaeopathological assessments for this population.

However, sex distribution in the neighbours population was negatively affected by these confounding preservation factors. The majority of individuals of indeterminate sex were described as poorly preserved. This indicated that their determination as sexually indeterminate was based on a reduction of available features of sexual dimorphism, and it greatly reduced the proportion of the male and female individuals that could be included in comparisons of sex-based mortality and morbidity rates between the two populations.

The conflict-zone population was in a significantly better overall state of preservation than the neighbours population. These differences were specifically observed in the adult individuals who were estimated to have died between 15 and 24 and 35 and 44 years of age, and in the non-adults who died between two and five years old. However, the significantly poorer preservation of individuals in the neighbours population indicated that the palaeopathological observations in this population were most likely underestimates of the rates present in the living population when the individuals were buried in the cemetery.

These differences were particularly expected in prevalence rates reported by sex in the neighbours population. The conflict-zone female adults and adults of indeterminate sex were significantly better preserved than the neighbours females. In contrast, there was no significant difference in the reported preservation of the males between the populations. These data suggested that the poorer preserved neighbours

individuals were possibly erroneously sexed as females, specifically the young adults, and disproportionately affected the estimated female mortality and morbidity rates in the young adult age category. Additionally, the overrepresentation of individuals of indeterminate sex in the neighbours population, specifically in the adults who died between 25 and 34 years old, created mortality and morbidity figures in the neighbours population that underrepresented male prevalence rates. Thus, any interpretations of a health trends in males and females between these two populations must be made cautiously.

The biases observed by previous researchers in demographic data caused by preservation issues in the burial environment would also apply to the conflict-zone populations in this study (Kelley, 1979; MacLaughlin and Bruce, 1990; Walker, 1995). However, these issues were confounded in the neighbours population due to dispersal of the collections throughout various research facilities, and reburial of significant portions of the individuals. The additional biases introduced by poor preservation put additional caveats on the interpretation of disease prevalence rates which affected children between two and five years old, adults between the ages of 15 and 24 and 35 and 44 years old, and women. The poorer preservation of neighbours individuals in these particular age and sex categories most likely led to an under-representation of prevalence rates for metabolic and infectious disease. A resolution was attempted by excluding individuals unobservable for specific lesions from the prevalence rate calculations. However, this issue severely affects the ability to accurately diagnose specific diseases which require observation of the complete skeleton. For example, individuals diagnosed with a non-specific infectious disease because of periosteal lesions on the tibiae may have had lesions in the spine, hands and feet indicative of tuberculosis; however this diagnosis is impossible in a skeleton that has been partially reburied because the spine, hands, and feet were not present to observe. Therefore, additional caution was used when interpreting indications of health and disease patterns observed in the neighbours population that differed significantly from those in the conflict-zone population.

Additionally, these data show the harmful impact that reburial programs have on the quality of research materials in Britain. The trends observed between these two populations could be greatly altered by re-analysing the regional comparisons using better preserved skeletal populations from northern England and southern Scotland. Skeletons from cemetery sites which have not been subjected to reburial programs

need to be curated by museums and universities for future research projects of this nature. More efficient communication between excavation units, storage facilities managing skeletal collections, and the research community would facilitate the more frequent use of such collections for bioarchaeological research, thus continuing to validate their research potential.

5.2 Demographic Differences

Mortality rates in the Anglo-Scottish border populations were hypothesised to have been higher than in contemporary neighbouring populations. The results of a direct comparison between four conflict-zone skeletal samples and four samples from populations outside of the region of socio-political instability showed no significant differences in mortality rates, or in overall life expectancy between the two populations. However, female life expectancy in the neighbours population was significantly lower than for the conflict-zone women.

The conflict-zone individuals were also hypothesised to have been smaller in size than their contemporary neighbours due to chronic nutritional depravation during their skeletal development. However, there were no significant differences in adult stature and body mass estimates between the populations. There were also no observed differences in growth rates of non-adults between the populations based on estimates of stature in these individuals.

There were small differences in platymeric and platycnemic indices between the conflict-zone and neighbours populations. The neighbours adults of indeterminate sex had a significantly higher platymeric index than the adults of indeterminate sex in the conflict-zone population. There was also a significantly lower platycnemic index in the conflict-zone populations than in the neighbours. More individuals in the conflict-zone were described as platycnemic and hypoplatycnemic.

These results rejected the central hypothesis of demographic differences between the conflict-zone and their contemporary neighbours. However, the significant differences observed highlighted confounding factors in the interpretation of the conflict-zone as a region of differential morbidity and mortality.

5.2.1 Mortality

Chamberlain (2006: 77) has described non-combatant mortality as deaths, "attributable to hostility directed by combatants against civilians and to the disruptions that inevitably occur to food supplies, health care and hygiene amongst civilian populations." The Anglo-Scottish conflict-zone population was not expected to have been disproportionately affected by trauma because the historical documents from the medieval period do not list high civilian mortalities as an effect of the border wars (Summerson, 1992; Lomas, 1996a; McCord and Thompson, 1998; Winchester, 2000). A preliminary comparison of the overall rates of trauma between the conflict-zone (15.3%) and neighbours (11.6%) populations confirmed there were no significant differences between the regions ($X^2_{(1)}$ = 1.166, p = 0.280). Of the 50 individuals in both populations with signs of trauma, 38 had fractures that were either healed or were healing at the time of the individual's death (Ortner, 2003; Bennike, 2008). Five individuals had joint changes suggesting dislocations and five had bone changes suggesting soft tissue injuries. Bone changes indicative of sharp force trauma were observed in three conflict-zone individuals and one individual in the neighbours population, all four of whom were adult males. The presence of these indications of blade injuries suggests conflict was a part of life in the Anglo-Scottish border (Boylston, 2000), but the rates of sharp force trauma between the populations were not significantly different ($X^2_{(1)}$ = 0.619, p = 0.632). These data indicate that mortality rates in both populations were not associated with differences in exposure to trauma and there was no evidence of hostilities directed at large civilian segments of the conflict-zone population (Boylston et al., 2000; Bishop and Knüsel, 2005). Disruptions to food supplies were hypothesised to have increased mortality in the conflict-zone population through increases in infectious diseases and malnutrition.

The conflict-zone population from the Medieval Anglo-Scottish border region was hypothesised to have demonstrated a non-combatant mortality curve, with higher rates of overall mortality and a peak in mortality rates in the young adult age category, in comparison to the neighbours mortality curve. The neighbours age-at-death profile was expected to have represented the attritional baseline of medieval population mortality. However, the difference in the age-at-death trends between these regional populations was in the opposite direction from the expectation (Figure 5.1). Although the differences in the overall distribution of death rates through the age categories

between these two populations was not significant ($X^2_{(7)}$ = 6.394, p = 0.495), there was a difference in mortality trends observed between the populations.
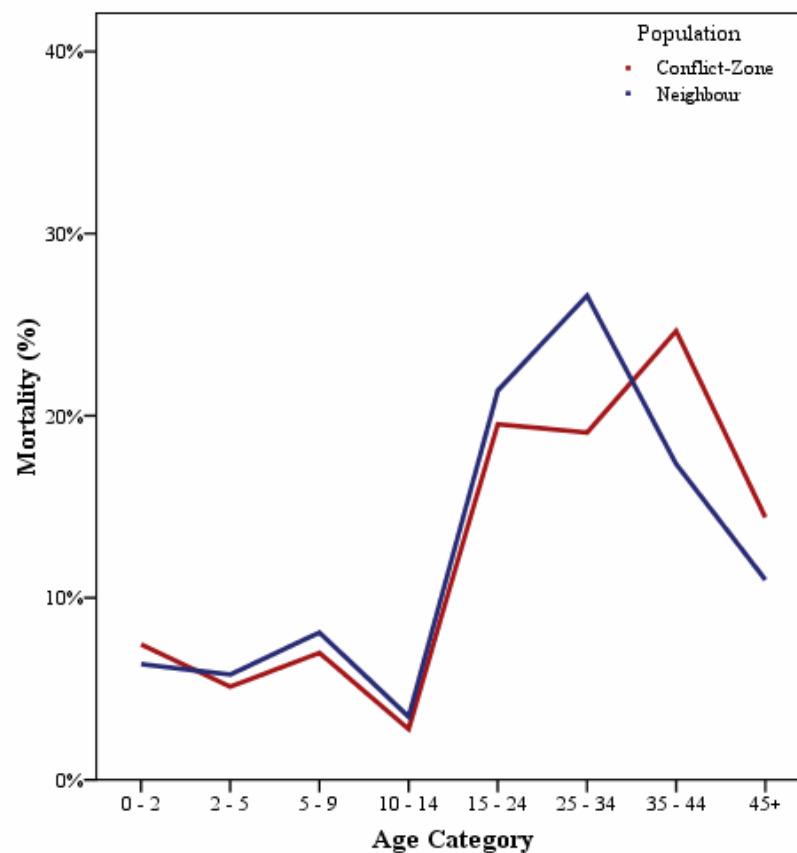
Figure 5.1: Mortality rates for the conflict-zone (red) and neighbours (blue) populations.

The highest percentage of the neighbours population was estimated to have died between 25 and 34 years old which is consistent with mortality profiles observed in attritional archaeological populations (Chamberlain, 2006). Of the proportion of the population who survived to skeletal maturity in this region, the ratio between men and women remained almost equal. This population demonstrated the age-at-death rates expected for a stable, agricultural population which could be used as a baseline comparison with the conflict-zone population.

In contrast to the expectation of an overall higher rate of death observed in all the conflict-zone age categories, the mortality rates in the Anglo-Scottish border population was slightly lower than, or equal to, death rates in the neighbours population. The adult age-at-death rates between 15 and 34 years old were notably lower than the rates in the neighbours population. The highest percent of the conflict-zone population was estimated to have died between 35 and 44 years old. There was a significantly higher count of 35 to 44 year old adults in the conflict-zone cemeteries

than in the neighbours population. However, this difference in count was likely due to differential preservation between the two sites. When calculated as a percent of the total deaths observed in the population, there was no significant difference between the conflict-zone and neighbours death rates in the 35 to 44 year age range ($X^2_{(1)}$ = 1.929, p = 0.165).

Of the portion of the population who survived to skeletal maturity in this region, the ratio between men and women remained almost equal. The conflict-zone population had a significantly higher count of males than the neighbours population. However, this was also related to preservation associated with sex estimation in the neighbours skeletal collections (Kelley, 1979; Meindl et al., 1985a). When calculated as a percentage of their total populations, there were no significant differences observed in the proportion of males in both populations ($X^2_{(1)}$ = 3.125, p = 0.077).

A strict interpretation of the age-at-death profile would suggest that very few infants and children died in both populations during the medieval period. This relatively low mortality in infants and children has been interpreted in previous bioarchaeological studies as an under-representation of young children due to factors associated with medieval burial rituals and diagenetic processes in the burial environment (Lewis, 2007; Saunders, 2008). When compared to published historical data estimating 27% infant mortality in 16th century England (Orme, 2001), the rates of 7.4% and 6.4% mortality in the conflict-zone and neighbours respectively are low.

Life expectancy in the neighbours population at birth was estimated to have been 26.60 years. Similarly, life expectancy in the conflict-zone population at birth was estimated to have been 28.80 years. Waldron (2007) reported similar life expectancies for the Barton-upon-Humber cemetery population from Lincolnshire, with a range of between 22.0 and 30.2 years for the individuals dating from the 950 to 1500 AD phases of cemetery burials. For those who survived to adulthood, life expectancy of women in the neighbours population (34.80 years) was higher than for males (33.45 years). The life expectancy of Anglo-Scottish border women (39.70 years) was higher than for men (33.00 years). However, the female life expectancy in the conflict-zone population was significantly higher than in the neighbours population. This difference in female life expectancy highlighted overall the differences in mortality rates observed between the populations. The higher young-adult mortality rate in the neighbours population was specifically observed in the female mortality rates (Figure 5.2).
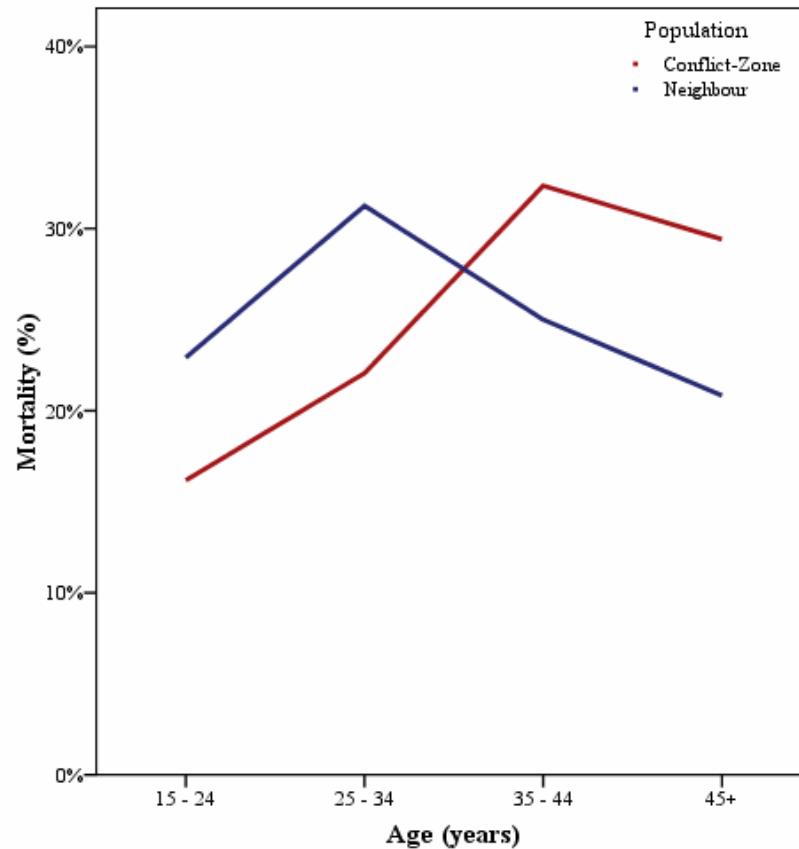
Figure 5.2: Female adult mortality rates for the conflict-zone (red) and neighbours (blue) populations.

The age-at-death profiles of both populations overall mirror the trends observed in previous studies of mortality rates in populations with an agricultural economy (Eshed et al., 2004: 322). The similarity of the age-at-death trends in both the conflict-zone and neighbours populations indicated that the same biases of under-estimating the age-at-death of older adults, and the under-representation of children, were equally applicable to both skeletal samples (Chamberlain, 2006: 90; Saunders, 2008). Compensating for the bias in bioarchaeological samples could be accomplished by applying Bayesian statistical analysis to the age-at-death data, which has shown in previous studies to resolve to some degree the under-estimation of the age of older adults in skeletal populations (Aykroyd et al., 1997; Aykroyd et al., 1999; Samworth and Gowland, 2007).

If it is assumed these age-at-death rates provide the population age distributions, with the understanding that older adults are systematically under-aged in skeletal analyses, then the conflict-zone population was composed of relatively older individuals than their contemporary neighbours. This absence of 25 to 34 year old adults in the population from the Anglo-Scottish border could be an indication of

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population migration out of the conflict-zone. If the border was experiencing a disproportionate rate of violence, famine, and disease, then the portion of living populations most apt to leave are young adults (Cardozo et al., 2004; Avogo and Agadjanian, 2010; Degomme and Guha-Sapir, 2010). "Migration tends to be age structured, with people in their early twenties together with their dependent infant offspring exhibiting the highest mobility and hence the highest probabilities of migration" (Chamberlain, 2006: 39). The higher mortality rates in the 25 to 34 year neighbours population, specifically in the females, could indicate that the border populations migrated to less volatile locations near the border region that were geographically and economically similar.

In contrast, this trend could suggest a system of delayed marriage and reduced fertility among the conflict-zone population. Medieval peasants had to receive permission from and pay a fee to their feudal lord before their daughters could marry (Dyer, 2000; Horrox and Ormrod, 2006). These fees were generally small, but could be prohibitively expensive for families living in relative poverty. Some medieval records indicated women in the peasant classes married later than their wealthier counterparts, due partly to the need to earn money for the associated fees and dowry and to satisfy obligations of support to their parents (Alexandre-Bidon and Lett, 1999; Dyer, 2000). The economic hardships in the border region could have exaggerated this trend and delayed marriage among border women into their late-20s. By delaying marriage, female death rates associated with childbirth would also be delayed. This shift in cultural practices could have reduced the mortality rates in females associated with childbirth during the ages of 15 and 24 years and increased these same rates in the women between 25 and 34 years old.

5.2.2 Body Shape

This study assumed that all the British populations in this study had the same genetic potential for attaining normal skeletal growth and adult body size (Brothwell, 1981). The aim was to compare the body size achieved by skeletally mature adults in the conflict-zone population to their contemporary neighbours. The conflict-zone population was hypothesised to have been skeletally smaller, and specifically shorter and thinner at the time of their skeletal maturity, than their contemporary neighbours. The results of this study did not support this hypothesis.

5.2.2.1 Stature and Body Mass

Mean stature in the conflict-zone male adults was 168.85 cm and in the neighbours population was 169.14 cm. Similarly, mean stature in the conflict-zone females was 159.68 cm and in the neighbours was 159.43 cm. These estimated statures were not significantly different.

These data indicated that the individuals in the conflict-zone population who reached skeletal maturity were not stunted in comparison to their contemporary neighbours. Catch-up growth has been described in modern studies after periods of nutritional deficiency and retarded skeletal growth (Humphrey, 1998; Cameron, 2002b). Similarly lack of association between stature and general indications of stresses has been reported in archaeological populations (Ribot and Roberts, 1996; Lewis and Roberts, 1997; Humphrey, 2000).

Gunnell et al's (2001) previous study of long bone lengths in the skeletal population from Barton-upon-Humber, Lincolnshire found that those individuals who were estimated to have been taller in life lived longer than those who were shorter. Using various long-bone lengths, the authors were able to associate longer bones, presumably associated with healthier individuals during youth, with longer life expectancy. Waldron (2007) attempted to repeat the results of this analysis by assessing longevity of individuals from Barton-upon-Humber based on their femur length. However, the results indicated that femoral length was not associated with longer life in this population and he suggested that the results of the previous analysis were biased by other factors affecting long-bone length in other areas of the body.

The mean femoral lengths in the adult individuals also did not show a change in value in connection with age-at-death in the two regional populations in this study (Table 5.2). In a one-way ANOVA test of the difference in the mean femoral length between the three adult broad age categories found no significant difference in stature associated with older age for either the male (F = 1.728, df = 2, p = 0.190), or female (F = 0.578, df = 2, p = 0.567) individuals. The same result was also found in the neighbours males (F = 0.728, df = 2, p = 0.495), and females (F = 2.463, df = 2, p = 0.121).

Table 5.1: Mean femoral length by age category and sex.

Population	Sex	Age Category	No.	Femur Length (mm)
Conflict-Zone	Males	Young Adults	12	450.79
	Males	Adults	28	449.68
	Males	Older Adults	5	428.90
	Females	Young Adults	4	415.00
	Females	Adults	20	430.75
	Females	Older Adults	12	426.17
Neighbours	Males	Young Adults	5	443.60
	Males	Adults	14	454.29
	Males	Older Adults	4	447.50
	Females	Young Adults	3	388.50
	Females	Adults	10	424.25
	Females	Older Adults	4	434.87

Similarly, body mass estimations from these two populations did not differ significantly for either the males or females who reached skeletal maturity in northern England and southern Scotland. Similar results were recorded for both the femoral head diameter body mass estimation method, and the bi-iliac breadth method. The conflict-zone males were estimated to have been an average of 68.61 kg to 68.68 kg in weight and the neighbours males 66.93 kg to 66.82 kg. The conflict-zone females were estimated to have been an average of 61.93 kg to 58.53 kg in weight and the neighbours females 63.55 kg to 59.42 kg. These results mirror the trends in stature between the populations; similar overall body size was seen for all of populations studied in northern England and southern Scotland, regardless of their proximity to the Anglo-Scottish border.

Recent research on the association of metrical variation in the skeleton associated with palaeopathological indicators of stress has described a correlation between vertebral neural canal size and early mortality in young adults (Clark et al., 1986; Watts, 2010). This correlation has indicated that measurements of other bones in the body, which fuse during various stages of skeletal development, might be more indicative of growth retardation during childhood (Watts, 2010). Conversely, Watts' (2010) study also highlighted the potential in the developing human skeleton for catching up to its biological potential after experiencing periods of nutritional or environmental stress. This was because rates of early mortality did not correlate with estimated adult stature in the Fishergate House skeletal population from York.

Non-adult stature also demonstrated no significant difference between the two populations. Although non-adult mean stature was only directly comparable for seven ages between the conflict-zone and neighbours populations, comparisons were possible for the non-adults between the ages of birth to 10 years old. The trends

observed in growth rates in the two groups could also be described with regression equations, which were largely identical. Additionally, a scatter plot of estimated non-adult statures in these two populations showed a no observable separation between them and no significant outliers were observed in either population (Figure 5.3).
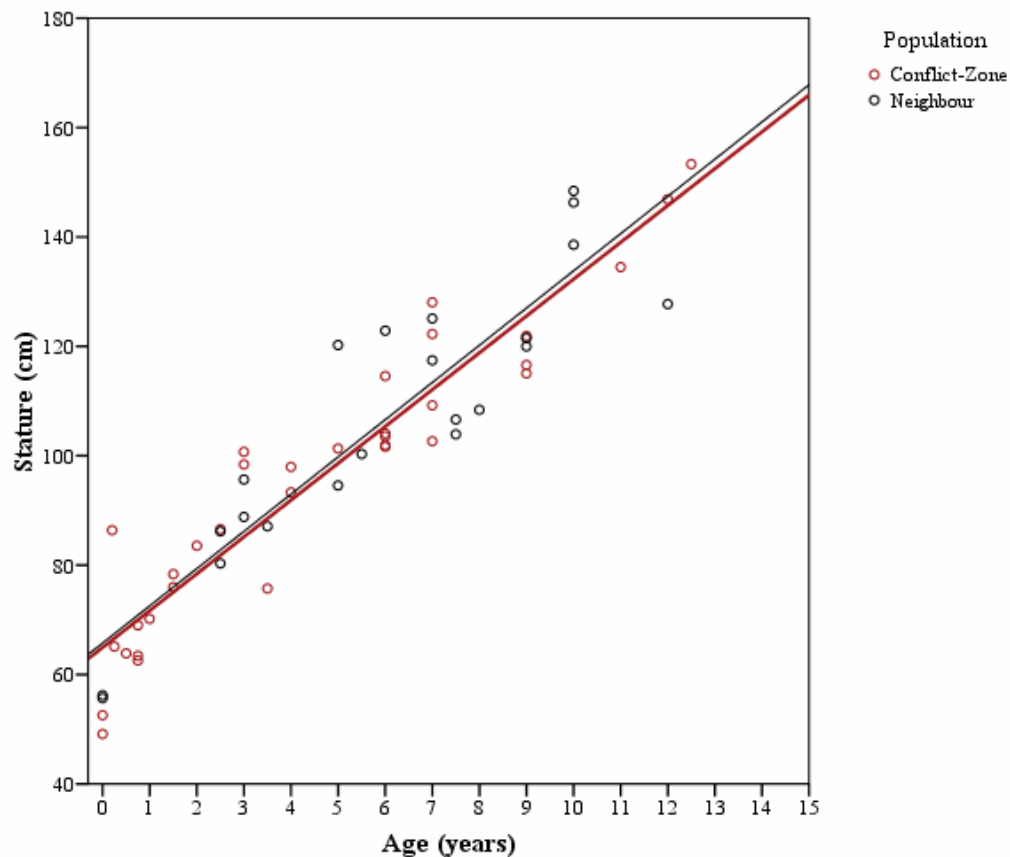
Figure 5.3: Non-adult stature estimations and regression equation lines for the conflict-zone (red) and neighbours (blue) populations.

Unfortunately, it was not possible to compare estimated body mass of non-adults between the ages of birth and 15 years between these two populations, because of differential preservation. It was not possible to record femoral head diameter for any of the 15 conflict-zone non-adults, estimated to have died between the ages of seven and 15 years. This comparison requires a more focused study of non-adult body mass estimation in future research. Additionally, new body mass calculation methods have been published for non-adult skeletal remains which could be a useful tool for comparisons of body mass in younger children (Robbins et al., 2010).

These data indicate that, although the children in the conflict-zone cemeteries may have been in generally poorer health than their contemporaries because they died in childhood rather than surviving to adulthood (Wood et al., 1992), they were no

smaller than their contemporary counterparts from neighbouring populations who also died during childhood.

Ribot and Roberts's (1996) study of non-adult long-bone lengths found similar results in their assessment of 'stressed' versus 'unstressed' children in two medieval populations. Their comparison of growth rates in 183 non-adults, 90 from an urban hospital in Chichester, Sussex (southern England) and 93 from the rural population of Raunds, Northamptonshire (Midlands) did not correlate with 'indicators of stress' in either population. These results suggested that non-adult growth may be less affected by stress and chronic malnutrition in past populations relative to the less-stressful conditions experienced in populations exposed to similar environments.

Anthropomorphic measurements of stunting and wasting have also been called into question as reliable indicators of chronic malnutrition in describing health in modern populations. "Wasting is generally the most dramatic consequence of malnutrition for a child. It is also the shortest-lasting, and once the supply of basic food is re-established, it tends to recede relatively quickly" (Agadjanian and Prata, 2003: 2522). This indicator may not be observable in the archaeological record due to rapid 'catch up' growth in the body of a child when nutritional resources are restored to the environment (Mosier, 1989). Agadjanian and Prata's (2003) study of modern Angolan children demonstrated that the primary effect of war on the nutritional status of children is essentially to exaggerate general health differences that already exist in a socio-cultural environment; this reveals trends in heath that are already observed in the general population when researchers control for the effects of war. "Like immunization, stunting is significantly associated with household material and sanitary status: children in radio-owning (i.e., economically better-off) households, and in households where drinking water is regularly treated, have lower odds of stunting. Although these effects hold for the war cohort and the peace cohort alike, the impact of both predictors is stronger in the peace cohort model, suggesting that the condition (or the imprint) of war may attenuate the conventional socioeconomic differentials in nutrition" (Agadjanian and Prata, 2003: 2524).

Alternatively, stunting has been found in living populations that are not located in conflict-zones. For example, stunting and wasting was associated with poverty in modern children from Kentucky (Crooks, 1999), directly associated with the education and employment levels of their parents. This study found that higher incomes and higher levels of education in the adult population was significantly

correlated with children who grew to their fullest biological potential (Crooks, 1999).

Kinfu (1999) presented demographic data on height and weight measurements taken of Ethiopian children in 1992, during the year following the end of a multi-generational civil war. This study aimed to compare height-for-age, weight-for-age, and weight-for-height indices of 22,059 children between the ages of 6 months and 5 years old within different regions and socioeconomic groups in Ethiopia (Kinfu, 1999: 405 - 6). Children classified as stunted were less than two standard deviations below the mean height-for-age of a World Health Organization reference population; similarly, children were classified as wasted if their weight-for-height ratios were less than two standard deviations below the reference population mean (Kinfu, 1999: 405). Kinfu's (1999: 410) results indicated that 62.0% of children in drought-prone and war-affected areas, and 58.7% of children in other regions of Ethiopia, were classified as stunted. Similarly, 3.3% of children in drought-prone and war-affected areas, and 4.4% of children in other regions of Ethiopia, were classified as wasted (Kinfu, 1999: 410). These rates were specifically highlighted to have been much higher than rates observed in other regions of Africa (Kinfu, 1999: 412). The author described a significant correlation between these high malnutrition rates with socially determined weaning practices, the presence of endemic water-born infections, and the 'militarization' of the national economy which altered farm-based economy practices from subsistence grain production to lucrative cash crop production in an effort to purchase military supplies and sustain fighting within the country (Kinfu, 1999). However, these causal factors could not be distinguished from each other in their role as contributor to overall malnutrition in the Ethiopian children. The regions of conflict were also inextricably associated with regions of drought in this population, and therefore environmental causes of observed malnutrition could not be ruled out as the primary causal factor for stunting and wasting.

5.2.2.2 Platymeric and Platycnemic Indices

Metrical indications of differences in shape between the two populations were observed in platymeric and platycnemic indices, describing the shapes of the femur and tibia, respectively.

The conflict-zone adults of indeterminate sex had a significantly lower platymeric index (79.64) than their counterparts in the neighbouring population (88.46). These differences were not observed between specific sexes in the

populations, and one-way ANOVA comparisons of the mean indices between the three broad age categories of adulthood found no age-related differences in either the conflict-zone (F = 0.096, df = 2, p = 0.908), or neighbours populations (F = 1.277, df = 2, p = 0.286).

Similarly, the conflict-zone platycnemic indices overall (69.85) were significantly lower than in the neighbours population (72.29). These differences were not observed between specific sexes in the populations and one-way ANOVA comparisons of the indices between the three broad age categories of adulthood found no age-related differences in either the conflict-zone (F = 0.115, df = 2, p = 0.891), or neighbours populations (F = 0.982, df = 2, p = 0.380).

These differences suggest that some physical differences were present in the body shapes of the conflict-zone populations that were unique from their contemporary neighbours. However, those differences were not specific to sex or age categories in either population and are within the range of reported indices for other medieval British skeletal populations (e.g. Cross and Bruce, 1989; Waldron, 2007). These data provide indirect evidence of possible 'stress' in the conflict-zone adult populations. However, relating this result to a particular causal factor is problematic. The causes for this difference could include nutritional, genetic, or general environmental differences (Buxton, 1938; Lovejoy et al., 1976; Brothwell, 1981). The unknown specific aetiology of differences in these indices confounds the issue so that the only conclusion that can be drawn is that there is a general difference in shape of the tibia between the regional populations. There were also differences in shape in the femur, but these differences were only in the adults of indeterminate sex.

5.3 Evidence of Disease

Similar rates of general indicators of stress [cribra orbitalia, enamel hypoplasia, and non-specific infection lesions] and metabolic bone diseases [vitamin C and D deficiencies, and osteoporosis] in both populations suggest that simply living in a region of conflict cannot alone cause the skeletal changes associated with stress. However, the rates observed in the non-adults did indicate that trends of chronic stress were present during skeletal development of the individuals buried along the Anglo-Scottish border. The absence of metabolic bone diseases in the conflict-zone adults provided direct evidence against the hypothesis that malnutrition was chronic and

severe in the region where socio-political violence was occurring in comparison to their contemporary neighbours. Non-specific infection prevalence rates did indicate population differences between the conflict-zone and their neighbours. The high rates of maxillary sinusitis and dental caries could indicate a multitude of causes. Socio-economic differences, environmental changes, and social practices of weaning children could also have caused differences in the rates between these two regions.

5.3.1 Indicators of Stress in Conflict-Zone

It was hypothesised that higher rates of non-specific pathological lesions associated with nutritional stress would be demonstrable in a conflict-zone population in association with high levels of malnutrition and infection rates (Goodman et al., 1988). Rates of cribra orbitalia, enamel hypoplasia, and non-specific infection were not significantly higher in the conflict-zone overall. However, there were higher rates of cribra orbitalia and periosteal lesions in the conflict-zone non-adults, and a higher rate of enamel hypoplastic lesions in the conflict-zone young adults. These data suggested that childhood illness that lead to bone changes during skeletal development may have been more prevalent in the Anglo-Scottish border region than in the neighbouring contemporary populations.

5.3.1.1 Cribra Orbitalia

There were no significant differences observed in the overall cribra orbitalia prevalence rates between the conflict-zone (32.4 %), and the neighbours (34.1 %) populations. This relationship was observed in all the sex categories and all the adult age groups. However, there was a significantly higher rate of cribra orbitalia lesions in the conflict-zone infants (57.1 % or 12 orbits affected out of 21 observed), than in the neighbours infants (14.3 % or 2 orbits affected out of 14 observed). This difference highlighted the overall trend of higher prevalence rates of cribra orbitalia in the conflict-zone non-adults (Figure 5.4). This could be an indication of poor maternal health and nutrition in conflict-zone women during pregnancy which has previously been associated with higher infant morbidity in studies of cribra orbitalia (Piontek and Kozlowski, 2002; Walker et al., 2009). A higher rate of cribra orbitalia in infants has also been associated with cultural weaning practices and nutritional deficiencies in the diets of young children (Fildes, 1986; Lewis, 2002a; Lewis, 2002b; Wapler et al., 2004).
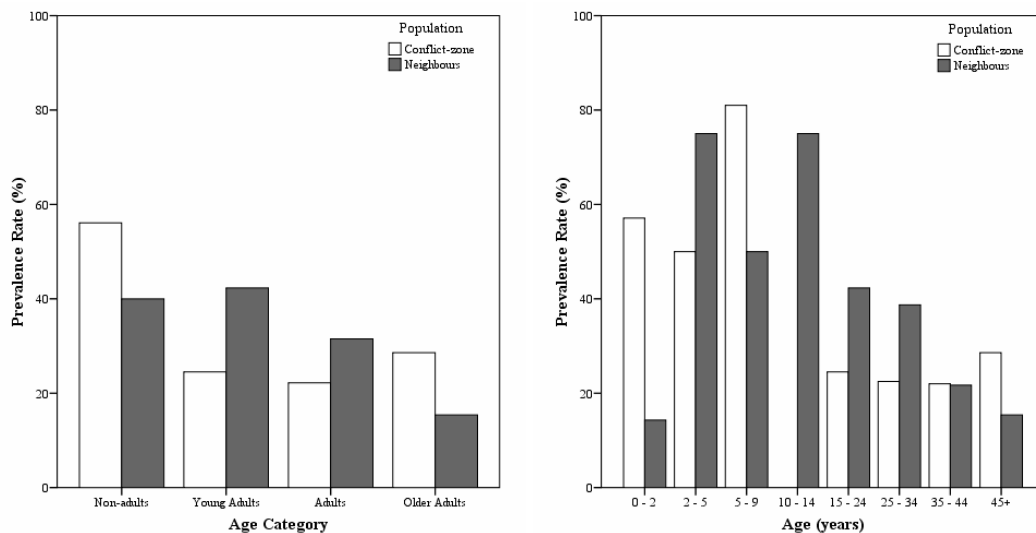
Figure 5.4: Cribra orbitalia prevalence rates by age and population.

In contrast, there was a significantly higher cribra orbitalia prevalence rate in the neighbours children between 10 and 14 years (75%) than in the conflict-zone population (0%). A small number of individuals in the 10 to 14 year old age category were observed in both the conflict-zone (n = 4), and neighbours (n = 2), populations. This result of significant differences is most likely a false positive identification of a non-significant relationship (Drennan, 1996). Higher rates of cribra orbitalia have been recorded in older children exposed to the adverse urban environments of later-Medieval and post-Medieval Britain (Lewis, 2002a; Roberts and Cox, 2003). As all four of the neighbours sites were located in urban late-medieval settlements, the cribra orbitalia rates in the neighbours children may have been higher than in the more rural populations from the conflict-zone. Unfortunately the counts of orbits observed in this study were too small to accurately describe the true population trends.

Lewis (2002b) associated higher rates of general indicators of stress with the medieval practice of apprenticeship among the peasants, merchants, and craftsmen in medieval Britain. Parents often sent children at the age of seven out to work as labourers in another family's home as a way of training them for future work skills necessary in medieval society (Orme, 2001). Both boys and girls were sent away from home to begin training for their expected roles in adulthood (Orme, 2001). Children of the aristocracy either began formal education as a school student for future clerical, monastic, or political roles, or an apprenticeship for future knighthood (Orme, 2001). Girls learned social skills, home management, arts, music, entertainment, sewing and embroidery skills among the aristocracy (Orme, 2001).

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Similar divisions in training were observed in the peasant classes, but there was less division of labour based on sex and more similar learning experiences involved in running a farm or training in a craft (Orme, 2001). This migration of young children within medieval society introduced children to new infectious disease in populations and environments that they were wholly unfamiliar with as infants and toddlers (Lewis, 2002b). If the higher prevalence rate of children in the neighbours population cemeteries with cribra orbitalia is indeed a true difference from the conflict-zone population, then this difference could be an indication of the health consequences of the migration of immuno-deficient and nutritionally stressed border children to neighbouring regions during their skeletal development. These differences in cribra orbitalia rates among the children, however, did not translate into observed differences in adult rates of these same lesions between the conflict-zone and neighbours populations.

5.3.1.2 Enamel Hypoplasia

The initial analysis of enamel hypoplasia rates presented a contradictory result. The rates of total individuals affect by enamel hypoplasia in the conflict-zone (68.4 %) and the neighbours (66.3 %) populations were not different. However, the rate of total teeth affected by enamel hypoplastic lesions in the conflict-zone (28.6 %) was significantly higher than the rate in the neighbours teeth (19.6 %).
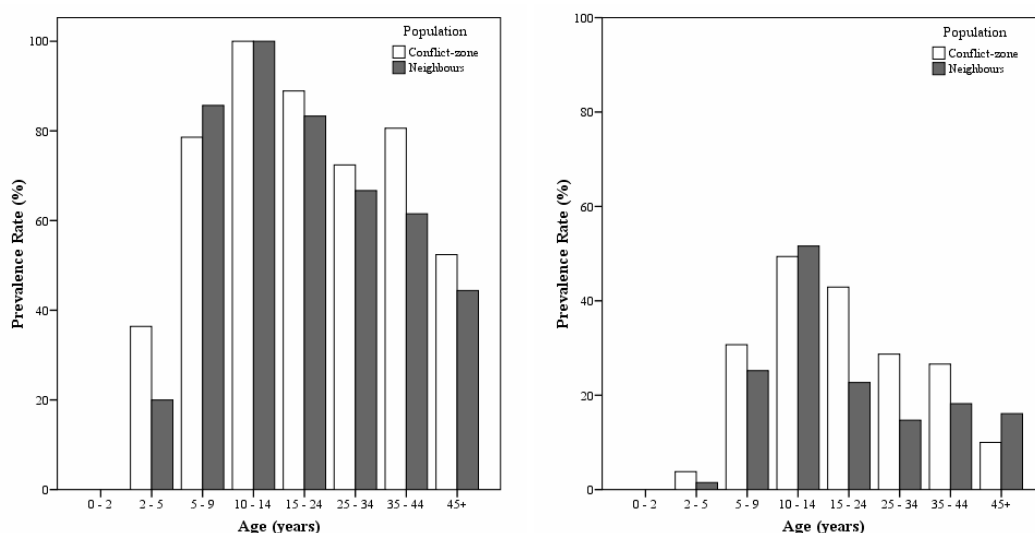
Figure 5.5: Enamel hypoplasia prevalence rates by age and population calculated as individuals affected (left) and teeth affected (right).

This difference was specifically significant in the counts of permanent teeth observed in the adults between 15 and 44 years old (Figure 5.5). This difference was observed in both sexes for the 15 to 24 year age ranges and the 35 to 44 year age ranges. While the rates in the 24 to 35 year old males remained significantly higher in the conflict-zone (27.2% versus 15.5%), the female rates (19.0% versus 15.7%) were not significantly different.

The count of teeth available for observation in the conflict-zone population (n = 2993) was much higher than the count of teeth available in the neighbours population (n = 1759), which suggested this difference in significant versus non-significant rates might be a function of differential preservation. As enamel hypoplasia most commonly occurs on the incisors and canines (Hillson, 1996), the disproportionate loss of these teeth through ante-mortem dental disease or post-mortem damage to the skeleton could inadvertently skew the observed enamel hypoplasia prevalence rates. A comparison of the counts of teeth present and observed for each individual with teeth in both populations showed similar counts of teeth available for each dentition, with a mean of 18.62 teeth per conflict-zone individual and a mean of 18.51 teeth observed for each neighbours individual. These differences in the mean counts of teeth per individual were not significant between the two populations (t = 0.097, p = 0.923). This result contradicted the idea of differential preservation creating the significant differences in the rates of teeth affected.

The higher rates of teeth affected in the conflict-zone adult population could be the result of multiple episodes of nutritional deficiency or infectious diseases experienced during the development of the dentition. Multiple events of illness or nutritional deficiency throughout the development of the permanent dentition, between the ages of six months and seven years, could affect multiple teeth as they begin to develop in the jaw (Goodman et al., 1987; Reid and Dean, 2006; Halcrow and Tayles, 2008). For example, the neighbours individuals who experienced only one episode of growth delay could have had only their incisor and canine teeth affected, which form at earlier stages in childhood (Reid and Dean, 2006). In contrast, the conflict-zone individuals could have also experienced a second or third episode of developmental disruption in the later years of their childhood, thus affecting the development of the premolar and molar teeth (Reid and Dean, 2006). This situation would result in the total counts of teeth affected equalling 12 teeth for a neighbours individual while totalling 20 for a conflict-zone individual. Multiple

enamel hypoplastic lesions observed on the same tooth could be indicative of this trend (Reid and Dean, 2000, 2006). This issue could be further clarified by returning to the original data and recalculating the enamel hypoplasia prevalence rates by tooth type for each individual, by specifically counting the total number of separate hypoplastic features on each independent tooth, and by estimating the age of occurance for the lesions observed (Goodman et al., 1987; Reid and Dean, 2000; Hubbard et al., 2009).

Calculation of these enamel hypoplasia rates did not take into account the presence of dental calculus, dental caries, or severe dental wear as possible factors in obscuring tooth surfaces from view. The adult enamel hypoplasia prevalence rates could have been disproportionately lowered in the neighbours adults if higher rates of dental disease or more severe dental wear existed in this regional population. The similar rates of enamel hypoplasia observed in both populations in the erupting permanent dentitions of the non-adults, 22.5% for the conflict-zone and 23.5% for the neighbours, suggested that dental disease expressed later in adulthood may have been a significant confounding factor in obscuring the true enamel hypoplasia rates in both populations for the adults who died between 15 and 44 years old. Calculation of the rates of dental calculus rates for both populations would shed light on this issue.

Differences in mortality rates have been observed in populations between individuals with enamel hypoplasia and those without (Palubeckaite et al., 2002; Boldsen, 2007). This trend was also observed in the adult mortality rates for both the conflict-zone and neighbours populations. The adult male and female individuals in the conflict-zone population with enamel hypoplasia died at significantly younger ages than those in the conflict-zone population who did not have enamel hypoplasia (males ($X^2_{(3)}$ = 11.849, p = 0.008), females ($X^2_{(3)}$ = 8.362, p = 0.039)). This same trend was observed in the males and females in the neighbours population; however, the correlation between the presence of enamel hypoplasia and younger mortality was not significant for either males ($X^2_{(3)}$ = 6.825, 0.057) or females ($X^2_{(3)}$ = 0.743, p = 0.863) in the neighbours population.

Although these trends suggested there were higher rates of death in adults with enamel hypoplasia at younger ages in the conflict-zone versus the neighbours population, within the subgroup of individuals with enamel hypoplastic lesions, there was no significant difference observed in the age-at-death rates between the conflict-zone and neighbours population for either the males ($X^2_{(3)}$ = 1.738, p = 0.626) or

females ($X^2_{(3)}$ = 1.773, p = 0.621). This indicated that the demographic trend that conflict-related health changes magnify differences in health already present in a population held true in the Medieval Anglo-Scottish borders (Kinfu, 1999; Agadjanian and Prata, 2003; Avogo and Agadjanian, 2010).

There were no differences observed in enamel hypoplastic rates in the non-adult teeth, which directly contradicted the previously summarised evidence that high rates of infant mortality and cribra orbitalia in the conflict-zone population could be associated with poorer maternal health in the Anglo-Scottish border. This result supports the conclusion that the nutritional status of infants in both populations remained at similar levels throughout the in-utero formation of deciduous teeth, a status which is derived solely from the mother (Lejarraga, 2002) during the medieval border wars. Health differences observed between conflict-zone and neighbours adults were derived from differences in health and nutrition during childhood in both populations. However, this trend was exaggerated in the conflict-zone populations, possibly due to multiple exposures to nutritional deprivation and epidemic disease.

5.3.1.3 Non-specific infection rates

The non-specific infection rates also demonstrated health differences between the conflict-zone and neighbours populations. The overall trend in infection was higher rates of endocranial lesions, maxillary sinusitis, and rib lesions in the neighbours population than in the Anglo-Scottish border cemeteries. However, there were higher prevalence rates of periosteal lesions in the conflict-zone population. The only significant difference in overall non-specific infection prevalence rate was in maxillary sinusitis where the neighbours rate was significantly higher than that of the conflict-zone population.

However, this trend differed greatly by age. There was a significantly higher rate of overall non-specific infectious lesions in the conflict-zone non-adults (66.7 %) than in the rates for the neighbours children (39.0 %). This difference in rate was specifically significant in the children from both populations who died between the ages of five and nine years old. The general rates of infection in all the conflict-zone children was higher in the children younger than 10 years old when compared to the neighbours children who were estimated to have died before the age of 10.

Endocranial Lesions

The rates for endocranial lesions between the conflict-zone (16.8%) and the neighbours (23.2%) populations were not significantly different. However, the rates in the 25 to 44 year old adults in the neighbours population (38.9%) were significantly higher than in the conflict-zone (10.8%) (Figure 5.6).
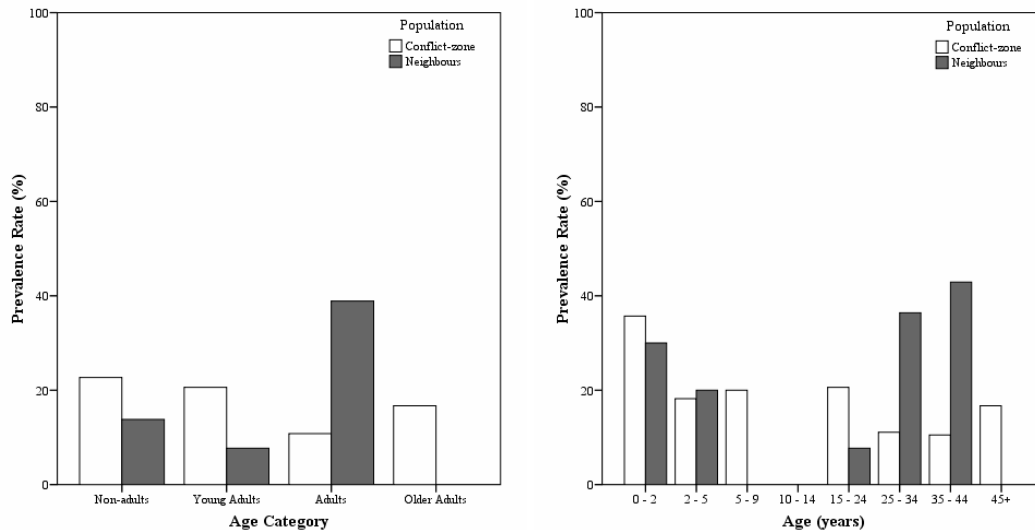
Figure 5.6: Endocranial lesion prevalence rates by age and population.

There were no significant differences in endocranial lesions observed within the sex categories. However, the females between the ages of 35 and 44 years had a notably higher prevalence rate in the neighbours population (50.0%) than in the conflict-zone (18.8%).
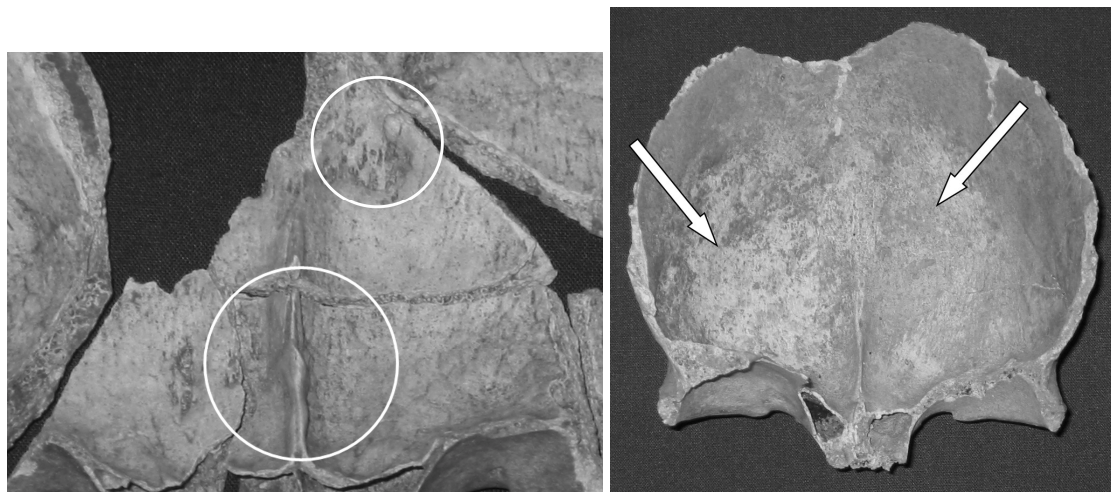
Figure 5.7: New bone formation on the frontal endocranial surface of a 17 to 25 year old male (AU801, left) and a 30 to 35 year old female (PH066, right).

The majority of endocranial lesions in the adults in both populations were observed on the frontal bone (Figure 5.7). The prevalence rate for this frontal lesion in the neighbours population was significantly higher in the adult age groups (Table 5.3), and this relationship was particularly observed in the 35 to 44 year old females. The removal of the frontal endocranial lesion prevalence rates from the comparisons of observed endocranial lesions between the adults in both populations reduced the prevalence rate in the conflict-zone from 10.8% to 7.7%, and in the neighbours population from 38.9% to 8.3%. This difference in revised endocranial lesion prevalence rates in the adults was not statistically significant ($X^2_{(1)}$ = 0.013, F = 1.000).

Table 5.2: Comparison of conflict-zone and neighbours adult frontal endocranial lesion prevalence rates by sex and age.

| Age (years) | Sex | Conflict-zone | | | Neighbours | | | Comparison | |
		No.	Cases	TPR %	No.	Cases	TPR %	$X^2_{(1)}$	F/p
Adult	Combined	61	2	3.3	33	11	33.3	16.232	<0.001
	Males	23	1	4.3	10	4	40.0	6.891	0.021
	Females	28	1	3.6	17	5	29.4	6.112	0.023
25 – 34	Combined	24	-	-	21	6	28.6	7.912	0.007
	Males	8	-	-	6	2	33.3	3.111	0.165
	Females	12	-	-	11	2	18.2	2.390	0.217
35 – 44	Combined	37	2	5.4	12	5	41.7	9.730	0.007
	Males	15	1	6.7	4	2	50.0	4.460	0.097
	Females	16	1	6.3	6	3	50.0	5.615	0.046

The cause and aetiology of these frontal endocranial lesions is unknown (Ortner, 2003). Endocranial lesions have been suggested to be indicative of non-specific infections affecting the meningeal tissue between the brain and the skull (Schultz, 2001), but meningitis kills an individual very soon after infecting them and bone changes most likely would not have enough time to develop on the endocranial skull before death from meningitis (Roberts and Manchester, 2005). Hyperostosis frontalis interna (HFI) could be a possible diagnosis for these lesions observed in both populations. HFI, an asymptomatic bone-forming condition, is found predominantly in modern female populations and is associated with both a prolonged oestrogen stimulation and increasing age (Hershkovitz et al., 1999). These data indicate that the frontal endocranial lesion prevalence trends in the neighbouring populations are similar to those observed in modern prevalence rates of HFI (Hershkovitz et al., 1999). However, the aetiology and associated causal factors of HFI remains unknown

and the appearance of the frontal lesions in these skeletons is more subtle than the overt bone deposits usually associated with HFI (Hershkovitz et al., 1999).

Figure 5.8: Endocranial lesion on a two to five year old non-adult from The Hirsel (TH142).

The lack of a difference in endocranial lesion rates between non-adult individuals in the populations indicated that the causes of these lesions in non-adult skeletons (Figure 5.8) were not disproportionately higher in the conflict-zone (Lewis, 2004). As with adult manifestations of endocranial lesions, these causal factors remain potentially various and largely unknown (Hershkovitz et al., 1999; Lewis, 2004).

Maxillary Sinusitis

There were significantly higher rates of maxillary sinusitis in the neighbours population (81.9 %) than in the conflict-zone (56.8 %). There were significantly more in the 15 to 34 year old adults with observable bone changes observed in the maxillary sinuses (Figure 5.9).
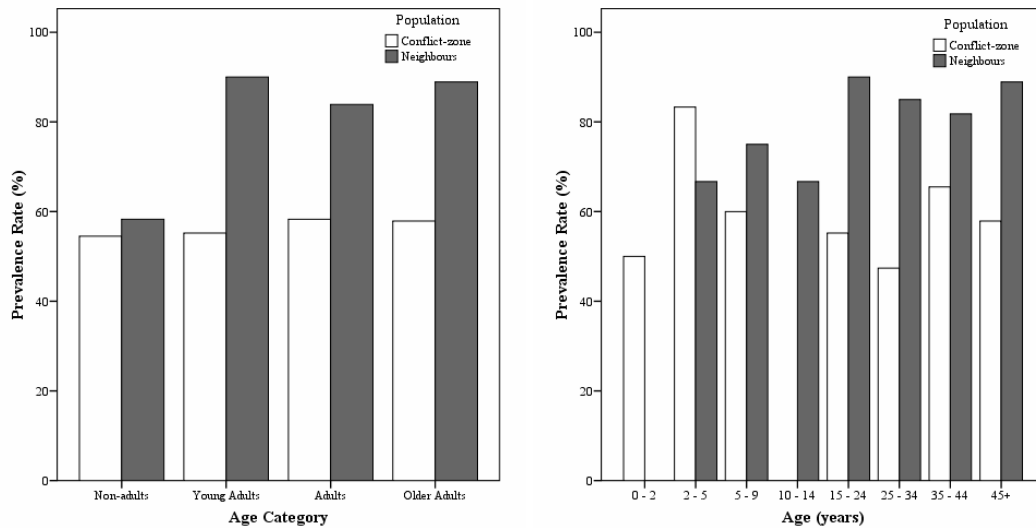
Figure 5.9: Maxillary sinusitis prevalence rates by age and population.

Male prevalence rates were significantly higher in the conflict-zone 25 to 34 year old adults, whereas there was no significant relationship found between the population rates in the adult females (Figure 5.10).
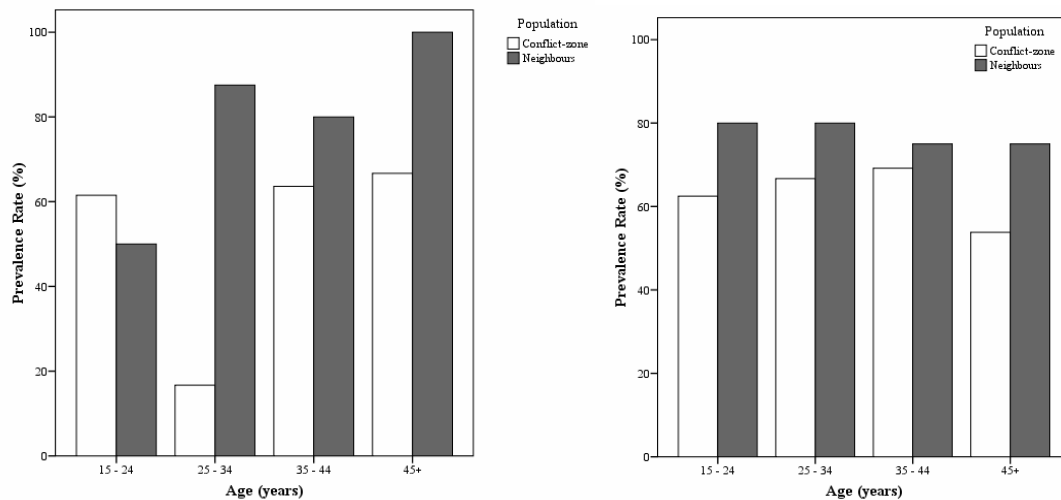
Figure 5.10: Maxillary sinusitis prevalence rates for males (left) and females (right) by population.

These trends are similar to those found by Roberts (2007) in a survey of the prevalence rates from various archaeological populations around the world. The overall prevalence rates reported in medieval British cemetery populations ranged from 48.6% at Fishergate House, York to 71.9% at St. Helen-on-the-Walls, York (Roberts, 2007: 797). This study identified economic-based differences in maxillary sinusitis prevalence rates between populations. The prevalence rates observed in urban population centres in agriculturally-dependent economies were higher (48.5 %) than in the rural settlements dependent on the same economy (45.0 %) (Roberts,

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2007). These differences between urban and rural settlement patterns changed the distribution patterns of the lesions between the sexes. Urban populations were observed to have had similar prevalence rates between males and females, in contrast to rural populations where the rates in females were higher (Lewis et al., 1995; Roberts, 2007: 799). Similar trends were observed in the conflict-zone and neighbours populations, with an overall even distribution of lesions between the sexes within each region. The differences between the populations appeared to be based on the development of urban population centres around the neighbours cemetery populations. The absence of truly rural cemetery populations in the neighbours regional survey may have adversely inflated the rates of maxillary sinusitis in the neighbours populations in this study (Daniels, 1986; Dilworth, 1994; Spall and Toop, 2005; Toolis, 2005). The development of urban centres of industry in the medieval towns of York, Hartlepool, and Edinburgh were hallmarks of the later-Medieval transition into the post-Medieval Industrial Revolution (Lees, 1889; Todd, 1953; Mason, 1987; Dean, 2008). In contrast, three of the four Anglo-Scottish border cemeteries analysed in this study were located in rural medieval landscapes (Cramp and Douglas-Home, 1979; Nolan, 1998; Crone, 2007). Lewis and Gowland's (2007: 126-7) survey of post-Medieval documentary evidence for British urban health described, "the majority of urban deaths were caused by diarrhoeal diseases, which killed eight times more in the urban area (40%) than in the rural (5%), and crowd diseases such as measles and scarlet fever were three times more prevalent, with tuberculosis double that of the rural areas." These differences in the rates of infectious diseases in urban centres could be the causal factor behind the higher rates of maxillary sinusitis rates in northern England and southern Scotland in the urban centres neighbouring the Anglo-Scottish border. A reassessment of the prevalence rates in these populations between the rural and urban cemetery populations could shed more light on this possible association.

Conversely, maxillary sinusitis has been shown to have a close link to dental disease in archaeological populations (Roberts, 2007). Dental disease prevalence rates were recorded in this study and a full analysis of these data in the future could also indicate if the changes in maxillary sinusitis rates were associated with changes in diet or dental diseases in the neighbours populations.

Rib Lesions

There were no significant differences observed in the rib lesion prevalence rates between the conflict-zone (7.0%) and neighbours (11.8%) populations. The rates recorded in the conflict-zone population were generally lower than the rates in the neighbours population across all ages (Figure 5.11). There was also no significant difference in the rates between the adult males and females in each population. This could be indirect evidence in support of the hypothesis previously suggested by the maxillary sinusitis prevalence rates, that respiratory infections in the Medieval populations in northern England and southern Scotland were associated with an increase in population density during urban development.
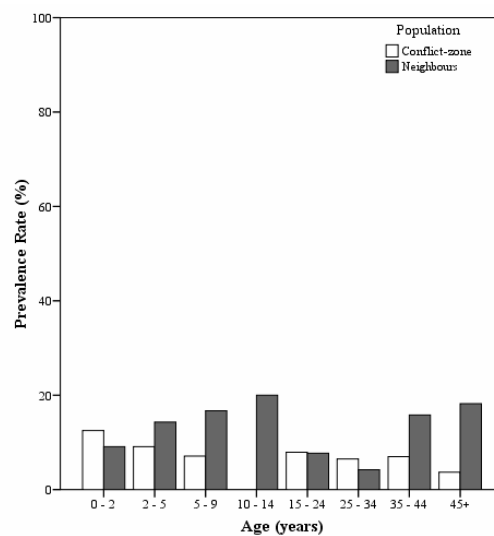
Figure 5.11: Rib lesion prevalence rates by age and population.

Rib lesions have been associated in previous palaeopathological studies with pulmonary tuberculosis (Roberts et al., 1998; Santos and Roberts, 2001; Lambert, 2002; Matos and Santos, 2006; Santos and Roberts, 2006). However, these lesions can also be indicative of other infections such as pneumonia, bronchiectasis, treponemal disease, non-specific osteomyelitis, and syphilis (Aufderheide and Rodríguez-Martín, 1998; Roberts et al., 1998; Ortner, 2003; Stone et al., 2009). Although an exact diagnostic relationship between rib lesions and a particular pulmonary disease is not possible, "there is general acceptance that the lesions described on the ribs are probably the result of a pulmonary infection initiating an inflammatory response on the visceral surfaces of ribs" (Roberts et al., 1998: 58).

The similarity in rib lesion prevalence rates in both the conflict-zone and neighbours populations indicates that the occurrence of chronic respiratory

inflammations were similar in the two geographic regions. This similarity existed across all ages in both populations. The count of female adults affected by rib lesions in the conflict-zone was nominally higher than in the neighbours populations, but this difference was not statistically significant. In contrast, the proportion of male adults in the neighbours population affected by rib lesions was higher than in the conflict-zone, but, again, this difference was not significant.

Periosteal Lesions

The periosteal lesion rates in the conflict-zone population overall were higher than in their contemporary neighbours. The trends in infection rates between the populations by age, however, were very different (Figure 5.12). The rates in the conflict-zone population stayed consistently between 40% and 60% throughout the broad age categories, while the prevalence rates in the neighbours population increased with age and surpassed the reported conflict-zone prevalence in the adult and older adult ages. These same trends were observed in the more specific age ranges, with the conflict-zone prevalence rates consistently higher than their contemporary counterparts in the non-adults and young adults. Conversely, the prevalence rates in the neighbours population were higher in the adults who died after the age of 25 years. The observed difference in the prevalence rates between the populations was only significant, however, in the non-adult skeletons. The rates in the conflict-zone non-adults (54.3%) was significantly higher than those in the neighbours non-adults (20.0%); however, these significant differences did not translate to a specific age range within the children in either regional population.
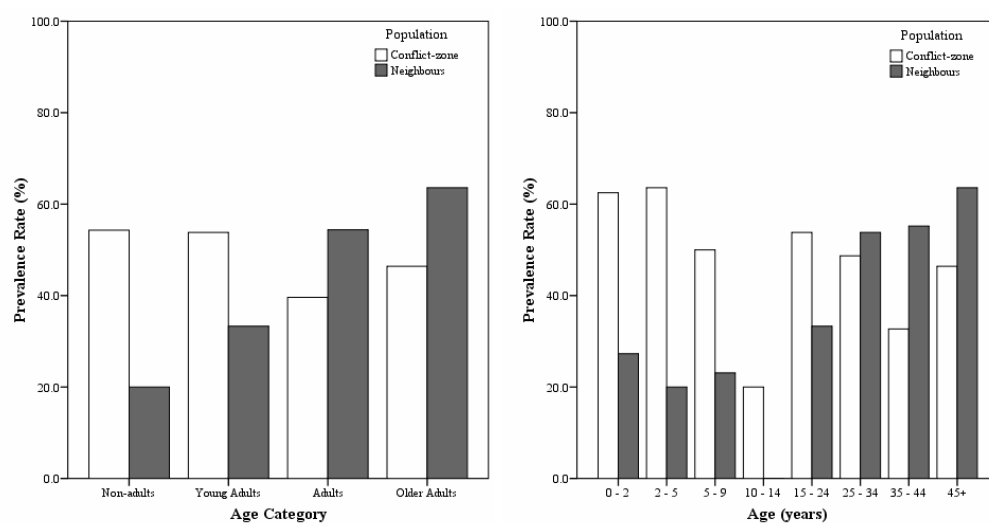
Figure 5.12: Comparison of conflict-zone and neighbours periosteal lesion prevalence rates by age.

Within the adults in both populations, however, the trends of periosteal lesion prevalence rates differed by age between the sexes (Figure 5.13). Although there were no significant differences observed in the male prevalence rates by age, the rates in the conflict-zone males remained consistently high throughout the adult age categories. The rates in the neighbours males, however, increased dramatically in the 45+ age range. This trend was most likely due to the small count of male adults estimated to have died older than 45 years old in both populations. Only a total of 11 male individuals, seven in the conflict-zone population and four in the neighbours population, were observed in this age range. Periosteal lesions were observed in nine of these skeletons, which included all four male skeletons in the neighbours population. Therefore, a prevalence rate of 100% in the neighbours males was not an accurate reflection of the living rates of periosteal infections in this region of medieval Britain. More accurate rates for this lesion should be obtained through additional data collection in the skeletal remains of older adults before drawing conclusions about the differential rates in adult male populations in northern England and southern Scotland.
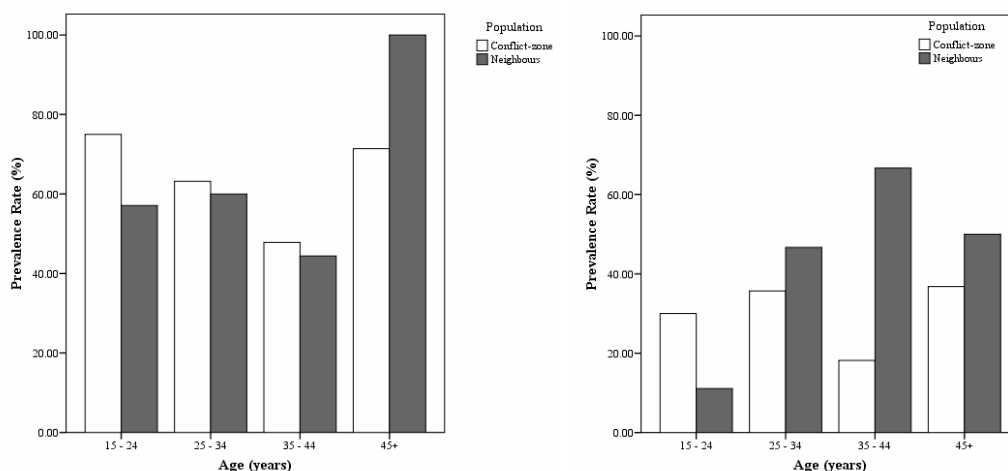
Figure 5.13: Periosteal lesion prevalence rates for adult males (left) and females (right) by population.

The female prevalence rates of periosteal lesions also remained relatively consistent in the conflict-zone population, with rates observed of between 15% and 35%. The rates in the neighbours population females, in contrast, increased with age from 11% to over 60%. The difference between these population rates was only significant, however, in the 35 to 44 year age range. These data indicated that the female adults in the neighbouring populations were exposed to more health challenges which resulted in periostitis than their counterparts in the border populations. The prevalence rates of skeletal element affected by periosteal lesions showed no

difference in the distribution of lesions throughout the skeleton between the two populations. The highest rates of periosteal lesions in both skeletal groups were observed in the tibia and fibula.

Although the specific aetiology of periostitis is continually debated, these bone lesions have been associated with many infectious and nutritional deficiency diseases (Ortner, 2003; Lewis, 2007; Ortner, 2008; Weston, 2008). Higher rates of periosteal lesions in non-adult and young adult skeletons have been reported in populations where health has been poor and the population has been classified as 'stressed' (Rathbun, 1987; Larsen, 1997; Slaus, 2000; Bennike et al., 2005). Lewis's (2002a: 217) comparison of non-adult periostitis prevalence rates between rural and urban populations in medieval Britain, but found no significant differences in the rates. This indicated that the differences observed between the conflict-zone and neighbours populations most likely could not be attributable to health differences between rural and urban living environments. Therefore, the differences in rates between the conflict-zone and neighbours populations must have been a result of the greater exposure of the conflict-zone children to the causal factors associated with periostitis. High prevalence rates in the conflict-zone young adults of both sexes could have been an indication of lingering low-level, chronic infectious or metabolic disease present in the body from childhood encounters with these diseases. In contrast, the older adults in the neighbouring medieval populations must have been disproportionately more exposed to these same causal factors than their conflict-zone counterparts. At most, higher rates of these lesions could indicate that the conflict-zone children and young adults of both sexes were less healthy than their contemporary counterparts in the neighbours populations in the months and years before their deaths (Weston, 2008). This trend, however, did not carry over into the health of adults in the conflict-zone population, where the rates of periosteal lesions were lower for both men and women in comparison to their counterparts in the more urban centres of northern England and southern Scotland.

5.3.2 Metabolic Bone Disease

There were no significant differences in the overall metabolic disease rates between the conflict-zone (16.8 %) and neighbours (12.7 %) populations. However, higher rates of metabolic bone disease in the conflict-zone non-adult ages matched the trends

of poor health in border children as indicated in the high rates of cribra orbitalia and periosteal lesions (Figure 5.14).
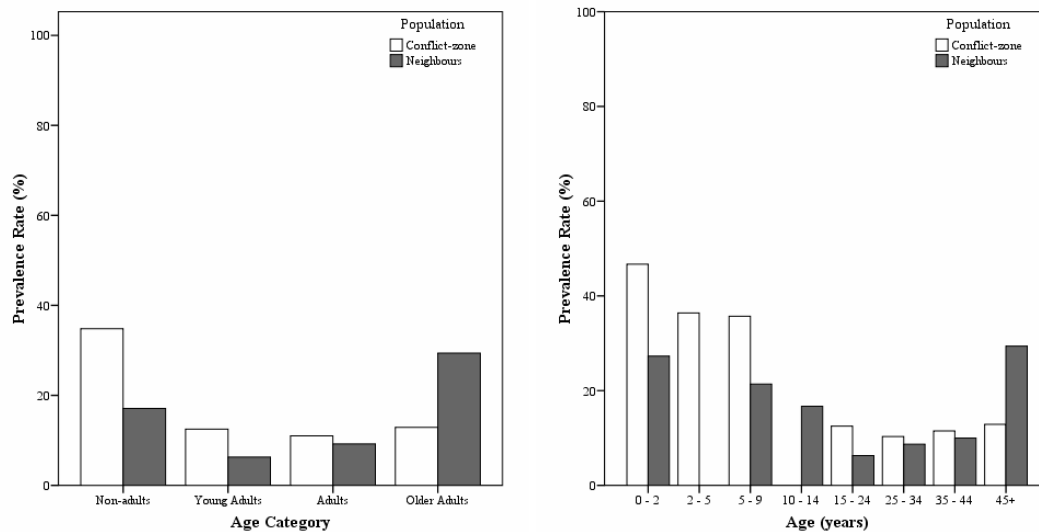
Figure 5.14: Metabolic bone disease prevalence rates by age and population.

Within the adult age ranges, however, the overall rates of metabolic bone diseases remained relatively consistent in the conflict-zone population. In contrast, prevalence rates in the neighbours population increased with age, although none of the differences in prevalence rates between the adults were significantly different. These trends differed between males and females (Figure 5.15). The rates of males affected by metabolic disease in the neighbours population appeared to increase with age, while the conflict-zone population appeared to have very low rates. Prevalence rates in both populations were very low for males, with only three cases in the conflict-zone population (4.3%) and four in the neighbours population (10.0 %). The females, however, demonstrated different trends in observed rates by age. The conflict-zone females showed a decrease in prevalence through adulthood, while the neighbours demonstrated an increase in prevalence with age. This difference in the female prevalence rates, however, was not statistically significant.
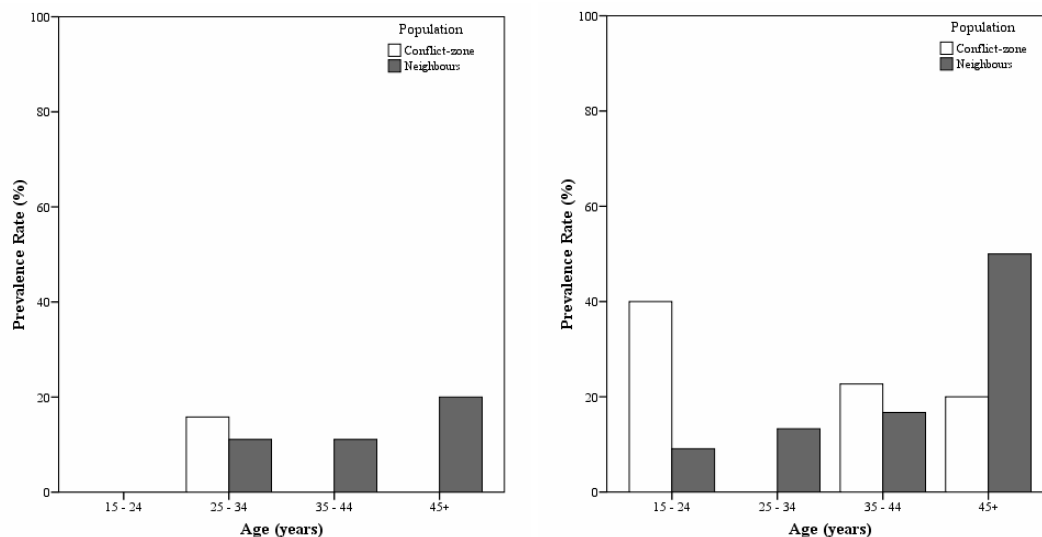
Figure 5.15: Metabolic bone disease adult prevalence rates for males (left) and females (right) by age and population.

Within the conflict-zone population, the females were observed to have had a significantly higher rate of metabolic bone disease than the males. This significant relationship, however, was not demonstrable in the neighbours population. When all eight of the observed populations were combined, a total number of 7 males (6.4%) and 22 females (19.6%) were observed to have had bone changes indicative of metabolic bone disease. These data demonstrated a significantly higher prevalence rate in females in relation to the males when both populations were combined ($X^2_{(1)} =$ 8.617, p = 0.003). This indicated that a sex-based difference in access to nutrient-rich food resources was possibly present in northern English and southern Scottish populations, regardless of their proximity to the border. This trend, however, could be indicative of nutritional deprivations and metabolic shifts that women experience during pregnancy, childbirth, and breast-feeding rather than a matter of sex differences in access to food resources (Brickley and Ives, 2008).

5.3.2.1 Vitamin C deficiency

There was no difference in the overall rates of vitamin C deficiency between the conflict-zone (6.3%) and neighbours (4.5%) populations. However, there was a significant difference in the distribution through the age groups between the two regions. The frequency rate of lesions was significantly higher in the conflict-zone non-adults (26.1%), in comparison to the neighbours non-adults (7.3%). Although the differences within the more specific non-adult age ranges were not significant, the

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rates in the infants and older children in the conflict-zone population were markedly higher (Figure 5.16).
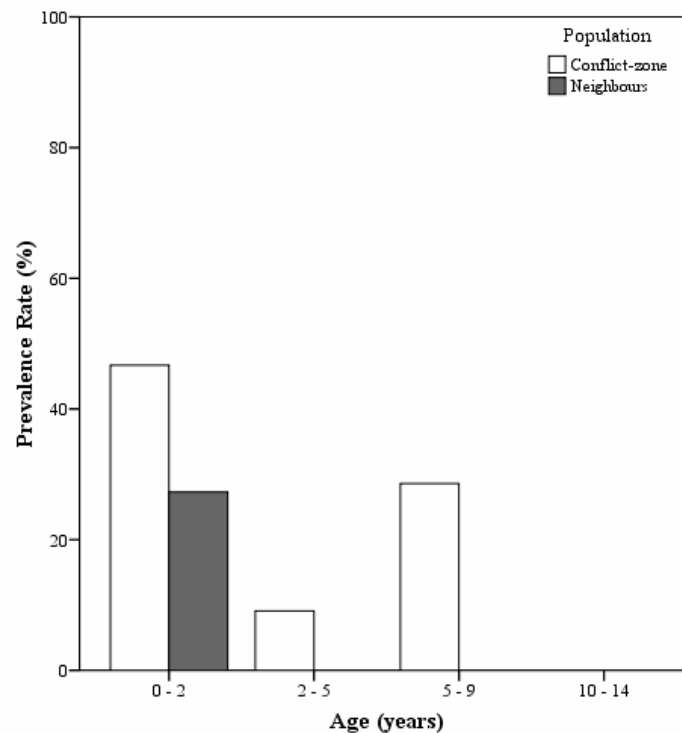
Figure 5.16: Vitamin C deficiency non-adult prevalence rates by age and population.

This result indicated that vitamin C resources in the conflict zone population were more restricted than in their contemporary neighbours, and that this dietary restriction disproportionately affected the conflict-zone children. Food resources that are rich in vitamin C include fresh fruits and vegetables, with smaller quantities available from milk, meat, and fish (Brickley and Ives, 2008: 41). Infants are usually born with a store of vitamin C derived from the mother, and scurvy is rarely seen in children younger than 6 months old (Ortner, 2003; Lewis, 2007). However, scurvy has been associated in modern contexts with premature, low-birth-weight, and twin, babies (Lewis, 2007: 127). Scurvy can also appear in children, most commonly between the ages of 6 months and 2 years, more rapidly than in adults (Stuart-Macadam, 1989; Ortner and Ericksen, 1997; Brickley and Ives, 2006; Lewis, 2007). The high prevalence rate of vitamin C deficiency in the conflict-zone children younger than 5 years is consistent with the results of Brickley and Ives's (2006) survey of infantile scurvy from St. Martin's Church, Birmingham, associated with a potato blight.

Figure 5.17: Bone destruction and new bone formation on the left scapula indicative of scurvy in a 1-year-old infant from Blackfriars cemetery (BF 252).

The high prevalence rate in the conflict-zone population suggested that the children could have experienced vitamin C deficiency during the early years of their life to a greater degree than their contemporary neighbours, because of the absence of fresh fruits and vegetables and fresh fish in their diets. The higher rates in infants could have been associated with issues of nutritional deficiencies experienced by their mothers during the course of pregnancy, and subsequent post-birth breast milk. A reassessment of the prevalence rates within more specific non-adult age categories of birth to six months, six months to two years, and older than three years, could identify more specifically the relationship between maternal and infant dietary deficiencies in the border populations associated with scurvy.

5.3.2.2 Vitamin D deficiency

There were no differences in the vitamin D deficiency prevalence rates between the conflict-zone (7.8%) and neighbours (8.5%). The majority of cases in both populations, 13 out of 16 in the conflict-zone and 9 out of 11 in the neighbours, were described as healed rickets. There were also no differences in vitamin D deficiency

prevalence rates between the populations when compared by age and sex. Individual cases of rickets and healed rickets were observed in the majority of age ranges in both populations and were identified at the same rates in both male and female adult individuals. The cases observed in adult individuals who were estimated as either male or female, were similarly distributed throughout the adult age ranges within each sex. These similarities indicate that the medieval populations in northern England and southern Scotland had relatively equal access to vitamin D resources and had the same rates of vitamin D deficiency regardless of the state of their socio-political environments.

5.3.2.3 Osteoporosis

There were also no differences in the observed rates of osteoporosis between the conflict-zone (2.4%) and neighbours (2.7%) populations. All four of the cases of osteoporosis in the neighbours population were observed in female individuals who were estimated to have been older than 35 years when they died. Similarly, there were four observed cases of osteoporosis in female individuals from the conflict-zone population who were estimated to have died in older age. However, there was one case in the conflict-zone population, BF258, described as a male adult between 25 and 35 years old with bones that were light in weight. The skeletal remains were not complete and the elements present were fragmentary. This individual could have been misdiagnosed with osteoporosis and lost bone mass due to diagenetic processes in the burial environment. A radiological or microscopic assessment of this case would help more accurately determine a diagnosis of osteoporosis in this individual.

The results of the population comparisons for osteoporosis indicated that there were no regional differences in the expression of this metabolic bone disease. Higher prevalence rates of osteoporosis were hypothesised to have been present in the conflict-zone population, particularly in younger adult individuals and associated with starvation (Goodman et al., 1988; Ortner, 2003). This hypothesis was not upheld by the data in this study. Chronic cases of calcium deficiency or starvation in the conflict-zone population were not observed at a higher rate than in the contemporary populations to the north or south of the border.

5.3.3 Caries Lesions

The conflict-zone and neighbours populations were both described as regions with similar diets in medieval historical sources (Dyer, 1989; Lomas, 1996a; Dyer, 2000; Winchester, 2000). Therefore, the prevalence rates of dental caries were hypothesised to have been similar for both groups. The observed rate of individuals affected by caries in the neighbours population (53.1%), however, was significantly higher than for the individuals affected in the conflict-zone population (38.3 %). This higher rate in the neighbours population was demonstrable across all ages (Figure 5.18). The prevalence rates when calculated as teeth affected, however, were not significantly different between the conflict-zone (5.1%) and the neighbours (5.3%) populations.
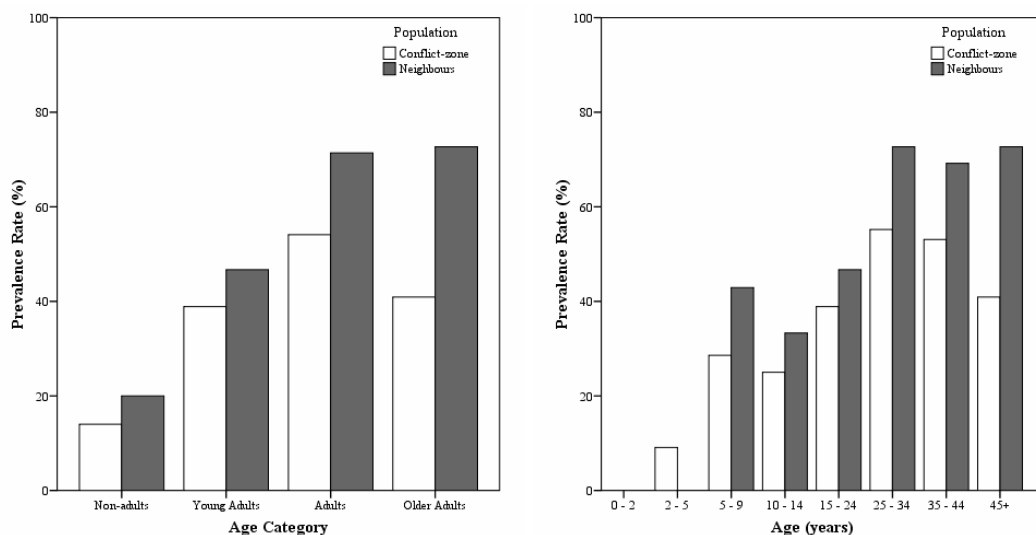
Figure 5.18: Dental caries lesion prevalence rates calculated as individuals affected by age and population.

Caries prevalence rates increased with age in both populations, except in the older adults. The caries rates decreased in the older adults in the conflict-zone while the rates in the neighbours older adults remained consistently near 70% of individuals affected and around 7% of teeth affected. The differences in count of both the individuals affected and the teeth affected within each age subgroup were not significant between the two populations.

There were no significant differences between the conflict-zone and neighbours caries lesion prevalence rates for either the males or females when calculated as individuals affected. However, the trends differed between the sexes (Figure 5.19). The male prevalence rate in both populations increased generally through adulthood, but a drop in the rates was observed in the 35 to 44 year old

conflict-zone males. In contrast, the rates dropped slightly in the 25 to 34 year age range in the neighbours males. The female prevalence rates were also similar in trend in both populations. The highest rates of caries lesions were observed in females in the middle of the adult age ranges, and a peak in the conflict-zone rates was observed in the females between 35 and 44 years old, while the peak in the neighbours population was in the 25 to 34 year old females.
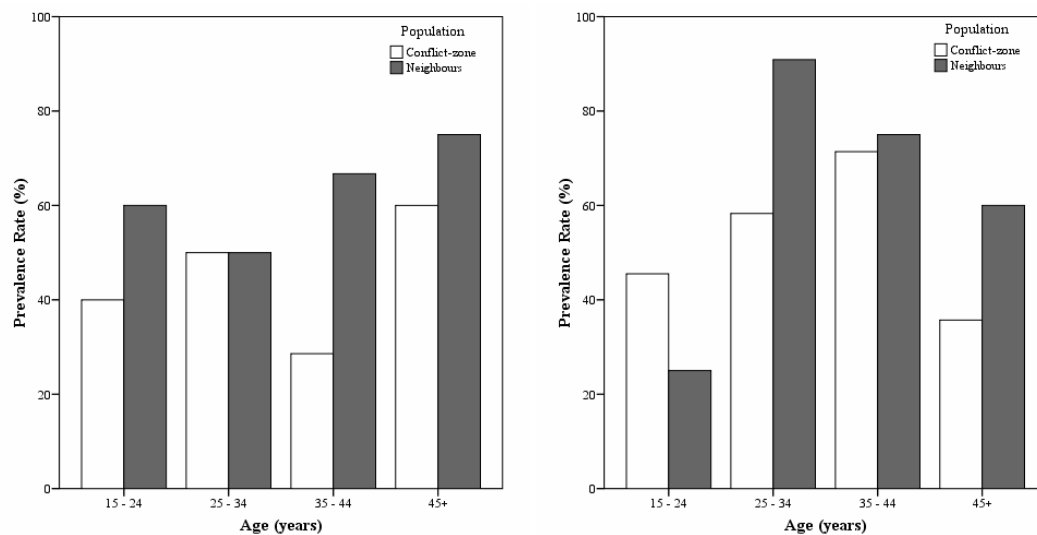
Figure 5.19: Caries lesions prevalence rates as individuals affected for males (left) and females (right) by population.

When calculated as a percentage of total teeth affected, the prevalence rates in both populations for males and females remained below 10% (Figure 5.20), but there were a significantly higher number of teeth affected in the conflict-zone females than in the neighbours females.
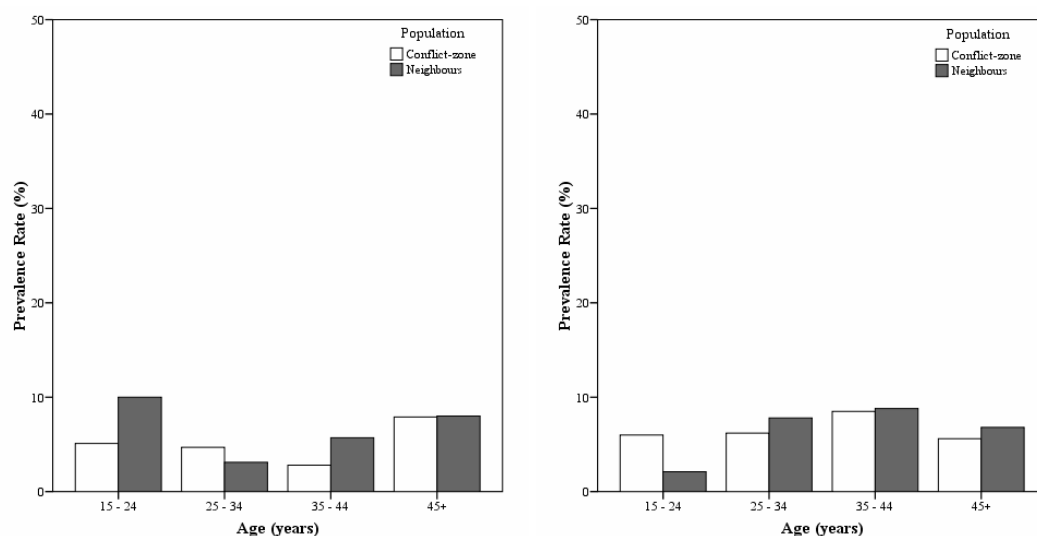
Figure 5.20: Caries lesions prevalence rates as teeth affected for males (left) and females (right) by population.

In both the conflict-zone and neighbours populations, the rates of observed caries lesions indicated that more neighbours people were affected by caries lesions, but that the total impact of caries on the count of teeth affected between the populations remained insignificant. Higher rates of caries lesions have been recorded in living populations in association with diets high in levels of sugar, specifically fructose (Woodward and Walker, 1994). These changes in dental health were markedly noted during the rise in sugar consumption in British diets during the later-Medieval and post-Medieval periods (Roberts and Cox, 2003; Caffell, 2004). This could indicate that the neighbours population diets consisted of more foods with sugars and fructose than the conflict-zone population. The higher social classes in medieval society had disproportionate access to higher quality foods and they also were the first to participate in new dietary trends (Dyer, 1989, 2000). Therefore, the higher rates of dental caries in the neighbours populations could indicate that the burial grounds associated with the general population might actually contain individuals of higher social classes than the conflict-zone cemeteries. The high prevalence rates of scurvy in the conflict-zone children could also be associated with differences in access to fresh fruits and vegetables between the regions. Similarly, the only observed cases of caries lesions in children younger than 5 years old were recorded in conflict-zone non-adults. Caries lesions in children under 5, enamel hypoplasia, and delayed dental eruption have been reported in modern studies of people with diets deficient in protein (Psoter et al., 2005). These differences in trends between the conflict-zone non-adults caries prevalence rates, and the higher overall rates of neighbours adults affected by caries, could suggest preferential access to fresh produce and protein resources in the populations just outside of the conflict-zone.

This could also indicate that infectious disease might be the causal factor behind the formation of caries in more neighbours individuals. Dental caries are contagious bacterial infections which develop in the mouth as a result of bacteria in plaque fermenting sugars in the diet (Hillson, 1996; Aufderheide and Rodríguez-Martín, 1998). These bacteria produce an acid by-product that erodes dental enamel and dentine to form cavities in the teeth (Hillson, 1996; Aufderheide and Rodríguez-Martín, 1998). The more densely populated Medieval urban centres in the neighbours population, as opposed to the more dispersed population settlements in the conflict-zone, could have exposed more neighbours adults to the infectious bacteria that cause caries.

Modern research has also described higher rates of dental caries in women in association with changes in hormone levels throughout life, particularly associated with pregnancy (Lukacs and Largaespada, 2006; Lukacs, 2008). The difference in the count of teeth affected for females did not differ between the populations. This indicated that the number of female individuals in the neighbours population were more likely to develop caries lesions than their conflict-zone counterparts. This could be interpreted as an expression of suppressed or delayed fertility in the conflict-zone females. If the females in the conflict-zone did not become pregnant until later in life, or had fewer children over the course of their life, the total caries lesions they could develop due to hormonal changes would be proportionally reduced (Lukacs and Largaespada, 2006).

Reassessing the mortality rates of adult females in the two populations, relative to the presence or absence of caries, might indicate if hormonal differences could be a causal factor in the higher rates of lesions in the neighbours females. Similarly, a re-evaluation of the caries prevalence rates between rural and urban populations, throughout northern England and southern Scotland, could indicate if this infectious disease process had more of an effect on the rates of caries, than the possible dietary or hormonal differences between the populations.

5.4 Bioarchaeological Evidence of Medieval Conflict-Zone Health

The results of this study did not support the hypothesis that the conflict-zone populations from the medieval Anglo-Scottish border experienced higher rates of morbidity and mortality than their contemporary neighbours. There was also no skeletal evidence to support the hypothesis that conflict-zone individuals were stunted or wasted in comparison to populations to the north or south of the border region. There were differences observed in the shape of the lower limbs in the conflict-zone individuals, which indicated that some differences were observable between the populations. The results of demographic comparisons did not indicate differences existed between the neighbours and conflict-zone populations, and the hypothesis that the medieval conflict-zone experienced higher mortality, stunting, and wasting as a result of socio-political stress was rejected.

Comparison of the prevalence rates of general indicators of stress, metabolic bone disease, and dental caries between the conflict-zone and the neighbours populations demonstrated more overt differences in child health, potentially associated with a conflict-zone lifestyle. There were significantly higher rates of cribra orbitalia and periosteal lesions in the conflict-zone non-adults. There were also significantly higher rates of enamel hypoplasia in the conflict-zone young adults and adults which was formed during childhood. Significantly higher rates of infantile and juvenile scurvy in the conflict-zone population also demonstrated that the border children suffered from higher rates of vitamin C deficiency than their contemporary counterparts outside of the border region. These general indicators of stress and nutritional deficiency demonstrated that the children who were born and raised in the conflict-zone experienced more chronic nutritional depravations associated with malnutrition or infection than their contemporary neighbours during their life.

Conversely, the higher rates of maxillary sinusitis and dental caries observed in the neighbours population, and the similar trends observed in the adults from both populations in prevalence rates for general indicators of stress and metabolic bone disease, did not support the hypothesis that the entire conflict-zone population was exposed to chronic stress throughout their life. This indicated that causal factors other than socio-political stress created the observed differences between the adults in the conflict-zone and neighbours populations. Therefore the hypothesis that the conflict-zone population was disproportionately exposed and effected by chronic stress was tentatively supported for the non-adult and young adult age ranges. This hypothesis, however, was not supported by disease differences between the two populations.

The higher rates of general indicators of stress and vitamin C deficiency in the border children were not associated with higher rates of mortality when compared to the mortality rates among the children who lived just outside of the conflict-zone. The border children survived these experiences long enough for illness or malnutrition to lead to bone changes in the skeleton (Wood et al., 1992). The higher rates of enamel hypoplasia in the conflict-zone young adults also indicated than many border children who were ill during their early childhood recovered well enough to survive to skeletal maturity, without permanent evidence of developmental retardation (i.e. stunted height or wasted body mass). These data indicate that the populations along the medieval Anglo-Scottish border were likely nutritionally deprived as children, but these deprivations did not lead directly to death.

5.4.1 Medieval Stress

Historical sources from both sides of the Medieval Anglo-Scottish border have described unrest associated with the border's creation from the decline of the Kingdom of Northumbria (approximately 900 AD) to the political end of the border troubles with the unification of the royal houses under James I and IV (1603 AD) as an era of chronic nutritional stress for local residents (Fraser, 1971; Winchester, 2000; Rollason, 2003). The primary documentary evidence of the medieval Anglo-Scottish border lifestyle was written by educated, wealthy, and powerful members of society (Given-Wilson, 2004). Medieval historians took issues of national or religious significance more seriously than common life and these histories are biased in favour of the upper classes, religious activities, and major political events (Leff, 1958; Given-Wilson, 2004). Descriptions of daily life can be inferred from illuminations in religious texts, but written descriptions of the 'lower orders' were generally recorded by land owners and tax collectors for the exchequer (Fraser, 1982; Given-Wilson, 2004).

Modern historians still debate the actual extent of the effects of this conflict on the local populations (Fraser, 1971; Lomas, 1996a; Larsen, 2006). Some historians argue that the documents did not exaggerate the conditions in the borders because they come from royal sources as evidence for tax relief claims (Fraser, 1971; Fraser, 1982; Goodman and Tuck, 1992; McCord and Thompson, 1998; Sadler, 2006). These historians have argued that the king would have known if they were exaggerating the damage and would not honour their claims for relief (Goodman and Tuck, 1992; Lomas, 1996b; McCord and Thompson, 1998). Dyer (2007) has also argued that medieval documents describe the defensiveness of the property owners in the face of threats to their income. The border wars could have provided the financial insecure aristocracy of the borders the opportunity to exaggerate the damages sustained on their properties for their own financial ease.

Many of the primary sources of evidence of border conflict were also monastic chronicles (Skene, 1872; Stevenson, 1991; Rollason, 2000; Summerson and Harrison, 2000). These documents were written by institutions which owned land and operated manors in the border regions under attack. Their need to maintain a monastic population dependent on the labours of their wards was paramount to the success of their communities (Dilworth, 1995). "The documents of the period habitually

overstate, describing buildings as totally ruined or almost level with the ground, and then one finds monks living in them, or perhaps the church in use, as in fact happened at Jedburgh in 1550. Reports of buildings in ruins are therefore to be treated with caution unless verified from another source" (Dilworth, 1995: 27-8).

Some modern historians have begun to moderate their interpretations of the 'Harrying of the North' and the border wars as periods of unrestrained violence. They have recognised that the actual extent of the crises and long-term effects of the scorched earth tactics might not have been as detrimental in the first instance, but that other factors, such as natural disasters and epidemics like the Black Death, compounded the effects of war-related raids (Lomas, 1989; Prestwich, 1996; Winchester, 2000). "Just how far warfare actually caused the long-term economic decline of northern England, and how far its effects were reversible, is a difficult question. Evidence that the Scottish raids of that period had a significant long-term impact is presented in the 'Inquisitions of Ninth' compiled in 1341, an assessment of agrarian incomes for taxation. In the source exemption from or reduction of taxation is sought on a variety of grounds…including sterility of the ground, default of tenants, impoverishment of parishioners, and drought" (McNamee, 2006: 248).

Table 5.3: Dates of recorded raids of forces into Scotland (ca.900 – 1600 AD) (Ward, 1999).

Date	Conflict Event in Scotland
ca. 850	Kenneth MacAlpin conquers the Picts and Becomes King of Scotia.
1296	Edward I, after installing his favourite, John Balliol, on the Scottish throne in 1291, invaded Scotland from Newcastle. The English defeated the Scots at Dunbar and forced John Balliol to give up the throne.
1298	Edward I defeats William Wallace at Falkirk.
1299	Edward I's army still in Stirling and in Edinburgh. Ships from Hartlepool brought supplies to the army at both locations.
1304	Edward I lays siege to Stirling Castle.
1306	Robert de Brus claims the Scottish throne.
1307	Scottish defeat English at Loudun Hill in Ayrshire. Edward I dies on this campaign.
1314	Scottish defeat English at Battle of Bannockburn and the English retreat south.
1332	Edward Balliol invades Scotland to claim the throne from King David II. Succeeds, but is expelled by the Scots the next year.
1488	Scottish King James III is defeated and murdered at Sauchieburn by rebels and James IV becomes King of Scotland.
1542	The English defeat the Scottish at Solway Moss.
1547	The Scots are defeated at Pinkie in Lothian.
1549	The English withdraw from Scotland.
1559	War breaks out in Scotland between Mary and her French supporters and Protestant reformers and their English supporters.
1560	War ends.

When examined from a chronological perspective, the dates of recorded raids across the border into both Scottish (Table 5.4) and English (Table 5.5) populations occurred regularly, but not consecutively. With the raids occurring every several

years, the local populations along the border would have been able to recover their fields, food stores, and livestock to a sufficient degree to sustain the population.

Table 5.4: Dates of recorded raids of forces into England (ca. 900 – 1600 AD) (Ward, 1999).

Date	Conflict Event in England
954	Eric Bloodaxe, Norwegian king of York, is defeated at Stainmoor and Northumbria becomes part of England until the House of Wessex claims royal control.
1066	Harold II becomes King of England and defeats the Norwegian King Harald Hardraada and Tostig at Stamford Bridge, near York. He is then defeated by Duke William II of Normandy at Hastings.
1069	William the Conqueror ravages the land between the Rivers Tees and Tyne after the inhabitants killed their newly appointed Norman lord, Robert Comyn.
1138	King David of Scotland invaded England (under King Stephen), but loses Battle of the Standard near Northallerton and returns to Scotland.
1297	William Wallace defeats the English army at Stirling Bridge and ravages Northern England in subsequent raids.
1311	Scottish King Robert I raided northern England in August and September after England's King Edward II returned to London from Berwick-upon-Tweed.
1315	Scottish lay siege to Carlisle
1322	The Scots raided Northern England after the uprising of the Barons and Earls against King Edward II in England.
1327	Scottish raids through Cumbria, Durham, and Northumberland.
1346	Scotland's David II invades England, but is defeated at Neville's Cross and David is captured by England's Edward III.
1388	Scottish army defeats the English at the Battle of Otterburn
1403	Percy's revolt against the English King Henry IV brought English troops into the East March. Sir Henry Percy is defeated at Shrewsbury and killed.
1513	James IV of Scotland invaded England, but was defeated at Flodden and was killed.
1569	Rising of the Northern Earls against Elisabeth I.

During the 14th through the 16th centuries the development of border reiving remained largely undocumented and could have added additional stress to the populations (Fraser, 1971; Sadler, 2006). However, the local reiving families and the March Wardens met regularly to settle the debts owed to parties on either side of the border (Fraser, 1971; Goodman and Tuck, 1992). This practice indicated that, although the local populations were active participants in the reiving economy, their primary aim was not to permanently disable or disperse the populations along the opposite side of the border. The modern pastoral populations in northern Kenya, where low-level endemic war involving cattle theft is still active today, maintain the same standard of population survival over their ethnic affiliations. Examples of one ethnic group (Turkana) defending a neighbouring village belonging to another ethnic group (Samburu) against attacks from more remote villagers of their own ethnicity have been reported, and belies the strictly ethnic causes of the conflict that have long been accepted as the battle lines (Pike et al., 2010: 49). "Protecting local resources in the face of chronic scarcity may take precedence over ethnic affiliation" (Pike et al., 2010: 49).

5.4.2 Coping with Conflict Stress in Modern Populations

Not all living populations exposed to the atrocities of war have experienced the same level of long-term health changes. Agadjanian and Prata's (2003) recent analysis of health in modern children in Angola, in connection with questions surrounding the best use of immunization resources throughout the impoverished nation, indicated that the effect of living in a region directly involved in civil war (1975 – 2002) was negligible on stunting and wasting rates in the face of disease and malnutrition associated with general poverty.

Anthropologists have also begun to describe the mitigating effects that social support and communal experiences of trauma can have on recovering from the negative health consequences of conflict experiences (Gibson, 1989: 661 - 3; Guiao, 1995; Pike et al., 2010). Outram's (2001) review of the mortality data available from the Thirty Years' War (1618 – 1648) in Germany contrasts the high levels of epidemic disease and mortality in German populations with much lower rates in contemporary English populations during the Civil War (1642 – 1651). Outram (2001: 183) attributed these differences to, "the limited level of atrocity in England, the presence of enduring social bonds, the absence of hostile 'inter-ethnic' relationships and of mercenaries, reduced the level of abuse and atrocity suffered by civilians, resulting in levels of distress migration which were low in comparison with those seen in Germany."

A more recent example of the positive effect of social support on the recovery of trauma victims comes from several studies conducted in Beslan, Russia, in the years following a hostage situation in a local school. Gunmen raided a school in Beslan, Russia in September 2004, and held 1300 people hostage in the school gymnasium for three days. "Hundreds of young children spent 57 hours sitting in an overcrowded, hot gymnasium wired with explosives and were denied food, water, and medication. They witnessed the beatings and murders of family members, friends, and teachers. On the third day, the hostage crisis ended in extreme violence with the explosion of grenades, shootings, and a fire that caused the death of 329 persons, 186 of them children, and injured many hundreds" (Moscardino et al., 2010: 27). Researchers have assessed the impact of terror-related trauma on the victims and the community at large since this traumatic event. Scrimin et al (2006) found high prevalence rates of PTSD in both children and adults directly involved in this event

during the three months after the attack. Moscardino et al (2010) also conducted a survey within Belsan of 14 to 17 year old adolescents attending the school which was attacked, and found increased family and community support of these adolescents resulted in lower rates of depression. Similarly, Al Eissa's (1995) survey of Kuwaiti children directly involved in the Iraq army invasion of Kuwait in 1991, described significantly higher rates of anorexia, constipation, weight loss, and lack of sleep as immediate health changes caused by witnessing war-related trauma. The author acknowledged that these symptoms were largely psychosomatic and could be short-term affects later mitigated by the return of stability and security to the children's environments (Al-Eissa, 1995).

Conversely, social ostracism has been shown to compound the negative health trends in individuals who experience trauma (Annan and Brier, 2010; Betancourt et al., 2010). Sierra Leone was involved in a violent civil war from 1991 to 2002 with children directly conscripted into fighting forces on all sides. At the end of the war, child soldiers were returned to their families and communities after witnessing and committing violent atrocities, experiencing rape and indoctrination into paramilitary groups. Despite the mediation efforts of the government and charity organisations, "females were frequently seen as sexually promiscuous or defiled, while many youth–male and female alike–were treated with apprehension" (Betancourt et al., 2010: 18). Betancourt et al's (2010) interviews with 152 former child soldiers after their return from service in 2002, and again in 2004, found perceived discrimination within the community significantly increased rates of depression, anxiety and hostility in these former child soldiers, independent of their actual war experiences (Betancourt et al., 2010: 24). This study highlights the effect that continued social stress can have on the mental health and recovery of former trauma victims. However, rape victims experienced significantly higher rates of anxiety and hostility through time regardless of their perception of social stigma, which indicates that not all traumatic events in war can be mitigated by community acceptance and support of its victims (Annan and Brier, 2010; Clark et al., 2010).

Medical researchers today are often unfamiliar with the cultural contexts of descriptions of health changes associated with war experiences, which can lead to misrepresentations of changes in public health due to conflict (Guiao, 1995). Jones and Wessley's (2005) survey of mental illness symptoms and medical diagnoses of physical illness in historical records from the Boer Wars (1899 – 1902) through to the

modern war in Iraq in western populations, described that psychosomatic symptoms associated with war experiences were expressed by the traumatised individual in a way that is culturally defined rather than medically or biologically explained. Those descriptions of trauma-related symptoms have changed in western war veteran medical records through time, which indicated that, "culture, along with advances in treatments, the discovery of new diseases, new diagnostic tools and the changing nature of warfare, plays a significant role in shaping patterns of symptoms (Jones and Wessely, 2005: 78)". Akello et al's (2010) study of Ugandan children, born and raised during that country's civil war from 1981 to 1986 which devolved into endemic warfare and low-level violence that remains part of the society today, reported many psychosomatic symptoms of pain were readily attributed to disease by medical personal. "Clinical officers focused on physical complaints and readily attributed them to malaria" (Akello et al., 2010: 218). The focus of western-trained medical personnel in diagnosing illness and pain, in order to treat patients who are suffering from PTSD, might be unintentionally inflating the counts of infectious disease prevalence rates in conflict-zone populations by misdiagnosing psychosomatic symptoms of headaches, stomach aches, and general pain as infectious diseases. These supportive communities and mutual respect for the lives of their fellow border residents could have sustained the conflict-zone populations along the medieval Anglo-Scottish border through episodes of socio-political stress.

The results of this bioarchaeological survey of health and disease patterns in the medieval Anglo-Scottish conflict-zone indicated that the relationship between causal factors of 'conflict-zone' mortality as observed in living populations was not present. There were no differences observed in the mortality trends between the conflict-zone and neighbours populations. In contrast, the trends of poor health in the conflict-zone were observed in the non-specific indicators of stress and vitamin C deficiency rates in the non-adults. These health trends, however, were not observed in the conflict-zone adults. Therefore, the hypothesis that 'stressed' medieval populations living along the contested Anglo-Scottish border, from the 10th through the 16th century, had significantly higher mortality rates and more skeletal indicators of stress than contemporary 'unstressed' populations living in other regions of Britain was tentatively supported when describing health in the youngest children and rejected for the general population.

6   Conclusions and Future Work

6.1 Conclusions

The aim of this study was to bridge the gap in the literature between biological anthropological population studies of the health consequences of living in a conflict-zone and bioarchaeological population studies of demographic and palaeopathological indicators of stress. This aim was achieved by conducting a bioarchaeological survey of people living in a medieval British conflict-zone to describe mortality rates and the rates of non-specific skeletal indicators of stress and metabolic bone diseases in a socio-politically 'stressed' population.

The primary objective of this study was to demonstrate that bioarchaeological research can contribute to contemporary discussions of the effects of conflict on health and disease patterns in human populations. This objective was achieved by demonstrating both the potential and the limitations of bioarchaeological studies of past populations to describe the long-term impact of conflict on human health. By conducting a bioarchaeological survey of health and disease patterns in a known region of conflict, the results indicated that long-term health changes can be experienced by human populations when modern medical treatment for illness associated with conflict-zone lifestyles remains unavailable. However, if higher rates of mortality are indeed a long-term effect of socio-political conflict, then the biases inherent in bioarchaeological methods for estimating age and sex in the skeleton limit the ability of researchers to demonstrate these differences in past populations. This limitation in bioarchaeological research must be removed before this objective can be fully accomplished.

The secondary objective of this study was to link historical evidence of socio-political instability along the medieval Anglo-Scottish border with bioarchaeological evidence of stress in skeletal populations. This was accomplished by standardising bioarchaeological data of mortality and morbidity trends in two populations, one 'stressed' and one 'unstressed', and testing the hypothesis that 'stressed' medieval populations living along the contested Anglo-Scottish border, from the 10th through the 16th century, had significantly higher mortality rates and more skeletal indicators of stress than contemporary 'unstressed' populations living in other regions of Britain.

Direct comparison of the two groups concluded that chronic exposure to socio-political instability:

- did not significantly increase mortality in local populations living in the conflict-zone
- did not overtly reduce the size of the men and women who grew up along the Anglo-Scottish border

Current anthropological research demonstrated that increased mortality rates and descreased body size are the most overt indications of conflict-zone health, yet the medieval Anglo-Scottish conflict zone did not reflect this trend. In fact, the overall trends observed in the data demonstrated that the average medieval life span in the conflict-zone population was longer, significantly longer for females, than in neighbouring regions of Britain. Stature and body mass estimations also showed there was no difference in the estimated body sizes between the two regions. There were slight differences observed in the shape of the lower limbs in the conflict-zone individuals, which indicated that some differences were observable between the two groups. However, the vague aetiology of platymeric and platycnemic indices left the relationship between the observed effect of different shapes open to various interpretations of potential environmental, biomechanical, genetic, and nutritional causal factors (Buxton, 1938; Lovejoy et al., 1976; Brothwell, 1981).

Comparison of prevalence rates for general indicators of stress, metabolic bone diseases, and dental caries lesions between the conflict-zone and neighbours populations demonstrated more overt differences between the two populations. The greatest differences between the conflict-zone and the neighbouring populations were:

- significantly higher rates of cribra orbitalia in the conflict-zone infants
- significantly higher rates of periosteal lesions in the conflict-zone non-adults
- significantly higher rates of enamel hypoplasia in the permanent dentition of the conflict-zone young adults
- the border children suffered from higher rates of vitamin C deficiency than their contemporary counterparts outside the border region

These indicators of stress indicated that the children who were born and raised in the conflict-zone may have experienced more chronic nutritional deprivation associated with malnutrition or infection than their contemporary neighbours during their life. The significantly higher rate of cribra orbitalia in the conflict-zone, however, was

based on observing only 35 infant orbit, 21 from the conflict-zone and 14 from the neighbouring sites. There was also a significantly higher cribra orbitalia rate observed in the neighbours youths, between 10 and 14 years old, which was based on only 8 orbits from the conflict-zone and 4 from the neighbours.

Significantly higher rates of vitamin C deficiencies in the conflict-zone non-adults was based on more robust counts of individuals observed, specifically 46 in the conflict-zone and 41 in the neighbours, and highlighted an unexpected nuance in the typical medieval diet along the Anglo-Scottish border. The bone changes associated with vitamin C deficiency can appear quickly in small children whose skeletons are developing rapidly; however, infants can avoid developing these skeletal changes if their mother's dietary intake of vitamin C during pregnancy and breat-feeding is sufficient for both herself and her child. The higher rates of vitamin C deficiency bone lesions in the conflict-zone infants meant that the population in the borders must have barely received enough vitamin C through their normal diets to support both an adult female and her in-utero or newly-born infant. Depravation of the grains, meats, and dairy products normally relied upon to sustain the border population should not have resulted in vitamin C deficiencies if the population resorted to eating only the fresh vegetables, fruits, and herbs grown in personal gardens and in the surrounding natural environment used primarily to supplement their normal diets. The data in this study suggested that the typical medieval diet, particularly in northern England and southern Scotland, relied on less fresh produce than previously suggested by documentary sources (Dyer, 2000, 2006). Conversely, similarities in vitamin D deficiency and osteoporosis prevalence rates between the conflict-zone and neighbours populations indicated that multiple nutritional deficiencies were not common in the borders and those experienced in childhood did not overtly affect long-term border health in adulthood.

The higher rates of general indicators of stress and vitamin C deficiency in the border children were not associated with higher rates of mortality when compared to the mortality rates among the children living outside the conflict-zone. The border children survived these experiences long enough for illness or malnutrition to cause bone changes in the skeleton. This could also indicate that the conflict-zone children were healthier because they were able to survive long enough to experience bone changes, whereas their counterparts in the neighbours population were too unhealthy to survive the acute stages of illness (Wood et al., 1992). The higher rates of enamel

hypoplasia in the conflict-zone young adults also indicated than many border children who were ill during their early childhood recovered well enough to survive to skeletal maturity, without permanent evidence of developmental retardation (i.e. stunted height or wasted body mass).

The conclusions that can be derived from this study are contradictory. The only skeletal evidence for conflict-zone stress in the documented medieval Anglo-Scottish border war zone is the slight higher rates of non-specific indicators of childhood stress, specifically enamel hypoplasia on the permanent dentition and cribra orbitalia and periostitis in the non-adult skeletons. The expected skeletal evidence of high mortality rates, stunting, wasting, and chronic nutritional deficiencies and infections throughout the age and sex categories was not born out in these data. The implications of these results call into question both the medieval documentary evidence of the severity and longevity of the conflicts experienced by the border populations and the sensitivity of osteological and palaeopathological data to health changes associated with a conflict-zone lifestyle. Medieval documents were written by and for the elite members of society and used as a record of politically and religiously important events (Given-Wilson, 2004). As such, these documents recorded the major socio-political changes and war events that punctuated the lives of those directly involved or affected. In contrast, the skeletal evidence available from medieval lay populations represents the averaging of the health and disease experienced by that individual. The minutia of the daily lives of peasants, farmers, and craft labourers can only be inferred from the legal documents and tax records which survive to date (Dyer, 2000). Skeletal evidence is the most direct archaeological evidence available to describe population health and nutrition in the past. Skeletal analysis, however, is confounded by the limitations imposed by skeletal biology. Brief changes in health may not affect the skeleton, bone lesions may be healed in subsequent periods of health and nutritional stability, or may be 'drowned out' by the overriding impact of climate, environment, or chronic stresses imposed by disease and hunger in pre-industrial Britain (Wood et al., 1992; Roberts and Cox, 2003). Additionally, this bioarchaeological assessment of medieval border lifestyles did not take into account other sources of archaeological evidence, such as zooarchaeology, archaeobotany, or settlement patterns, which could also inform our understanding of the impact of conflict on the medieval populations along the Anglo-Scottish border. The contradictory results of this study could be clarified by

incorporating these other lines of evidence into the regional analysis of health and disease patterns.

6.2 Limitations

The limitations in this study have been discussed as biases inherent in the methods and interpretation of bioarchaeological research. The limitations within bioarchaeology that directly affected the aims and objectives of this population survey included differential preservation of the archaeological materials and the inability to connect specific effects in the skeleton to particular causes.

6.2.1 Preservation

Poor preservation of the neighbours skeletal collections was a significant limitation in this study. Despite previous impressions that preservation of skeletal remains along the Anglo-Scottish border was not conducive to further skeletal analysis, the preservation state of the conflict-zone skeletons was significantly better than in the neighbours population. The limited number of skeletons generally available in the neighbours region also restricted the random selection process of skeletons for this study. These restricted numbers removed the ability of this study to randomly sample the neighbours cemetery populations and imposed unforeseen limitations on the scope of comparative data available. While the sampling strategy used to describe health and disease patterns along the Anglo-Scottish border provided a comprehensive sample of the mortality and morbidity trends in the conflict-zone, the same sample could not be replicated for the regions north and south of the border. The data available in the neighbours population was not sufficiently fine grained enough to accurately describe the health and disease patterns in 'unstressed' medieval populations from northen England and southern Scotland. Future research to identify and excavate more skeletal populations in northern England and southern Scotland for further data analysis would be beneficial to further describing the health and disease patterns within this region of Britain. They would also enhance the data in this study.

6.2.2 Skeletal Remains as Representatives of a Living Population

As with all bioarchaeological population studies, the individual skeletons selected for this study were unlikely to have represented a random cross section of the living populations from which the cemetery population was derived (Ortner, 1991; Scheuer

and Black, 2000a; Roberts and Manchester, 2005). The processes through which the human body goes following death and burial, including the impact of the burial environment on preservation, are not completely random and skeletons excavated from archaeological sites cannot accurately represent the complete range of human health and disease patterns in a living population (Waldron, 1987; Walker et al., 1988; Buikstra and Ubelaker, 1994; Larsen, 1997; Chamberlain, 2006; Pinhasi and Bourbou, 2008). The biases inherent in the current methods for assessing age-at-death have been shown to under-aging older adults and skew resulting demographic data in archaeological population studies (Lovejoy et al., 1985a; Saunders et al., 1992). Similarly, the biases in estimating both sex and age are heavily dependent on the biological proximity of the skeletal remains to the reference population used to develop the estimation methods (Walker, 1995). When estimations of life-expectancy, survivorship, and mortality rates are calculated from age and sex estimations that are inherently flawed, the viability of the estimates as representative of true mortality and life spans in medieval Britain is problematic. Although this study attempted to account for the inherent biases in the current age and sex methods by applying them consistently to all of the skeletons, thus equally biasing both the conflict-zone and neighbours population data, it cannot be confirmed that the demographic data in this study was equally affected by these biases. Only an exact comparison of the true age and sex distributions from the living medieval populations of northern England and southern Scotland could have accurately described the differences in mortality and morbidity between the conflict-zone and their neighbours.

6.2.3 The Osteological Paradox

The palaeopathological lesions described in this study were by their very nature non-specific indicators of disease and stress (Goodman et al., 1988; Larsen, 1997; Lewis, 2007). The inability to define a cause and effect relationship between some skeletal indicators of poor health and the illnesses that cause them significantly reduces the interpretive potential of bioarchaeological population research on the effects of stress in the body (Ortner, 1991; Roberts and Manchester, 2005). For example, the presence of pathological bone lesions in the skeleton do not mean that the individual died from the illness which caused the lesion (Wood et al., 1992). The presence of a pathological lesion can at most be interpreted as the presence of disease in that individual at some point during their life. Similarly, the absence of bone changes in a

skeleton does not necessarily mean that the individual was generally in good health before the illness or event that caused their death (Wood et al., 1992). Acute diseases kill a person too quickly to allow bone changes to develop in the skeleton and chronic diseases that affect only the soft tissues of the body might not create pathological lesions on bone. The majority of illnesses and nutritional deficiencies observed in modern conflict-zone population are acute conditions that affect the soft-tissues of the human body (Cardozo et al., 2004; Salvage, 2007; Degomme and Guha-Sapir, 2010). Therefore, the presence of the majority of health challenges today cannot be determined from skeletal remains.

6.2.4 Macroscopic Research Methods

The most effective macroscopic methods for assessing population morbidity and mortality were chosen for this study. The assumption made was that if macroscopic, non-destructive, methods produced data supporting the hypothesis proposed, then future work using destructive methods at a microscopic or biomolecular level could be justified to further test the hypothesis. The decision to restrict the methods used in this research removed the potential for radiographic, microscopic and chemical analyses to further assist in the diagnosis of pathological conditions associated with bone changes observed in the skeletons. The absence of additional data resulting from these analytical methods removes the robusticity of the disease diagnoses made from human skeletal remains (Roberts and Manchester, 2005; Brickley and Ives, 2008). For example, the individuals who were diagnosed with osteoporosis were observed to have had lighter bones which suggested lower-than-normal bone mass for their age. However, a radiograph of the long-bones from these individuals is necessary to accurately diagnoses a case of osteoporosis, where bone mass is more than 30% below the normal range by age. However, the results of this study indicate that future potential lies in these additional methods for interpreting health and disease patterns between these two medieval British populations.

6.3 Future Research

The results and conclusions of this bioarchaeological population survey have highlighted several avenues for further exploring conflict-zone health in past populations. The focus of this work must entail refining the relationship between the multiple causal factors for skeletal indicators of stress and the population differences

observed between the Anglo-Scottish border population and their contemporary neighbours.

6.3.1 Accuracy of differential diagnoses

Further analysis of the diseases diagnosed in these populations using more advanced methods would help to clarify the real prevalence rates for metabolic bone diseases and infectious diseases in both populations. The use of radiographs in particular would help to resolve issues of diagnoses in the observed cases of scurvy and osteoporosis (Brickley and Ives, 2008).

6.3.2 Explore population migration patterns

To compare mortality rates between the two populations, it was assumed that the cemetery populations analysed in the Anglo-Scottish border region represented stable populations. However, the differences between the populations as described in the mortality rates and the palaeopathological data indicated that this assumption is not valid. The observed differences in adult mortality in the conflict-zone population did not fit with the overall model for a stable archaeological population (Chamberlain, 2006). Additionally, historical evidence of the mobility of medieval populations has indicated that the border populations underwent seasonal migration (Young, 2007). The development of urban centres throughout England and Scotland increased emigration trends of the peasant populations in general (McCord and Thompson, 1998; Dyer, 2002). The economic opportunities available to both rural emigrants and foreign immigrants in the border regions increased the desire to relocate there (Vyner, 1990; Winchester, 2000). The presence of military forces garrisoned in the border regions alone introduced new pathogens to the local populations from soldiers from other populations (Prestwich, 1996; Dyer, 2002; Prestwich, 2006).

6.3.3 The effects of fertility and migration on population health

Local changes in fertility and migration have been trends observed in modern conflict-zone populations, specifically among women and young children, which could shed further light on the mortality and fertility rates along the Anglo-Scottish border (Babiae-Banaszak et al., 2002; Cardozo et al., 2004; Avogo and Agadjanian, 2010; Degomme and Guha-Sapir, 2010). Future research into the medieval Anglo-Scottish border region exploring the effects of migration on health and disease

patterns could help clarify remaining questions about rates of mortality and infectious diseases in these populations. Finally, stable isotope analysis is a valuable tool used by bioarchaeologists to explore in more detail dietary differences and migration patterns between populations (Bell et al., 2001; Muldner and Richards, 2006; Katzenberg, 2008). The differences in prevalence rates of dental caries indicated that there might have been dietary differences between the conflict-zone and neighbours populations. Further exploration of these trends using stable isotopic analysis could further clarify the relationship between stress, diet, and differences in health and disease patterns in northern England and southern Scotland.

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Appendix A:

Supplemental Materials Summaries

A.1 Conflict-zone Population

Historical and archaeological evidence from the Medieval Anglo-Scottish border suggested that people living in this region experienced nutritional and psychological stresses associated with international, socio-political conflict for control of the region. Four collections of human skeletal remains excavated from the conflict-zone region were included in this study. The sites were located in or near settlements suggesting the people buried in the cemeteries were the remains of individuals who resided in the local region. They were hypothesized to demonstrate increased mortality and a general decline in health, similar to the demographic and pathological changes experienced by modern conflict-zone populations, when directly compared to their contemporary neighbours.

A.1.1 Auldhame, East Lothian

Archaeological and historical evidence indicated Auldhame cemetery (NT 6016 8476) was used as a communal burial ground by a rural, Christian community in the Scottish parish of Tyninghame during both the early-Medieval decline of Northumbria and the late-Medieval border troubles. This community may have been associated with an early-Medieval abbey dedicated to St. Baldred and later supported the late-Medieval residence of the Douglas family at Tantallon castle. Documentary sources described Viking raids in the region during the decline of the Northumbrian kingdom, conflict among the local Scottish nobility in the 14th and 15th centuries, as well as direct involvement of the local nobility in Henry VIII's war of rough wooing. The available documentary evidence suggested Tyninghame villages experienced military occupation, crop burning, and reiving during the use of Auldhame cemetery.

Figure A.1: Aerial photograph of the Auldhame excavation site along the sea cliffs of East Lothian (Photo Courtesy of Royal Commission on the Ancient and Historical Monuments of Scotland).

Ploughing near the East Lothian village of Auldhame in February 2005 uncovered human skeletal remains from a forgotten medieval cemetery (Hindmarch and Melikian, 2006b). The site is located at the edge of an eroding sea cliff between the Scottish towns of North Berwick and Dunbar (Figure A.1). AOC Archaeology Group, under terms of the Historic Scotland Human Remains Call-Off Contract, conducted a field survey, test pitting, and open area excavation at this site during 2005 and 2006 (Melikian, 2009). This archaeological project aimed to determine the nature and extent of the archaeological evidence present, to remove the archaeologically significant material culture from the ploughed surface of the field, and to protect the in situ archaeological evidence below the surface of the active field from further plough damage (Hindmarch and Melikian, 2006b).

Excavation uncovered a burial ground adjacent to the stone foundation of a small, multi-phased building interpreted as a chapel (Hindmarch and Melikian, 2006a). The associated material culture indicated burials began in the 7th century and ceased by the end of the 17th century at Auldhame. Excavated burials contained few grave goods and were supine, consistent with Medieval Christian burial practices (Hindmarch and Melikian, 2006b). Changes in burial alignment were observed

during excavation of the cemetery which corresponded to temporal shifts in burial practices (Hindmarch and Melikian, 2006b).

Radiocarbon dates from associated skeletal material from the various alignments indicated three distinct phases of burial at Auldhame (Hindmarch and Melikian, 2006b). The first phase dated from 680 to 880 and was aligned north-west to south-east (ibid). The stone foundation cut through graves from this phase of interment before 900 AD, which possibly indicates an earlier chapel associated with the north-west to south-east burial alignment (ibid). The second phase of burials, aligned east-west and concentrated on the south side of the chapel, was dated to 890 – 1030 (ibid). The third phase, aligned south-west to north-east, dated from 1280 – 1400 and consisted of many non-adults clustered near the west end of the chapel (ibid). Where identifiable from burial alignment and radiocarbon dating, skeletons from the first phase of interment were not studied and disease patterns in early-Medieval Northumbrian populations were beyond the scope of this project.

Post-excavation skeletal analysis determined that a minimum of 239 individuals, 161 adults and 78 non-adults, were present in the skeletal collection, with 71.5% preserved in a moderate or good state (Melikian, 2009). The skeletal collection is currently stored at AOC Archaeology's Edinburgh facility and is undergoing further post-excavation analysis (Crone, 2007).

Historical Context

Previous archaeological research throughout Lothian has identified continuous human settlements in the region since the Bronze Age and Iron Age (Driscoll and Yeoman, 1997; Dunwell, 2007). Additional features found during the excavation at Auldhame, such as a coastal ditch, pits, and post-holes, suggested an Iron Age fort may have occupied the site before its use as a Medieval chapel and cemetery (Hindmarch and Melikian, 2006b). East Lothian lies geographically between the two Roman walls and previous finds of Roman material culture in Lothian attest to Roman settlements in southern Scotland during their occupation of Britain (Lowe, 1999).

The primary evidence of the political and cultural influences in Lothian after the Roman retreat comes from place names, Bede's *Ecclesiastical History of the English People*, and the Anglo-Saxon chronicles. Regional place names are predominately Anglo-Saxon which described Lothian as culturally associated with the kingdom of Bernicia which later became the northern half of Northumbria (Lowe,

1999: 33). The earliest documentary evidence for the area dates from Bede's writings in the 8th century AD. Bede, however, makes no specific mention of the Lothian region when describing the state of the kingdom of Northumbria in 731. He described the eastern half of an inland projection of the sea, the Firth of Forth, as a boundary between the English to the south and the Picts to the north which indicated Lothian was part of Northumbria (I. 12, Bede, 2008: 23). He also references two monastic houses, Coldingham, north of the River Tweed, and Abercorn, on the southern coast of the Firth of Forth, with ecclesiastical ties to Lindisfarne; this further indicates that this region was part of Northumbria in the 8th century (Bede, 2008).

Archaeological evidence from the Auldhame excavation suggested a population lived near the cemetery from the 7th century, and religious history states that St. Baldred lived in the Auldhame area during this period (Hindmarch and Melikian, 2006a). Baldred was described as living in isolation on Bass Rock which is visible from the Auldhame cemetery site (Hindmarch and Melikian, 2006a).

Documents written centuries after the decline of Northumbria recorded additional details about the early Medieval parish of Tyningham which may not be entirely accurate. There is reference in the *Historia de Santo Cuthberto* to an ecclesiastical affiliation between the local communities in the East Lothian region and a monastery of St. Baldred at Tyninghame (Melikian, 2009). The *Historia de Sancto Cuthberto* claimed the lands of Tyningham from Baldred as part of land gifts to St. Cuthbert while Cuthbert was bishop of Lindisfarne (South, 2002: 47). However, the monastery of 'St. Balthere' did not exist until after Cuthbert's death and therefore the Baldred monastic community could not have been gifted to him during his life (South, 2002). Auldhame is later described by Simeon of Durham as a separate parish belonging to the bishopric of Lindisfarne in 854 AD, making no reference to a religious community in the vicinity (Melikian, 2009). The information we can glean from these later references is that this region of Lothian may have been associated with Lindisfarne's religious authority since the 6th century, and the population may have later supported a monastic community dedicated to St. Baldred in the 8th century before its recorded destruction in 941 AD during a Viking raid (South, 2002). Late-Medieval records also reported the presence of a village in the vicinity of Baldred's House, which may allude to Auldhame and its geographic proximity to Baldred's early-Medieval monastery. However, the location of the village mentioned has not yet been archaeologically recovered.

The next primary source of information about Auldhame comes from the Anglo-Saxon Chronicle's description of Viking raids along the east coast of Britain. The Anglo-Saxon Chronicles stated Anlaf the Dane destroyed the monastery of St. Baldred and burned the village of Tyninghame in 941 AD (South, 2002; Hindmarch and Melikian, 2006b). Tyninghame lies two miles to the south of Auldhame and is associated with the St. Baldred monastic community in historical documents (Hindmarch and Melikian, 2006b). It is reasonable to assume that Auldhame could have been directly affected by Viking raids if they attacked other villages in the local region associated with Baldred's monastic community.

The Anglo-Saxon Chronicle also described the Scottish claims on the Lothian region, beginning in the 10th century, as the power of the Northumbrian political and ecclesiastical authorities declined. East Lothian was given to the Scots in 973 following almost a century of warfare between the Scots from north of the Firth of Forth, the Saxons from south of the Humber river, the Danes from Yorkshire, and the Anglo-Scandinavians from Strathclyde (Mackie, 1978; Lowe, 1999; Savage, 2002). The Scottish King Malcolm II's victory at the Battle of Carham in 1018 confirmed the Lothian region north of the River Tweed was under Scottish rule (Lowe, 1999).

This border between the northern Scots and the unifying English to the south was still hotly contested between the various factions in the Scottish nobility and the last Saxon kings of England, specifically Cnut and Harold, before the Norman Conquest (Mackie, 1978; Savage, 2002). Records indicated North Berwick was under the control of the Scottish Earl of Fife at the time of the Norman Conquest. Historical documents described the Lothian region as particularly susceptible to changing political allegiances between England and Scotland during the 10th and 11th centuries. Lothian was attacked repeatedly by William the Conqueror's and Malcolm III's armies between 1070 and 1093 (Rollason, 2003; Sadler, 2006). Malcolm burned the fields of Lothian in advance of William's army during the 'Harrying of the North' in both 1070 and 1080 to remove the ability of William to supply his army with local resources (Sadler, 2006: 16) East Lothian appears to have remained under Scottish political control throughout the 11th century despite its susceptibility to Norman raids. The newly founded Durham religious community was granted the parish of Tyninghame, including Auldhame, in 1094 AD by the Scottish King Duncan II (Lowe, 1999: 12). This grant also suggested northern England was under Scottish control at various times following William the Conqueror's invasion.

There is no record of fortification in the East Lothian region during the 12th or 13th centuries. A Cistercian nunnery was built in the immediate area around 1150 and may have been founded on the location of the previous St. Baldred's monastic community, although its exact location remains unverified by archaeological evidence (Melikian, 2009). This monastic foundation signified a shift in power with England's increasing political influence over Lothian, and indicated there was a population still living in the Auldhame region which could economically support a nunnery.

English Kings took advantage of the weakness of the Scottish crown during the 13th century and gradually expanded their control from Newcastle-upon-Tyne north to Edinburgh (Sadler, 2006). This expansion of English authority was repulsed by Scottish revolts beginning in 1296 and culminated in the Scottish Wars of Independence (McNamee, 2006). The lack of fortifications constructed near Auldhame during the 13th century Scottish Wars of Independence was consistent with Robert de Brus's policy against castle-building, thus denying his English enemies shelter when they invaded the south of Scotland (Tabraham, 1986; McNamee, 2006). Records of a claim dispute between the Earl of Fife and the Earl of Douglas over the barony of North Berwick in the mid-1300s suggests this property was redistributed among the Scottish elite following the crowning of Robert de Brus (Tabraham, 1986).

Tantallon castle, constructed in view of the chapel and burial ground at Auldhame in 1358 by William Douglas, served as a base for the 'Red' Douglases during fighting within the border's powerful Douglas family in the 1400s (Tabraham, 1986). Despite its initial purpose as an opulent residence for the Earl of Angus, Tantallon Castle served as a military fortification and a prison for the nobility during the 15th and 16th centuries; the duchess of Albany was held here in 1425 and Alexander, Lord of the Isles, was held here in 1429 (Tabraham, 1986). In 1445, the barony of North Berwick was plundered while James, the 3rd Earl of Douglas, was summoned to the Scottish court for fighting with the 'Black' Douglases (Tabraham, 1986). In 1528, Tantallon Castle lay under siege by James V for 26 days due to the rebellion of the Red Douglases to his authority (Tabraham, 1986). Although the castle did not fall, the Earl was exiled for treason and Tantallon Castle became a royal castle from 1529 to 1543 (Tabraham, 1986).

Records stated the Auldhame region featured prominently during Henry VIII's Rough Wooing due to the changing loyalties of the Earls of Douglas and the strategic location of North Berwick between both kingdoms (Tabraham, 1986). In May of

1544, the Earl of Hertford's raiding English army passed by Tantallon Castle in an attempt to rattle the military garrison stationed at the castle (Tabraham, 1986). The castle and surrounding countryside was again attacked during the Civil War in 1651 (Tabraham, 1986). Burials at Auldhame appeared to have ceased before this attack during the Civil War (Hindmarch and Melikian, 2006a).

Archaeological evidence suggested the Auldhame cemetery was a communal burial ground throughout the formation of and contention over the Anglo-Scottish border from the 10th through the 16th centuries. The local population experienced a conflict-zone lifestyle throughout its use of the Auldhame burial ground.

A.1.2 Blackfriars Street, Carlisle

> "Carlisle was the principle city in the west; the great, red sandstone mass of the castle, stark, square and utterly uncompromising, had been built as a challenge to the Scots and remained so, defying several determined sieges" (Sadler, 2006: 7).

The modern city of Carlisle lies nine miles south of the modern political border with Scotland and is adjacent to Hadrian's Wall. During the late-Medieval period, Carlisle was the principal urban centre of England's West March. Historical and archaeological evidence from Blackfriars Street, Carlisle (NY 4003 5580) indicated the human skeletal population interred there by Dominican Friars, between 1240 and 1539, was composed of individuals from the monastic community and a portion of the local secular community (Jones, 1990). Documentary evidence from the 11th through the 16th centuries described Carlisle's direct experiences of military sieges, 'scorched-earth' military raids, and border reiving (Fraser, 1971; Summerson, 1993; Summerson and Harrison, 2000; Sadler, 2006). The Blackfriars Street cemetery population was hypothesised to express demographic and palaeopathological evidence of a conflict-zone lifestyle despite the protection afforded the community by the medieval defences and military garrison stationed at Carlisle.
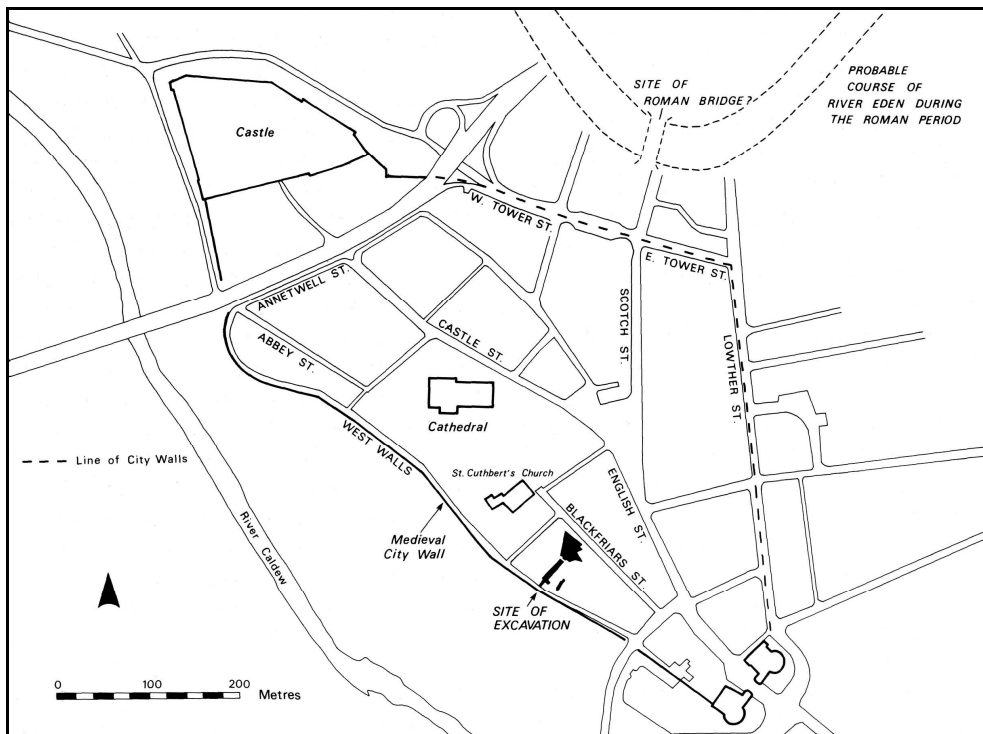
Figure A.2: Map of modern Carlisle city centre with excavation location and Medieval city walls *(McCarthy, 1990: 5).*

The Medieval cathedral and castle, both still standing in the city centre, is material evidence of a large, urban, Christian population that lived Carlisle during the Medieval period (McCarthy, 1990: 359). The exact location, however, of the documented late-Medieval Dominican Friary church were largely unknown before excavations were conducted at Blackfriars Street between 1977 and 1979 (McCarthy, 1990; Moffat, 1996). These excavations, within the Medieval city walls of Carlisle between Blackfriars and West Walls Streets (Figure A.2), were both an archaeological exploration of the previously occupied location and a rescue excavation conducted before the construction of a Marks and Spencer's car park (McCarthy, 1990).

Excavations uncovered a Medieval stone foundation with an associated burial ground, a series of Roman buildings, and evidence of Neolithic occupation along the current street frontage (McCarthy, 1990: 4). Late-Medieval fragments of walls found in Trenches B and H confirmed the positions of the Friary church and cloister that are depicted in a bird's eye view map from 1560 (McCarthy, 1990: 373). Timber remains from the church confirmed the construction of the Friary with dendrochronological evidence of the late 13th century (McCarthy, 1990). Late-Medieval coins, metal objects, glass, and pottery found in association with the Friary and graves, also confirmed late-Medieval use of the site (McCarthy, 1990).

The excavated cemetery contained both supine interments, with heads aligned west, and disarticulated human remains (McCarthy, 1990). No evidence of grave cuts could be distinguished due to the shallow depth of the cemetery in relation to modern pavement levels, and because of intercutting throughout the cemetery's use (McCarthy, 1990). Few grave goods were found, but iron nails positioned around the edges of graves indicated the use of wooden coffins (McCarthy, 1990).

Post-excavation skeletal analysis determined a minimum number of 214 individuals (201 adults and 13 non-adults) (Henderson, 1990: 330). Only 15 skeletons in the population were described as in a good state of preservation; 78% of the skeletons present were categorised as poorly or very poorly preserved (Henderson, 1990: 331). The human skeletal remains from Blackfriars Street are currently stored at the Tullie House Museum in Carlisle (Padley, per comm.).

Historical Context

Historical records and previous archaeological excavations have shown Carlisle was a population centre from the Roman period (Hogg, 1955, 1964; McCarthy, 2000). A Roman fort was constructed around 72 AD and marked the beginning of Carlisle's importance as a regional urban centre (McCarthy, 1990). A Roman town, *Luguvalium*, was described in tablets along Hadrian's Wall as centred around a fort "established in 72-3 AD and continued in use until 320-30 AD" (McCarthy, 2004: 3). Although there is clear archaeological evidence for the use of the Blackfriars Street site during the Roman period, there are no specific documentary references to its function within the town (McCarthy, 1990: 359). Bede described St. Cuthbert's visit to the ruins of a Roman city wall at Carlisle in the 6th century AD, but there is no archaeological evidence for a Roman defensive wall around Carlisle (McCarthy, 1990; Bede, 2008: 228). It has been hypothesised that these walls were the remains of the original Roman fort structure itself which were inaccurately described by Bede as a curtain defensive wall (McCarthy, 2004).

Archaeological evidence indicated that Carlisle remained a population centre of some wealth after the Roman withdrawal (McCarthy, 2004). Historical sources describe Carlisle as the seat of power for the Celtic kingdom of Rheged which was focused around the Solway Firth (Lowe, 1999). Rheged's political boundaries, strength, and extent of regional influence, remains uncertain as no written documents from the kingdom have survived (Cramp, 1994). Only passing references to the

kingdom and its Celtic population were made in Bede's *Ecclesiastical History of the English People* and the Anglo-Saxon Chronicles (Savage, 2002; Bede, 2008).

The Anglo-Saxon Chronicles described the 6th-7th century AD military campaigns of conquest over the populations living in and around Carlisle as a result of the expansion of Northumbria (Lowe, 1999; Savage, 2002). However, Bede's previously mentioned description of St. Cuthbert's visit to *Luguvalium* in 685 highlighted the greater effect the Northumbrian religious establishments had on Carlisle (Cramp, 1994; Bede, 2008). Cuthbert is credited with establishing a monastery at Carlisle associated with the Northumbrian religious authority at Lindisfarne (South, 2002: 47). However, there is speculation among modern historians that a Celtic religious order centred around the site of the current Cathedral existed in Carlisle before Cuthbert's visit (McCarthy, 2004). This community could have been associated with an Irish monastic or pagan religious establishment within Rheged which was later superseded by a Northumbrian religious authority in the face of its political and cultural expansion.

Foundations of a building, a pit, and a well from the Anglian period suggested the Blackfriars Street site was occupied between 700 and 900 AD (McCarthy, 1990). Anglo-Saxon coins, pins, pottery, and remains of a Scandinavian style glass vessel also confirmed Northumbrian influence in Carlisle's early-Medieval material culture (Graham-Campbell, 1990; Hunter, 1990; McCarthy and Taylor, 1990; Pagan, 1990). Before the Norman Conquest, Carlisle was an urban settlement at the centre of a larger Cumbrian political entity which supported a landed gentry as well as the religious community (Summerson, 1993: 15). Early-Medieval documentary evidence credit Cumbrians with paying tithes to support this monastic community before 1091 (Summerson, 1993; Bede, 2008). Carlisle was ruled by Dolfin, a regional king whose loyalties shifted between King Malcolm III of Scotland and King Siward of Northumbria, immediately before the Norman Conquest affected Cumbria (Summerson, 1993).

William Rufus captured Carlisle in 1091, as he moved through northern England and southern Scotland to subdue the region and bring it under Norman rule (Summerson, 1993). Rufus is credited with rebuilding Carlisle even though a substantial local settlement already existed there. The effect of the Norman Conquest on Carlisle lay in its transformation from an administrative and religious town to a fortified city and military garrison. The Anglo-Norman city of Carlisle was

constructed first by William Rufus, building a royal castle in 1092, secondly by Rufus's redistribution of the surrounding lands to families and religious communities loyal to the new Norman monarchy, and finally the resettlement of the countryside with peasants who conformed to the newly refurbished Norman feudal system (Mackie, 1978; Summerson, 1993; Eales, 2003). The transformation was so successful that Carlisle took from Richmond the responsibility of protecting the north-western border of England from Scotland in the 12th century and became "a base from which English forces could launch rates into Scotland" (Eales, 2003: 58).

Blackfriars Street appeared to fall out of use between the Anglian period and the foundation of the Dominican Friary in the 13th century (McCarthy, 1990). The Lanercost Chronicle recorded the arrival of the Dominican religious community in 1233 (Summerson, 1993). By that date, Carlisle had grown into a Medieval urban centre with a castle and curtain wall (McCarthy et al., 1990). The Close Rolls from 1234 to 1237 recorded the construction of a Friary outside of the Medieval city walls along the highway which was ordered to be demolished in 1237 because the building was damaging the highway (Jones, 1990; Summerson, 1993: 17). The Close Rolls again recorded construction associated with a Dominican Friary from 1238 to 1240 within the city walls indicating the community had moved to the Blackfriars Street location (Jones, 1990; Summerson, 1993).

The Blackfriars community was tangentially mentioned in city records throughout the late-Medieval period. A dispute between the Friars and Carlisle's Prior about the waste drainage was recorded in the Judicial Rolls of 1292 (Jones, 1990: 376). Walter of Guisborough, a Medieval chronicler, recorded the Blackfriars' buildings were not destroyed in the fire of 1292, which destroyed most of the city including the Priory, the parish churches, and the Franciscans' Friary (Jones, 1990: 376). Archaeological timber remnants at the site suggested the buildings might have been damaged in a 1303 fire. Dendrochronology dated the wood at the Blackfriars Street site to 1293 ± 9 years, which confirms building work at the Friary after one of these fires (Jones, 1990: 376; McCarthy, 1990).

As with other monastic communities during the Medieval period, the Blackfriars relied on grants and donations from the Carlisle citizens to support their monastic community. "Increasingly from the fourteenth century [the] Friars were favoured with gifts of money, and their churches and graveyards were preferred places of burial for the citizens of Carlisle and its neighbourhood" (Jones, 1990: 375).

A list of supporters of the Blackfriars who were interred at the Friarage at the time of their deaths included prominent citizens of Carlisle, religious leaders from nearby rural parishes, and members of the nobility who held estates in Cumbria (Jones, 1990: 375). John Aglionby was hired by the Blackfriars in 1464 to manage their small estate and land grants in exchange for the brothers' promise to bury him in their nave and say prayers at his tomb daily after vespers (Jones, 1990: 375). He died in 1477 and was interred at the Friarage (Jones, 1990: 375).

Throughout the border troubles, Carlisle "remained an essentially military outpost, and indeed, it needs to be stressed that however much it might develop in other respects later, the defensive and offensive functions which Carlisle acquired at this time were ones which it would continue to perform throughout the Middle Ages" (Summerson, 1993: 13). To that end, English Kings invested heavily in maintaining the March governments, the defensive architecture, and the military stores at Carlisle (Prestwich, 1987, 1996). Pipe Rolls, which listed royal expenditures on castles, recorded over £268 invested in Carlisle's castle between 1186 and 1205 (Summerson, 1993: 17). This expense was relatively small in comparison to the total royal investment in castles throughout southern England during the same time period. For example, approximately £250 was spent on York's defences between 1189 and 1194, and less than £50 was spent on Newcastle-upon-Tyne between 1186 and 1205, which suggests the amount of repairs and modifications required at Carlisle was comparable to the work done at York (Brown, 2003: 160 - 72). This discrepancy in expenses between Carlisle and Newcastle can be accounted for by the construction of a new stone keep at Newcastle from 1167 to 1178 (Brown, 2003: 160 - 72). The additional investment in Carlisle was necessary to bring the castle and walls up to the same standard as the new fortifications at Newcastle. Edward I modified Carlisle castle again in the late-13th century from a motte-and-bailey to a concentric castle fortification before the onset of the Scottish Wars of Independence (Summerson, 1993; Sadler, 2006: 8).

The West March Warden's office, deputy, and constable were based at Carlisle and the warden was charged with maintaining the English border and supporting royal initiatives in western Scotland (Sadler, 2006). "In a crisis Border government tended to dissolve and reform along different lines, especially around the great castleries of Carlisle, Bamburgh and Newcastle, and around escheats and custodies temporarily in the hands of the Crown" (Brown, 2003: 169).

In addition to its defensive role along the border, Carlisle was used as a base of operations for military incursions into Scotland. As such, Carlisle maintained a role as a trade centre for both the local communities and the larger Irish Sea trade routes (Holt, 1961; Summerson, 1993). "Elaborate calculations were made of what quantities of foodstuffs were needed, instructions were issued to Sheriff's to collect them, and expertise of merchants was drawn upon" (Prestwich, 1996: 10). Carlisle received many of its supplies for both the city and the English royal stores from Ireland. In 1315, Edward de Brus invaded Ireland with Scottish troops, on behalf of his brother, Scottish King Robert I, which greatly affected the supply lines to Carlisle (Morgan, 2001). "The English chancery shows that supplies at Carlisle were at their lowest in March and September 1315, immediately before and immediately following the Irish expedition" (Morgan, 2001: 214).

Carlisle's proximity to the Scottish border and its distance from the English royal centres in London and York made it a prime target for Scottish military raids throughout the border troubles. Its location allowed a Scottish raiding party to remain in the region, destroying property and stealing valuables, for several days before reinforcements could be mustered from other regions of England (McNamee, 2006). The countryside around Carlisle was most directly affected by the visitations of the Scottish army and Scottish supported raiding parties who attempted to destroy the agricultural economy which supported both the English nobility and supplied the English army when in the region (Prestwich, 1996; McCord and Thompson, 1998; McNamee, 2006). Prestwich (1996: 10), quotes the Close Rolls of 1346 as describing the devastation of 70 Cumberland manors and villages by Scottish raids: 'burned and totally destroyed, with the corn, animals and other goods therein, by hostile incursions of the King's Scottish enemies, after Michaelmas last.'

Carlisle itself was besieged three times during the Scottish Wars of Independence in the early 14th century (McNamee, 2006). The city's three gates were bricked up before Robert de Brus's siege of 1315 and remained closed for six months, during which the citizens lost all access to their lands and possessions outside of the city walls (McNamee, 2006: 221). Although this access was not essential for the wealthier community members who maintained residences and food stores within the city, peasants from the surrounding countryside abandoned their crops and livestock to the devastation and sought refuge within the defensive walls of Carlisle (McNamee, 2006; Sadler, 2006).

The threat of violent and destructive raids continued throughout the late-Medieval period for the populations in and around Carlisle (Fraser, 1971; Jones, 1990). Northwest England remained one of the first regions assaulted by Scotland when its Kings perceived a weakened or distracted English monarch might be unable to respond to their attack (Frame, 2006: 443). The Scots invaded repeatedly during the Hundred Years War, when England was heavily involved in France (Summerson, 1993). During the War of the Roses, Queen Margaret of England, the wife of Henry VI, attempted to barter Carlisle to the Scots in 1461 in exchange for helping her husband maintain his hold on the crown (Sadler, 2006: 314). Even during the 1536 Pilgrimage of Grace, a peasant revolt against Henry VIII, the citizens of Carlisle could not shift their focus from their defence of the border despite their sympathies with the cause. "To turn their backs to the Solway and march south was to invite attack" (Sadler, 2006: 460).

Conflict continued among the region's families even after the dissolution of the Dominican Friary on Blackfriars Street and burial ceased to occur in the Friarage cemetery (Fraser, 1971; Sadler, 2006). The church was recorded in a state of disrepair and the cemetery lying waste in 1539 (Moffat, 1996: 3). Outbuildings on the property were used for storage of military supplies (Jones, 1990: 375), and a post-Medieval manor was built on the site, with the former cemetery serving as a garden (Jones, 1990).

A.1.3 Blackgate, Newcastle

Historical and archaeological evidence for Newcastle-upon-Tyne indicated that the site of the Blackgate cemetery (NZ 250 638), was used as a communal burial ground by a rural, Northumbrian, Christian community from the decline of the Northumbrian kingdom through to the Norman Conquest. This community might have been associated with a religious house or with a royal residence in the region. This population most likely resided in dispersed rural locations or small villages which may have experienced violence associated with Viking attacks on the Northumbrian kingdom during its decline in the 9th and 10th centuries. Documentary evidence from the 11th century indicated these populations directly experienced conflict associated with the Norman Conquest, including the 'Harrying of the North,' which defined Newcastle as a strategic military location near the disputed Anglo-Scottish border.

Newcastle grew into a major urban centre of both military importance during the border troubles, and industrial importance as a key port for wool and coal. The cemetery at Blackgate, however, ceased to be used as a community burial ground immediately after the construction of the stone keep at Newcastle (Figure A.3). The population interred at Blackgate, Newcastle was hypothesised to have experienced the demographic and palaeopathological differences associated with a conflict-zone lifestyle during creation of the Anglo-Scottish border.
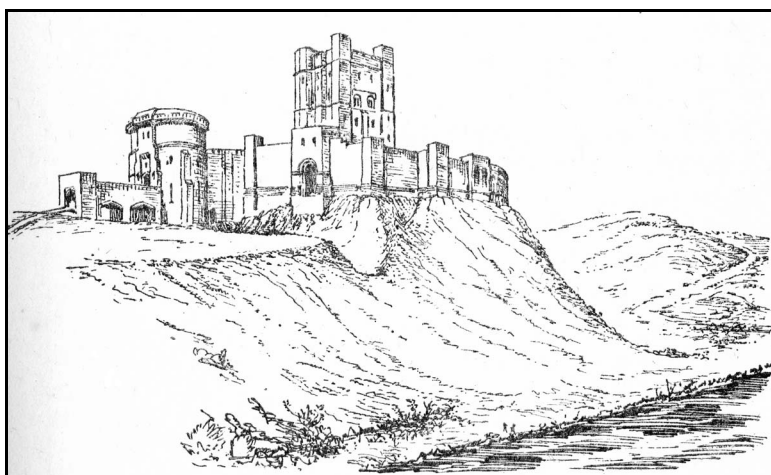
Figure A.3: *Artistic impression of the Norman stone keep and castle built in 1168 at Newcastle-Upon-Tyne over the site of the Blackgate cemetery (Knowles, 1925: 3).*

Construction at a railroad bridge near the keep of the Medieval castle in Newcastle-upon-Tyne uncovered human skeletal remains from a Medieval cemetery, and eight archaeological excavations were conducted between 1977 and 1992 at the site (Nolan, 1998). A Medieval cemetery and a single-celled building, suggested as a possible chapel associated with the cemetery, were uncovered during the excavations, but the exact boundaries of the entire cemetery remained unclear (Nolan, 1998). Coins dating from 810 to 985 AD and shroud pins types dating from the 7th to the 9th centuries were found in the cemetery, suggesting that the burials at the site began in the 8th century (Nolan, 1998). Several surface grave markers recovered were stylistically estimated to date from the end of the 11th century (Nolan, 1998). Radiocarbon dates from skeletons recovered in the 1990-92 excavations indicated the cemetery was used from approximately 880 to 1160 AD (Nolan, 1998: 2).

A change in burial practices was noted in the cemetery and the temporal sequence of interment styles is still being investigated (Chamberlain, per comm). A variety of burial styles was observed, including simple cut, supine, single graves, supine burials in stone-built cists with recumbent stone grave markers and head and

foot stones, and graves with slab-built headboxes (Nolan, 1998). There was evidence for reuse of the surface grave markers as cist lids (ibid). Additional environmental changes after use of the cemetery, specifically erosion of the Norman rampart, slippage, and levelling, commingled the burials throughout the site (ibid).

Use of the northern part of the cemetery ceased with the construction of a Norman castle in 1080, but contextual and funerary evidence in other areas of the cemetery suggested interments continued at Blackgate after construction of the first castle (Knowles, 1925; Nolan, 1998; Moffat and Rosie, 2005). The castle ditch and rampart disturbed some graves and covered other parts of the site, further disrupting the stratigraphic relationship within the cemetery (Nolan, 1998). The castle was refortified in 1168 and this construction coincided with cessation of burials at the site (Knowles, 1925; Nolan, 1998; Brown, 2003).

A minimum number of 638 individual skeletons, 407 adults and 231 sub-adults, were excavated from the site over the course of eight excavation seasons (Boulter and Rega, 1993; Nolan, 1998). Post-excavation skeletal analysis of 131 skeletons excavated during the 1977 and 1978 seasons was carried out at Durham University (Nolan, 1998). Additionally, 227 articulated burials from the 1990 and 1992 excavation seasons were analysed at the University of Sheffield (Boulter and Rega, 1993). The complete skeletal collection is currently housed at the University of Sheffield's Department of Archaeology where it is used as a research and teaching collection (Chamberlain, per comm).

Historical context

Roman documents record that a Roman military unit constructed a bridge, Pons Aelius, across the River Tyne in approximately 120 AD (Moffat and Rosie, 2005). A stone fort was constructed on the current site of the Medieval castle in 150 AD to protect the bridge (Moffat and Rosie, 2005). The Medieval cemetery "overlies the ruins of a Roman fort," which was abandoned after the Roman retreat from Britain (Nolan, 1998: 1). Fragments of Roman walls were present on the cemetery surface and are hypothesised to have been used as both boundary markers for the later Medieval cemetery, and as alignment guides for the interments (Nolan, 1998). Researchers have hypothesised that a small settlement lies in the immediate vicinity of the fort, but no specific mention of a village is made in the available Roman documentary sources and no archaeological evidence has been uncovered to suggest

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its possible location (Nolan et al., 1993; Moffat and Rosie, 2005). The last mention of Pons Aelius in a Roman document appeared in a list of military outposts from 400 AD (Moffat and Rosie, 2005).

Little historical or archaeological evidence exists for populations in the Newcastle region between 400 AD and the foundation of the Norman castle in 1080 (Nolan, 1998). Available evidence has identified the Tyne river valley as under the political control of Bernician and Northumbrian power centred at Bamburgh, and under the religious influence of Northumbrian Christian monasteries founded at Lindisfarne and Jarrow and Wearmouth before the Norman Conquest (Lowe, 1999; Savage, 2002; Rollason, 2003; Cramp, 2006; Bede, 2008). Bede (2008) described a royal estate 12 miles inland along Hadrian's Wall, which could be a reference to early-Medieval occupation at Newcastle, but there was no specific mention of a population centre in the region of the current city.

Symeon of Durham, during the late-Medieval period, wrote of a settlement of monks at Monkchester on the northern side of the Tyne which belonged to the bishopric of Durham and fell within the political jurisdiction of Northumbria (Rollason, 2000). Monkchester has been assumed by researchers to be at Newcastle although the precise location of this settlement remains unknown (Nolan, 1998; Moffat and Rosie, 2005), but a monastery existed at Gateshead in 653 AD (Moffat and Rosie, 2005). The circumstantial evidence available suggested that populations living in the Newcastle region were Christian Northumbrians residing in either rural or small urban settlements which were not of a particular size or importance. These local residents could have been associated with a monastic house at Monkchester or a royal residence along Hadrian's Wall.

The Blackgate cemetery population most likely resided in dispersed rural locations or small villages which might have experienced violence associated with attacks on the Northumbrian kingdom during its decline in the 9th and 10th centuries (Rollason, 2003). In 875, the Danish King Halfdan led an army that attacked and pillaged various monasteries in the area, and it is believed that Monkchester was assaulted during this raid (Savage, 2002). Historical accounts of the experiences of local populations during the Norman Conquest in north-east England describe both great Northumbrian resistance to the invading Norman lords and destruction inflicted on the local populations by the Norman army's retribution in the 'Harrying of the North' (Platt, 1978; Lomas, 1996a; McCord and Thompson, 1998; Rollason, 2003).

Robert, the son of William the Conqueror, built a wooden motte-and-bailey castle on the site of the former Roman fort in 1080 following his punishing raids to subdue Northumbria (Knowles, 1925; Rollason, 2003). Newcastle received a significant investment of over £1000 between 1167 and 1178, which accounted for the construction of a Norman stone keep to replace the timber structure (Brown, 2003). The current city derived its name from the stone castle constructed as a 'new castle upon Tyne' in 1168 (Knowles, 1925: 7). As an urban population centre grew around the castle during the 11th and 12th centuries, a defensive ditch and curtain wall was built around the city and was continuously modified throughout the late-Medieval period (Nolan et al., 1989; Nolan et al., 1993; Fraser et al., 1994). Recent archaeological excavations have highlighted Newcastle's development as an important regional urban centre during the 13th century, with a major program of reclamation along the modern quayside and evidence of an active limeburning industry where the Tyne meets the River Swirle (O'Brien et al., 1989; Ellison et al., 1993). Newcastle grew into a major urban centre of both military importance during the border troubles, and industrial importance as a key port for wool and coal exports from the 13th through the 16th centuries (Fraser, 1982; Lomas, 1996a; McCord and Thompson, 1998). The castle remained a fortified garrison for centuries after the cessation of burials at Blackgate (Nolan, 1998; Moffat and Rosie, 2005), and a post-Medieval house was later constructed over the foundations of the earlier chapel structure (Nolan, 1998). Although these economic developments and the growth of Newcastle helped the Norman town develop into a major centre of industry in England, these developments did not affect the population buried at Blackgate. This population would have experienced the decline of the Northumbrian religious and political centres along the Tyne River, the Norman Conquest, and the foundation of the Norman castle at its current location. They experienced a conflict-zone lifestyle within a rural and agricultural economic context.

A.1.4 The Hirsel, Coldstream

The Hirsel, located in the village of Coldstream on the Tweed River in the Scottish county of Berwickshire (NT 830 406), was a Medieval parish church with an associated cemetery adjacent to the modern Anglo-Scottish border. The skeletal population interred in the church cemetery consisted of local residents from a rural,

agricultural community that economically supported the Coldstream Priory and a Cistercian Abbey at Coldstream. Medieval records described this population's first-hand experiences of the border conflict, including military occupations, crop-burning, cattle-thefts, and border reiving, throughout the use of The Hirsel burial ground.

The church and cemetery was discovered by ploughing in June 1977, which unearthed stones from both funerary monuments and architectural fragments (Cramp and Douglas-Home, 1979). Resistivity and magnetometer surveys were conducted in March 1978, which suggested the site was composed of an enclosure with two major areas of buildings (Cramp and Douglas-Home, 1979). A full excavation of the site was conducted from 1979 to 1984 (Cramp, 1980, 1981, 1982, 1983, 1985).

These excavations revealed a stone church with four phases of construction followed by a fifth phase of domestic occupation in the repurposed nave (Cramp, 1985). Evidence of an earlier timber structure below the apse of the stone church suggested an earlier church possibly existed on the site (Cramp and Douglas-Home, 1979; Cramp, 1983). Cramp (1985) has described the first phase of the stone church, which consisted of a single cell, as similar to 'Late Norse' structures in the Northern Isles. Pottery from the same archaeological context possibly dates this initial building to the 10th century (Cramp, 1985). Three phases of subsequent expansions and repairs were observed in the church fabric dating from the 10th through the 13th centuries (Cramp, 1985). The nave was enlarged during the third phase in a similar method as the Norman church at Old Berwick in Northumberland (Cramp, 1983). The fourth phase of occupation, tentatively dated to the 14th through the 16th centuries, indicated the nave portion of the church was reused for a domestic purpose after a period of general abandonment of the entire church (Cramp, 1983, 1985). The presence of a series of postholes, suggesting the addition of wooden screens, and a hearth containing animal bones and pottery in this occupational layer, suggested the nave portion of the church was reused as a bastile house, with storage on the ground floor and domestic living rooms on upper floors (Cramp, 1983, 1985). The nave of the church was "gutted by fire in phase 5, and very large quantities of carbonised grain have been retrieved from the floor – six crop plants were present in the samples: bread wheat, oats, barley, rye, legumes and a brittle rachis not further identified" (Cramp, 1983: 59). There was no archaeological evidence for rebuilding or occupation of the church after the fire (Cramp, 1983).

The cemetery associated with the church occupied ground both to the north and to the south of the church (Cramp, 1982, 1983). A total of 345 burials were excavated from both burial locations (Cramp, 1982, 1983, 1985). Primarily traditional Medieval Christian funerary practices were observed in this cemetery population, including east-west burial alignments, supine interments, and few grave goods (Cramp, 1982, 1983). Adults were interred in earth cut graves with occasional pillowstones, head stones, and foot stones while the non-adult burials were clustered closer to the church walls (Cramp, 1982, 1983). There were also several cist graves and two crouched burials (Cramp, 1982). The burial ground to the south was more intensively used throughout the life of the church and interments continued on the south side of the derelict church even after its conversion to domestic use (Cramp, 1983). The burials to the north of the church were covered by a layer of rubble containing 14th century pottery with no evidence of later disturbance during the domestic use of the nave (Cramp, 1981). Radiocarbon dates from both northern and southern burial locations date interments from approximately 1100 – 1400 AD (Cramp, 1982; Melikian, 2009).

Post-excavation skeletal analysis identified a minimum number of 331 individuals, 181 adults and 150 non-adults, were identified in this skeletal population (Anderson, 1994). Preservation was noted as "generally in fair condition" (Anderson, 1994: 1). No quantitative data regarding skeletal preservation was included in the skeletal report, but a note was made of unwashed skeletal material present at the time of post-excavation analysis (Anderson, 1994: 1). The skeletal collection is currently held by the Museum of Scotland in Edinburgh (Caldwell, per comm.).

Historical Context

Bede (2008) described the region between the two Roman walls as under Rome's influence before 400 AD, if not its direct political control. He went on to describe the region as ravaged by the Irish and Picts from northern Scotland following the Roman retreat: capable warriors who dominated the helpless Britons and influenced them with their drunkness, lies, and un-Christian ways (Bede, 2008). Although largely religious hyperbole, Bede's comments are consistent with the archaeological evidence from the Tweed River valley that depict the region's transformation from a Roman border region into the core of the early-Medieval kingdom of Bernicia (Cramp, 1985; Lowe, 1999; Bede, 2008). Early Christian Cumbrian and Anglian sculpture indicative

of an early-Medieval occupation were uncovered at The Hirsel (Cramp, 1985). Place names and religious iconography found in the Coldstream area suggested the local communities maintained their Christian faith after the Roman retreat from Britain, and a monastic community existed at nearby Melrose in 664 AD (Cramp and Douglas-Home, 1979; Bede, 2008: 160). Bede and the Anglo-Saxon Chronicles describe the expansion of Northumbrian authority into Cumbria to the west of Coldstream throughout the 6th to the 9th centuries, which also indicates that the Coldstream region was firmly under their control throughout this period (Cramp, 1994; Savage, 2002; Bede, 2008).

Although a Viking raid of Lindisfarne in 793 was devastating to the Northumbrian communities along the coast, the Anglo-Saxon Chronicles recorded that in-land communities did not experience Viking raids until 875 when a Scandinavian occupying army established a winter camp along the Tyne River (Savage, 2002). Raids among the local Northumbrian communities, as well as among the Picts and Strathclyde Welsh [possibly Cumbrians], were described during this encampment (Savage, 2002). Further to the evidence of Northumbrian political and religious authority over Berwickshire, Lindisfarne maintained extensive land holdings along the Tweed under the jurisdiction of its See after the destruction of the monastery in the Viking raid of 793 (Cramp and Douglas-Home, 1979). "The Community, even when removed to Chester-le-Street and Durham, remained interested in their dependencies in the Tweed Valley" (Cramp and Douglas-Home, 1979: 230).

The decline of Northumbrian political power during the 10th and 11th centuries introduced political instability to the Tweed River valley. The ambitions of the rising Scottish Kings north of the Firth of Forth brought their armies into the Berwickshire region in an effort to take fertile agricultural land away from the weakening Northumbrian Kings (Mackie, 1978; Savage, 2002; Rollason, 2003). In 1018, the Tweed River was established as a new political border between Northumbria and Scotland by Malcom II after the battle of Carham (Lowe, 1999; Rollason, 2003). This region of Berwickshire was recorded under the control first of Earl Gospatrick, lord of Allerdale in Cumbria, then the Earl of Dunbar at the time of the Norman Conquest (Cramp and Douglas-Home, 1979). As with East Lothian, this region of southern Scotland was consistently changing political affiliations before the Norman Conquest between the Scots, the Northumbrians, the Cumbrians, and the English Anglo-Saxon

Kings (Mackie, 1978; Savage, 2002). The Norman Conquest itself did little to settle the issue and directly contributed to more violence in the region through the 'Harrying of the North' (Mackie, 1978; Rollason, 2003).

A Cistercian abbey was founded at Coldstream in 1165 and the nuns were granted "a carucate – that is, from sixty to a hundred acres – of the Hirsel, together with the church of that place" by the wife of the Abbey's benefactor, the Earl of Dunbar (Rogers, 1879: ix). The Earls of Dunbar owned both Old Berwick and The Hirsel during the early 12th century, so the observed similarities in the Norman construction style of The Hirsel's Norman church suggest that a community equal in status to Old Berwick existed at the Hirsel before its mention in the Coldstream Abbey chartulary in 1165-6 (Cramp, 1983). The original grant charter suggested that The Hirsel consisted of a village with a church of established rights which contributed to the support of Coldstream Priory before 1165 (Cramp and Douglas-Home, 1979). The exact location of the medieval village or hamlet which the church served remains unknown; however field walking to the west of the church and cemetery site has produced evidence of medieval settlement in the vicinity (Cramp, 1982). Although the property was legally owned by the regional lords, The Hirsel was repeatedly granted to, and remained within the abbey's direct control until 1545 (Rogers, 1879; Cramp and Douglas-Home, 1979).

The Chartulary of the Cistercian Abbey at Coldstream recorded first-hand accounts of the political and social instability experienced by the Coldstream region from approximately 1165 to 1545, when the abbey was burned to the ground (Rogers, 1879). The inclusion of the parish church and its surrounding property in the inventory of the Coldstream Abbey meant the material damage inflicted on these properties by the border troubles was specifically recorded in the abbey's records. These records described how The Hirsel lands were passed back and forth between Scotland and England throughout the 13th- 16th centuries. Throughout this period, the abbey begged forgiveness of taxes and requested physical protection from both Scottish and English kings (Rogers, 1879).

The region was particularly brutalised during England's King Edward I's campaigns in the 1290s to gain control over Scotland. Edward I and his army stayed in Coldstream in August 1290 and again in March 1296 (Rogers, 1879)), and the abbey claimed extensive damages to their property and foodstuffs during Edward's 1296 residence (Rogers, 1879). England's Edward III, in 1333, issued a letter of

protection to the Priory and Abbey of Coldstream, showing the continued presence of English authority in the region throughout the Scottish Wars of Independence (Rogers, 1879: xviii; McNamee, 2006). In the 1450s, Scotland's James III confirmed land gifts to the Abbey bestowed by James II, which confirmed Scottish authority over the region had been reinstated (Rogers, 1879: xix; Sadler, 2006).

The political prowess of the Abbey's prioress Dame Isabella Hoppringill was well documented in correspondence from the early 16th century connected to Henry VIII's war of 'rough wooing'. The Coldstream abbey lay within Scotland, but the prioress's loyalties lay with England's Henry VIII. Records show she supported Scottish authority until the Battle of Flodden in 1513, and then worked as an informant and supporter of Henry's border raids during the 1520s (Rogers, 1879). The political manoeuvring of Prioress Isabella during Henry VIII's war of rough wooing also seem born out of hope for self-preservation; the letters of support on her behalf to Henry VIII specifically request the abbey wasnot to be assaulted during border army raids due to her previous loyalties to the English cause (Rogers, 1879). The abbey was burned to the ground by the Earl of Hertford in 1545 (Rogers, 1879).

The church and cemetery at the Hirsel are mentioned specifically in the Coldstream Abbey's charters during the 13th and 14th centuries (Rogers, 1879). There is also a specific reference to a chapel dedication at the Hirsel in 1246 by Bishop David of St. Andrews, a right given to all of the churches in his diocese in that year (Cramp and Douglas-Home, 1979). The church appears to have existed in 1561, because the *Book of the Assumption of Benefices* recorded rent for the Priory of Coldstream which consisted of land and a church at the Hirsel (Cramp and Douglas-Home, 1979: 224).

After the Protestant Reformation, the previous Abbey lands were granted by Scottish Royal charter to various individuals, including the Home family, and the Coldstream Priory was dissolved (Cramp and Douglas-Home, 1979). Rogers (1879: ix) also noted, in referencing the *Account of Certain Parishes* published in 1627 by the Maitland Club, the church was not present in 1627, but that the graveyard was still in use. Documents from the 17th century reference both 'Hirsel' and 'Old Hirsel' as well as a tower house (Cramp and Douglas-Home, 1979). These references are of locations which exist within the present Home estate at Coldstream and could be an indication of the nave's reuse as a land owner's residence after the initial closure of the church and conversion of the burial ground to a private cemetery for the estate

owners (Cramp and Douglas-Home, 1979). During parish burials at The Hirsel, the Coldstream village changed from a community located in the heart of the powerful Northumbrian kingdom to a population on an unstable international border between Scotland and England.

A.1.5 Conflict-Zone Populations Summary

Contemporary documentary sources from the border region described political instability, military occupation, sieges, destruction of crops, theft of livestock, and the destruction of dwellings from the decline of the Northumbrian kingdom in the 9th century until the end of Henry VIII's reign in the 16th century. The four skeletal populations selected for study were composed of people who lived in the border region during the era of it being a politically unstable conflict-zone. These populations were hypothesised to have similar bioarchaeological profiles as modern conflict-zone populations when directly compared to four contemporary, non-stressed neighbouring population (described in the following section). The age-at-death profiles were expected to show increases in mortality for both young children and young adults, and pathological indications of malnutrition and developmental retardation during childhood, and specifically evidence of stunting, wasting, and delayed skeletal maturation. Adults were predicted to have higher prevalence rates of healed or healing nutritional diseases and infection, along with more skeletal indicators of childhood nutritional stress.

A.2 Neighbours Population

Four human skeletal collections were identified from archaeological excavations in the English and Scottish regions immediately adjacent to the border counties. These collections were similar to the conflict-zone skeletal populations in that they were archaeologically excavated from cemetery sites that functioned as communal burial grounds for local populations from 900 to 1600 AD. Historical evidence suggested these populations did not directly experience the socio-political instability described along the Medieval Anglo-Scottish border. These populations were hypothesised to demonstrate demographic and palaeopathological trends similar to those observed in previously published late Medieval British populations (Roberts and Cox, 2003), assumed to be less stressed.

A.2.1 Fishergate House, York

Located 350 meters south of the Medieval defensive wall surrounding the centre of York, Fishergate House (TF 0845 4367) was excavated from July 2000 to July 2002 by Archaeological Planning Consultancy in advance of a redevelopment construction project (Figure A.4). Skeletal evidence from this excavation indicated a Medieval parish cemetery population, associated with a small church, interred at the site. Documentary evidence suggested Fishergate was an economically declining suburb of York and consisted of individuals who farmed or crafts manufacturers. The cemetery was a communal burial ground from the end of the Anglo-Scandinavian rule of York through to the 16th century. Yorkshire was involved in William the Conqueror's 'Harrying of the North,' for it was the populations north of the Humber which actively opposed William's rule and violently overthrew their new Norman lords in the region. William's policy of laying waste to the countryside, which provided the agricultural and pastoral economic support for all the region's populations, was recorded to have left "no village [left] inhabited between York and Durham" (Prestwich, 1996: 199). Although this event could have directly affected the suburban populations of York, the city experienced nutritional deprivation associated with war only in 1070. The Medieval population at Fishergate was protected from the border wars by its distance from the Anglo-Scottish border and its proximity to the city's defensive walls. The individuals interred at the Fishergate House cemetery would have experienced a suburban Medieval lifestyle.

Figure A.4: Location of Fishergate House excavation south of York's city centre (Dean, 2008: 43).

The Fishergate House excavation uncovered evidence of human occupation from the Roman period through the 20th century. The first layer of continuous occupation consisted of Roman cremations and inhumations and the remains of a flanking ditch from the Roman's main north-south road (Spall and Toop, 2005). These featured most likely dated from the 1st - 3rd centuries AD and provided further evidence for the extent of the Roman settlement identified in previous archaeological research (Evans, 2004; Spall and Toop, 2005; Hunter-Mann, 2007). The early-Medieval occupation layers consisted of several phases of activity ranging from burials to domestic and manufacturing evidence (Spall and Toop, 2005). "More evidence was revealed for the nature of [early-Medieval] activity in the form of pit groups, and the rich contents of these pits included waste from bone-, metal- and textile-working" (Spall and Toop, 2005). The Fishergate House excavation helped to understand the extent and layout of the '*wic*' to the south of the former Roman fort.

Four burials from the Medieval cemetery at Fishergate House were initially encountered during evaluation work the site in 1994 (YAT, 1995), when one

individual skeleton was discovered, and at nearby Marlborough Grove (FAS, 2000), when a 2m x 2m trench uncovered three individuals. Burials were expected to have been encountered within the grounds of Fishergate House during the 2000-2002 excavations, although, the density of burial was unexpected (Spall and Toop, 2005). The most recent excavations exposed an area of 400 square meters within the grounds of Fishergate House which uncovered a total of 250 inhumation burials (Spall and Toop, 2005).

Possible evidence for structural activity on the site was revealed in a robber trench or cobble-filled foundation trench cut by a burial encountered in an excavation trench opened along the northern boundary of the current property (Spall and Toop, 2005). Features encountered in trenches to the south of the House appear to represent the demarcation of the southern boundary of the cemetery in the form of a bank and ditch (Spall and Toop, 2005). The total area of the Medieval cemetery was reconstructed using these features in combination with previous research at Marlborough Grove, the cemetery being described a rectangular strip of land perpendicular to Fishergate that extended west from the Roman road to the Foss River (Spall and Toop, 2005).

Although no remains of the chapel or church were uncovered in the Fishergate House excavations, researchers hypothesised that it is located underneath a current standing structure based on the boundary features and arrangements of the burials uncovered (Spall and Toop, 2005). The only burials in stone coffins were encountered on the western side of the excavation and were argued to have been the 'special' burials reserved for the wealthy and privileged members of the church (Spall and Toop, 2005). In the excavation trench to the north of the House, a cluster of nine infant burials was uncovered, suggesting that this was the preferred burial location for very young children (Spall and Toop, 2005). Medieval church doctrine defined the east end of the internal and external church structure as the position for higher status burials, and the north-east corner of the church structure as the location for the burial of stillbirths or small children who died before their baptism (Shahar, 1990; Spall and Toop, 2005). The archaeological evidence from Fishergate House suggests that the church remains unexcavated beneath the foundation of the current property but was located within the boundaries of the defined cemetery (Spall and Toop, 2005).

The cemetery consisted of east-west aligned, supine interments arranged in rows. Three individuals were interred with grave goods dating from the late-Medieval

period; a shell pilgrimage token from Santiago de Compostella in Spain, a ring, and a metal fitting inscribed with a cross (Spall and Toop, 2005), but no dateable material was located in the foundation trench (Spall and Toop, 2005). Pottery recovered from the backfill of several graves suggested a date of the mid-14th to mid-15th century for the burials; thus the foundation trench dated from an occupation period prior to the 14th century (Spall and Toop, 2005). The depth of the cemetery and high frequency of truncated burials indicated the burial ground was consistently used for an extended period of time (Spall and Toop, 2005). Radiocarbon dating of five skeletons from the earliest and latest phases of burial, as indicated by their stratigraphic position, suggested the cemetery was used from the Anglo-Scandinavian period through the late-Medieval period, and the earliest burial dated from 920 (±35 years) and the latest to 1545 (± 40 years).

Of the 250 graves uncovered in the Fishergate House cemetery, 244 were excavated and six that were not threatened by development were left in situ (Spall and Toop, 2005). Post-excavation skeletal analysis identified 131 adult and 113 non-adult individuals (Holst, 2005). The majority of the skeletons were described as in a good or moderate state of preservation at the time of analysis (Holst, 2005: Figure 1). This skeletal collection is currently held by Durham University in the Department of Archaeology and is used as a teaching and research collection (Roberts, per comm.).

Historical Context

Since the Neolithic, a major prehistoric routeway crossed the area which is now York close to the River Ouse (Dean, 2008). Mesolithic flint tools have been recovered at the Fishergate House site, including large cores from manufacture and scraping tools, confirming prehistoric human populations moved through this portion of York (Spall and Toop, 2005).

Historical documents describe the Roman army's movement north of the Humber River in 71 AD and the establishment of a Roman fort at York (Johnson, 2005; Dean, 2008). Previous archaeological excavations have identified Roman occupation and material culture throughout the city (Evans, 2004; Macnab and McComish, 2004; Johnson, 2005; McComish, 2006; Hunter-Mann, 2007; McComish, 2008). The modern Fishergate Road in York follows the line of a major Roman thoroughfare (Spall and Toop, 2005). Roman cemeteries were established outside the city and cremation and inhumation burials were found at Fishergate House, positioned

inside a system of field enclosures (Spall and Toop, 2005; Hunter-Mann, 2007). The Roman retreat from Britain in the 5th century was followed by a period of vaguely defined yet continuous occupation of York (Dean, 2008). Anglian settlers moved to Britain and archaeological evidence of influence, if not Anglian individuals, from Danish and German cemetery practices have been found in York, and specifically urn burials with Anglian decorative art (Dean, 2008). The fortified city became the principal religious and trade centre of the early-Medieval kingdom of Deira (Bede, 2008; Dean, 2008). St. Gregory sent Christian missionaries to York in the 7th century to convert to Christianity the Anglians in the kingdoms of Deira and Bernicia, because these kingdoms were coalescing in Northumbria (Rollason, 2003; Bede, 2008). York remained the largest urban centre in Northumbria throughout the 7th and 8th centuries, and at the time of Bede's *The Ecclesiastical History of the English People* in 731 AD, York was "the only approximation to a functioning town that would have been found in Northumbria at this time" (Bede, 2008: xxx).

Roman occupation declined after the mid-3rd century at Fishergate House and reoccupation did not occur until the late 7th century when an Anglian settlement was established on the eastern banks of the Foss (Spall and Toop, 2005). Excavation encountered features which may be associated with the 7th to 9th century settlement of *Eoforwic* (Spall and Toop, 2005). Evidence for trade, such as imported pottery, stone objects and coins, for crafts, including bone-, antler-, and horn- and metal-working, and for textile production, was uncovered at Fishergate House which was consistent with other archaeological evidence from previous excavations in York (Evans, 2004; Spall and Toop, 2005; McComish, 2008). Although less intensive Anglian occupation was encountered at Fishergate House, pit groups may represent the disposal of rubbish and cess relating to individual properties or groups of properties. Zooarchaeological material was similar to other '*wic*' sites, reflecting a limited diet, and has been hypothesised to have originated from centrally redistributed food (Spall and Toop, 2005). In addition to evidence for occupation, it seems the settlement may have had an associated cemetery, and a burial at Fishergate House has been radiocarbon-dated to the mid-8th century (Spall and Toop, 2005).

Viking raids in the mid-9th century destabilised Northumbrian political and religious authority at Bamburgh and Lindisfarne, and drastically changed York. A Danish army captured York in 866 and held the city until the Norman Conquest (Savage, 2002; Dean, 2008). The Danes established a settlement, Jorvik, centred

around the Roman fort ruins and controlled the region until the death of King Eric Bloodaxe in 954 (Rollason, 2000; Savage, 2002; Eales, 2003; Dean, 2008). The Anglo-Saxon Chronicles described the 9th through the 11th centuries as politically unstable and violent for the city of York (Savage, 2002). Northumbrian kings, as well as other British kings from southern England, made continuous efforts to capture the Vale of York from the Danes (Rollason, 2003). The city maintained its religious significance and trade networks throughout this Anglo-Scandinavian period, although the population at York appears to have decreased (Macnab, 2003; Evans, 2004; Macnab and McComish, 2004; McComish, 2008). The city was particularly politically unstable in the century before the Norman Conquest as the political vacuum created by the death of Eric Bloodaxe brought rulers from neighbouring Wessex and Northumbria into conflict over the city (Savage, 2002; Eales, 2003; Rollason, 2003). At the time of the Norman Conquest, York was held by English King Harold and ruled by an earl on his behalf (Dean, 2008).

The Fishergate House site was abandoned during the 8th century and reoccupied by the late 10th century on a much less intense scale (Spall and Toop, 2005). At Blue Bridge Lane, pottery and artefacts found in some of the pits have been dated to the Anglo-Scandinavian period and suggests that the Fishergate suburb was occupied at this time (Spall and Toop, 2005). The Anglo-Scandinavian occupation on the site of Fishergate House ended with intermittent phases of burial: "Four burials have been dated to between AD 920 and AD 1035. Documentary research has led to the suggestion that this activity can be linked to the known Anglo-Danish foundation of St Helen's, Fishergate, previously thought to have been situated on the eastern side of Fishergate" (Spall and Toop, 2005: excavation, the cemetery).

The Norman Conquest marked another dramatic change for the city of York as it became William the Conqueror's most securely held northern city (McCord and Thompson, 1998; Morgan, 2001). "York became a frontier town on the limits of the Normans' northern control" (Dean, 2008: 15). The political and social instability experienced by York continued through 1070 as the populations in northern England attempted to rebuff William's control and the Anglo-Saxon nobility fought for their claims to lordship in the face of William's Norman replacements (Rollason, 2003). William successfully countered rebellions in northern England in 1068 and 1069 and finally gained permanent control over York and its surrounding countryside after his 'Harrying of the North' in 1070 (Rollason, 2003; Dean, 2008). William also began

his campaign of castle-building in the North with two motte-and-bailey structures at York (Platt, 1978; Eales, 2003; Dean, 2008). Although Northumbrian and Cumbrian populations continued to rebel against the Norman kings, York remained an English city and prospered as a royal centre of trade, religion, and administration throughout the Medieval period (Fraser, 1971; Platt, 1978; Lomas, 1996a; Dean, 2008).

The border wars of the late-Medieval period brought economic prosperity and administrative importance to York. The city was fined in the 1170s by King Henry II for smuggling arms, suggesting that the citizens were directly profiting from the border wars shortly after the Norman Conquest (Dean, 2008: 16). Between 1300 and 1327, York acted as an administrative center for the English crown (McNamee, 2006: 224). York's industries and markets also profited from aristocratic expenditure connected with the wars (McNamee, 2006). "A steep rise in food prices precipitated enactment of Civic Ordinances in 1301, and this seems to have been caused by the city's temporary status as seat of government" (McNamee, 2006: 224).

The town was protected from assault by the defensive walls constructed and maintained since the Roman occupation (Clarke, 1986; Eales, 2003). Military garrisons were stationed at York, particularly during the Scottish Wars of Independence (McNamee, 2006). These garrisons, however, were called out to confront Scottish raiding armies throughout the English borders and were not employed in defence of the city. "The York 'Custody' of 1315 assigned the defence of specific sectors [of the city walls] to men of particular city parishes. It also provided for a check on comings and goings at the city gates, for the expulsion of 'Scots and rascals', for nightly patrols; custody of keys, and penalties for contravention of security regulations" (McNamee, 2006: 222).

Yorkshire was threatened and attacked repeatedly by the Scots during the 14th century, but none of the raids directly affected York. For example, Robert I raided south from the Scottish border in 1316 through North Yorkshire from Barnard castle to Richmond (McNamee, 2006: 82). The *Prima Nova Taxatio*, a reassessment of the value of property in Yorkshire composed in 1317, documented the damage sustained by the surrounding villages before Robert's army turned west through Wensleydale and across the Pennines into Cumbria, but no damage was recorded for York (McNamee, 2006: 83). Robert I's army 'wasted' the countryside to the east of Knaresborough towards York again in May of 1318, but the closest recorded damage was eight miles outside the city at the village of Tadcaster (McNamee, 2006: 89). The

Scottish army raided south again in 1319, reportedly with the aim of capturing the Queen at York, and tax records list 106 villages in the North and West Ridings of Yorkshire which were exempt from taxation burned by the Scots (McNamee, 2006: 91). "The English administration and the court of the Queen were both at York, and the city was convinced that it was the target of attack. A garrison was maintained at York Castle from 4th to 13th September, and the Vicars Choral of York Minster paid a guard to keep watch along their section of the city wall for five nights consecutively. In fact the Scots never came nearer then 10 miles from the city" (McNamee, 2006: 91-4).

York citizens reportedly fought at the Battle of the Standard in 1138 against the Scots; this may have introduced stress related to conflict to the men of York who served in the battle (Dean, 2008: 16). However, the stress sustained in battle was also experienced by commoners conscripted into service throughout Britain in association with other wars, particularly wars waged against France during the medieval period. However, this was usually not a chronic form of nutritional stress as experienced by populations in a conflict-zone. The only damage reported in historical sources described a fight in 1322 that broke out between Hainaulter mercenaries and English infantry in York, resulting in the death of 527 Hainaulters and 241 Englishmen and a suburban parish being burnt down (McNamee, 2006: 224). Although this report would suggest that York sustained damage because of the presence of military forces associated with border wars, the lack of specific information about the suburb that was burned, and the unusually large number of reported deaths, suggested this report might have been an exaggeration of a mundane brawl between soldiers.

Fishergate remained a suburb of York from the Anglo-Scandinavian through the Medieval period, although the area did not participate in the city's Medieval prosperity and it experienced an overall economic decline from its early-Medieval status as a trade and industrial *wic* (Dean, 2008). The Domesday Survey recorded 84 carucates of land associated with York and listed three churches in Fishergate, All Saints Fishergate, St. Andrew Fishergate, and St. Helen Fishergate (Spall and Toop, 2005; Dean, 2008: 15). The development of the Fishpool, because of a dam associated with the construction of York Castle in 1068 to the northeast of Fishergate, isolated it from the other commercial districts of York (Dean, 2008). New roads were required to access the Walmgate suburb across the Foss River and the traffic through Fishergate decreased. This change resulted in economic decline for Fishergate; land

was abandoned in the 12th century and three churches were redundant by 1308, St. Stephen's, St. Mary's and St. Margaret's (Spall and Toop, 2005; Dean, 2008; McComish, 2008). Fishergate was divided in the 14th century when the city's defensive walls were extended through the suburb from Walmgate to York Castle, with the Fishergate House area lying outside of the new city walls (Dean, 2008). The economic decline was so significant in the 14th and 15th centuries that Fishergate Bar, the southernmost gate into the city, was bricked up in 1489 (Dean, 2008: 44).

"In the post-Conquest period, activity was dominated by nearby ecclesiastical foundations; the route of Blue Bridge Lane marked the southern limit of the precinct of the Gilbertine priory of St Andrews, and excavations encountered evidence for early high status occupation and later industrial activity" (Spall and Toop, 2005: Introduction). Fishergate House cemetery lies to the south of Blue Bridge Lane, yet was not associated with the Gilbertine priory as evidenced by the boundary ditches identified around the cemetery and contemporary Medieval documentary sources (Spall and Toop, 2005). Few documents remain regarding Medieval Fishergate, but tax records indicate all the Fishergate parishes were valued at less than five shillings in 1436 (Dean, 2008: 44). The parish churches in Fishergate, "fell out of use during the medieval period, and their location and histories are lost" (Spall and Toop, 2005 Introduction).

Although it remains unclear which Medieval church was associated with this burial ground, the evidence from the Fishergate House excavations and historical sources suggest a number of possibilities. By the late 10th century, three churches were founded in the area outside of the later Medieval defensive wall through Fishergate, including St Helen, St Andrews and All Saints (Spall and Toop, 2005). The dates, boundary indications, and skeletal evidence from Fishergate House indicate that the church associated with the cemetery was Anglo-Scandinavian in origin, occupied a long and narrow plot of land, and ministered to a parish church population, interring men, women, and children in its burial ground (Spall and Toop, 2005). St. Andrews has been identified as the Gilbertine priory through previous archaeological excavations, and the southern boundary of this ecclesiastical site was identified at the Blue Bridge Lane excavation site to the north of Fishergate House (Kemp and Graves, 1996; Spall and Toop, 2005). Tentative archaeological evidence of All Saints has been found 150 meters south of the Medieval city walls on the eastern side of the Fishergate suburb which matches with documentary evidence of

this church's location beneath the post-Medieval Cattle Market (Spall and Toop, 2005). St. Helen was founded before the Norman Conquest and was described as a small and unimportant church that was abandoned in the 16th century (Spall and Toop, 2005). It was granted to the monks of St Martin Marmoutier in 1100 and was described as a church with a 'toft' (Spall and Toop, 2005). Tofts in York were the standard Medieval unit of land that was a long and narrow plot generally running perpendicular to a street-front (Dean, 2008). The dates and layout of the Fishergate House cemetery suggest that this was the location of St Helen's Church, Fishergate (Spall and Toop, 2005). St. Helen's was described as a poor church in the tax records and only one reference to the burial of a church patron has been identified by historians (Spall and Toop, 2005). The church has also been associated in the documentary records with a hospital, which may possibly have been a leprosarium (Spall and Toop, 2005). The parish of St. Helen was combined with St Lawrence in 1585 and the church was recorded as demolished and the land sold (Spall and Toop, 2005). John Speed's map of York from 1610 indicates that Fishergate was a rural, unoccupied area outside the city walls (Figure A.5). Archaeological evidence has identified pastoral use above the cemetery in the 17th and 18th centuries, with the site not being occupied again until Fishergate House was built on the site in the early 19th century (Spall and Toop, 2005).
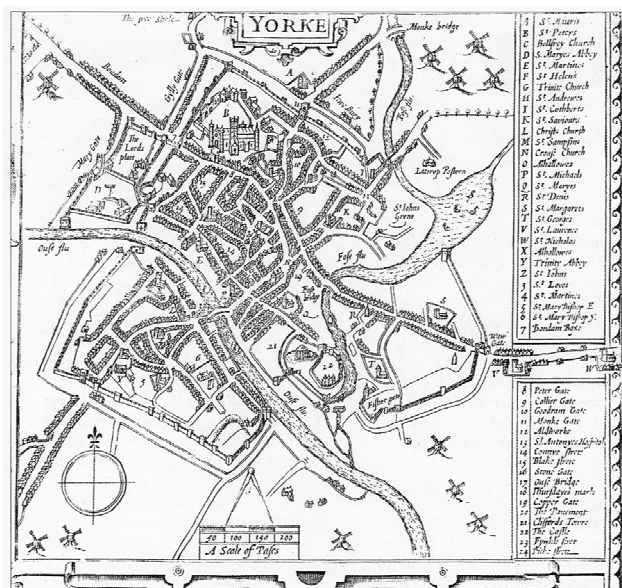
Figure A.5: John Speed's map of York depicting windmills at Fishergate in 1610 (Dean, 2008: 17).

A.2.2 Franciscan Friary, Hartlepool

Hartlepool, located in present day County Durham, is a coastal town constructed around a protected harbour on an isthmus projecting into the North Sea (Figure A.6). A rural, agricultural settlement existed at Hartlepool before the Norman Conquest and the port was granted the status of a town in the 13th century. The local population prospered in the Post-Conquest Medieval period as the town developed into a key fishing community, a port for military supplies for the border armies, and a safe harbour for the English fleet. Throughout the Medieval border troubles, the Franciscans buried Hartlepool community members in their cemetery. Documentary evidence indicates that the burials at the Franciscan Friary's church consisted of the friars themselves, wealthier community members who paid to be interred by the Friary, and possibly the ill who were cared for by the friars. The records also indicate that Hartlepool played a role in supplying and supporting the border wars, however, the town did not play a central role in the conflicts. The cemetery population at this site consisted of individuals who experienced the height of the border wars from a safe distance.

Figure A.6: Franciscan Friary excavation location within the Medieval town of Hartlepool (Daniels, 1984a: 261).

Re-development on the south-west corner of Friarage Field (NZ 529 338) in the early 1980s, formerly occupied by a Victorian school building, allowed Cleveland County Archaeology Section to excavate a portion of the land granted to a small

group of Franciscan friars in the 1240s (Daniels, 1986). Excavations conducted between June 1982 and March 1983, uncovered nine phases of human occupation from the natural soil to the demolition rubble of the Victorian school (Daniels, 1986). The first phase of occupation consisted of a series of grooves cut into the natural red-brown boulder clay, suggesting the area was ploughed for cultivation before the friary was built (Daniels, 1986). The second phase of occupation revealed the foundations of a timber building with plaster floors with an unknown function. It has been hypothesised that this building had an industrial purpose and may have later been transformed into a monastic building for the Franciscans when a plaster floor was installed (Daniels, 1986: 267). The third and fourth phases of occupation included a stone church, burials, and structural extensions which comprised the Franciscans' Church during their residence in Hartlepool from 1240 to 1545 (Daniels, 1986). The fifth phase was comprised of debris accumulated after the abandonment and demolition of the friary church. The sixth through the ninth occupational phases consisted of a subsequent 16th century mansion and Victorian school constructed and demolished on the site (Daniels, 1986).

The Medieval burials associated with the third and fourth phases of the excavation occurred both within the church, below its tiled floor, and in the adjacent land surrounding the building (Daniels, 1986: 271-2). Burials within the church were observed to be more concentrated than those in the areas excavated outside of the church (Daniels, 1986: 271). Of the 74 burials uncovered in the church, 62 graves were excavated (Daniels, 1986: 271). An additional 21 burials were excavated from the graveyard outside of the church (Daniels, 1986: 272). All of the burials were coffin or shroud interments, aligned east-west, and buried in a spine position (Daniels, 1986: 271). In 1989, a portion of the Friary church choir was disturbed by modern construction. Additional graves were uncovered and excavated by Tees Archaeology to remove the skeletal remains, but no additional excavations were undertaken at that time (Daniels, per comm.).

Of the 83 burials excavated in 1982-3, post-excavation skeletal analysis identified a minimum of 150 individuals, of which 125 were determined to be adults and 25 to be non-adults (Birkett, 1986: 292). These skeletal remains were described as "preserved in an excellent condition" (Birkett, 1986: 292). An additional 13 skeletons were excavated in 1989, 11 adults and 2 non-adults (Daniels, per comm.). Although a large portion of the skeletons from the 1982-3 excavation was reburied in

St. Hilda's parish church in Hartlepool, the remainder of this skeletal collection is currently stored with Tees Archaeology at the Hartlepool Museum (Daniels, per comm.).

Historical Context

Archaeological evidence of a Roman settlement at Catcote, which is now West Hartlepool, was excavated in the 1960s and represents Roman occupation of the north-eastern coast of England south of Hadrian's Wall (Austin, 1976). The earliest mention of Hartlepool in documentary sources occurred in Bede's account of a monastery established there during the 640s by Heiu, the first Northumbrian nun (Colgrave and Mynors, 1969; Ward, 1999). This monastery was lead by St. Hilda from 649 to 657, when she founded a new monastery at Whitby (Colgrave and Mynors, 1969; Ward, 1999; Bede, 2008). Recent archaeological excavations have discovered the monastic settlement and indicated that there was a thriving secular early-Medieval community in existence at Hartlepool before the foundation of the monastery (Cramp and Daniels, 1987; Ward, 1999).

Historical documents cite a Viking invasion as the cause of the abandonment of the Anglo-Saxon monastic community at Hartlepool, but recent archaeological excavations at both the monastic site and at the nearby Franciscan Friary church suggest Hartlepool experienced a decline between the 9th and the 12th centuries rather than destruction (Daniels, 1986, 2007). Around 790 AD, possibly at the same time as the destruction of Lindisfarne in 793, the monastery at Hartlepool was destroyed by the Vikings (Ward, 1999: 4). A document from 924, however, recorded Adam Hilton's gift to the monastery of a silver crucifix, which suggests the monastery was rebuilt after the Viking raids and was still thriving in the 8th century (Ward, 1999: 4). The *Historia de Sancto Cuthberto* recorded an estate built by Bishop Edgert at Hartness in the 9th century which he gifted to the community of St. Cuthbert (South, 2002: 51). Excavations at the medieval village of Hart, located four miles west of Hartlepool, provided evidence for a thriving agricultural population in the region throughout the Anglo-Saxon and Medieval periods (Austin, 1976). Medieval documentary evidence for Hart described the villagers' secular obligations to the local manor house and under the ecclesiastical jurisdiction of Durham priory (Austin, 1976). These historical and archaeological sources describe a thriving agricultural population in the eastern part of the modern County Durham during the reigns of the

Northumbrian Kings, a population that was able to support a Northumbrian monastic community and their associated estates.

The effect of the Norman Conquest on Hartlepool is not well-documented. Its location suggests it was involved in the 'Harrying of the North' when William's armies ravaged the countryside between the Humber and the Tees, although no documentary evidence from Hartlepool remains to confirm its participation (Rollason, 2003). The earliest documents pertain to the grant in 1119 of the Hartlepool area, including the nearby village of Hart, all part of the endownments of Guisborough Priory to the de Brus family (Ward, 1999: 5). The transition of power in north-east England, from the Northumbrian lords and monastic communities to the Norman elite, was complicated in the Hartlepool communities by the continuous raids of the Vikings. A mid-12th century Icelandic saga reports that King Eystein raided 'Hjartapoll' and destroyed ships, suggesting a population that relied on the Hartlepool harbour for income from fishing and shipping. This reference also demonstrated a population still resided in the Hartlepool headland between the previously documented Anglo-Saxon monastic settlement and the town charter issued in the 13th century (Ward, 1999: 5).

The town charters which survive in the British Library provide a primary source of documentary evidence of Hartlepool's role as a Medieval town and its citizens' legal rights and privileges under the authority of the signator. The first known charter was granted to Hartlepool by Adam de Brus during the second half of the 12th century, and it granted the residents of Hartlepool the status of burgesses with the same customs, laws, and statutes as the residents of Newcastle-on-Tyne (Todd, 1953). It also confirmed the de Brus's family's physical authority over the property and townspeople and that family's obligation to protect the burgesses (Todd, 1953: 6). A second charter was granted in 1201, by King John, to reaffirm the rights and privileges that the original charter granted to the burgesses and town of Hartlepool (Todd, 1953). King John's royal records from 1201 also record an outgoing payment for ship repairs at Hartlepool, demonstrating the residents reliance on the harbour for their economic prosperity (Ward, 1999: 7).

The first documentary evidence of the Franciscans' settlement in Hartlepool was a grant of fabric for tunics to the friars from Henry III in 1240 (Daniels, 1986: 260). No record of a gift of land or money to establish a friary survives to the present, although the location and similar architectural style of the stone church to the St.

Hilda parish church suggests the de Brus family was the principal benefactors supporting the community (Daniels, 1986: 260; Ward, 1999: 7). Masonry found during the excavation of the Franciscan Friary was of similar style as St. Hilda's parish church masonry, recorded to have been rebuilt by Robert de Brus VI in the years preceding the construction of the Friary Church (Daniels, 1986: 262). Historians have hypothesised that the same masons contracted to build the parish church were also charged with building the Franciscan's first stone church by the de Brus family (Daniels, 1984a, 1986).

The next reference, in 1243, was a description in the Assize Roll of a robber claiming sanctuary in the friars' church in Hartlepool which provides clear evidence that a church had been constructed by the Franciscans before this date (Daniels, 1986: 262). Few other references exist of the Franciscan community at Hartlepool throughout the late-Medieval period. Two references were documented in the 14th century to events at the church: record of an ordination service was noted in 1335, and the English King Edward III granted a license in 1358 to John, son of Elias of Brancepeth, to give three acres of his property to the friars (Daniels, 1986: 262). Town records state that the brothers relied upon local benefactors, a bursary from Durham Priory, and a portion of the revenue of the town oven for their annual income (Daniels, 1986). Records indicate that this income was supplemented by bequests from those wishing to be buried in the friary church or graveyard (Daniels, 1986). In addition, the Franciscans were known in the Medieval period as carers for the sick and infirm (Daniels, 1984a). This evidence suggests that the burials at the Franciscan Friary's church consisted of the friars themselves, wealthier community members who paid to be interred by the Friary, and possibly the ill who were cared for by the friars.

Robert de Brus's claim to the Scottish throne in 1306 led to the revocation of his claims to property in England (McNamee, 2006). His lands in County Durham, including Hartlepool, were redistributed by King Edward I to the de Clifford family (Ward, 1999: 8). Interactions between Hartlepool and Robert de Brus in the early-14th century, following his crowning as Scotland's Robert I, are the only documented episodes of conflict directly affecting this coastal town during the late-Medieval period. He directly threatened the town in 1315 and in 1318 through written truce agreements purchased by the Durham Priory (McNamee, 2006). Speculation on why Hartlepool was specifically targeted focuses on two possible motives: the citizens of the surrounding countryside no longer recognized the de Brus claims of lordship over

his previously held fiefdom, and the harbor at Hartlepool was functioning as a naval base for attacks on Scottish privateers in the North Sea (McNamee, 2006: 80). Capture or destruction of Hartlepool would have both protected Scottish naval interests and extended Robert's domination over the border counties south into Cleveland. The Mayor of Hartlepool raised taxes in 1315 to build a protective wall around the city in response to these threats from Robert de Brus. Documentary sources from Guisborough, Lanercost, and Coldingham recorded Hartlepool "despoiled" and burgesses captured, including women, by Robert's force in July 1315 (Ward, 1999; McNamee, 2006: 80).

Hartlepool petitioned King Edward II in 1318 for money to build a defensive wall around the city in response to Robert de Brus's "truce to all County Durham except Hartlepool, which he intended to burn and destroy because they had captured one of his ships" (Ward, 1999: 9). Excavations in 1983 along the standing fabric of the stone Medieval wall revealed that the townspeople initially fortified their isthmus by constructing a substantial bank and ditch defence along the neck of the peninsula (Daniels, 1984b). A wall of limestone blocks was constructed at a later date along the narrowest part of the peninsula, across the Medieval harbour, and along the sea coast surrounding the city (Daniels, 1984b). The stone wall enclosed the town, including the Franciscan Friary, the harbour, and a large part of the town fields (Daniels, 1984b). This archaeological evidence supports the documentary evidence for several phases of the wall's construction throughout the 14th century (Daniels, 1984b). Although damage caused by Scottish raids were recorded throughout County Durham in 1318 and in 1322, Hartlepool was not directly affected by these raiding parties (Ward, 1999; Sadler, 2006).

The town did play a role in the border wars as port city which supplied goods and crew for English war ships. In 1299, a ship from Hartlepool was employed by the English King Edward I to transport provisions to the English army at Stirling and Edinburgh, and it included a crew of 27 men (Ward, 1999: 8). Records indicate that in 1307 King Edward II impressed men and ships from the sea coasts of Durham and Northumberland into his war against the Scots (Ward, 1999: 8). Hartlepool also supplied the English royal ships returning south from the Scottish Front, as in 1314, when Edward II supplied his ships at Hartlepool after his defeat at Bannockburn (Ward, 1999: 8). The town also aided in England's defence in 1345, when two ships in Hartlepool were modified and used to deter marauders along the North Sea coast

(Ward, 1999). Although Hartlepool provided a strategic safe-harbour for the English against the Scots, their resources were also called upon in England's other wars; Edward III used 5 ships and 145 seamen from Hartlepool at the siege of Calais in 1347 (Ward, 1999). The first evidence of the conscription of the local population into direct military service was not until 1512, when laws were passed to enforce archery practice among the townsmen (Ward, 1999). This direct involvement of the Hartlepool population in conflict occurred well after the end of direct threats to the town by the border troubles.

England withdrew from Scotland in 1549 and the dissolution of the monastic communities in County Durham reduced the demand for fish; Hartlepool was "visibly declining after the loss of the fish trade to the religious houses" (Ward, 1999: 13). In 1565, the Bishop of Durham stated Hartlepool "had sixty-six householders and was governed by a mayor chosen by certain aldermen. There was one ship named the Peter of Hartlepool and three five-man boats plus seventeen small cobles all occupied in the business of fishing. They were fishermen not mariners. The town was a good haven and strongly walled and could provide anchorage for many ships of 200 tons between the town and pier, which was in decay together with many of the houses" (Ward, 1999: 13).

Records show the friary house was leased by Henry VIII in 1538 to the keeper of the Grey Friars and sold in 1545 (Daniels, 1986). At the final dissolution of the order in 1545, an inventory of their possessions was taken and the group disbanded. Burials also ceased at the Friary at the time of the land's sale (Daniels, 1986). The final inventory indicated the Friary either adhered to their vows of poverty or lacked a significant number of benefactors to enable material prosperity (Daniels, 1986: 263). The friary church was demolished and replaced by a 16th century mansion following the dissolution (Daniels, 1986: 264).

A.2.3 Parliament House, Edinburgh

The modern city of Edinburgh is the capital of Scotland and is located on the southern coast of the Firth of Forth. Edinburgh has hosted human settlements since the Bronze Age and developed into a regional capital during the medieval period. Historical evidence described the Firth of Forth as a border region between the pagan Highland Picts and the Christian Lowland Scots from the 6th to the 10th century. Communities

in the Edinburgh region represented the most northern populations under the political and religious control of the Northumbrians. It was also one of the first locations to become securely controlled by the Scots during the 10th century decline of Northumbria. Edinburgh became a royal burgh and grew in size and economic importance from the 11th century throughout the medieval period. The English sieged, burned, and sacked Edinburgh in the 14th and 15th centuries in an effort to gain control over their northern neighbours. However, the English were not successful and Edinburgh remained the capital city of an independent nation until the unification of the crowns in 1603.

Parliament House (NT 2577 7350) is a 2-hectare building complex located in the modern centre of Edinburgh city south of, and adjacent to, St. Giles Cathedral. This location was excavated from December 2001 to December 2004 as part of a redevelopment construction project for the Parliament House building (Toolis, 2005). The site functioned as a car park before excavation began. Beneath the car park, multiple layers of occupation and activity were uncovered which ranged in date from the 13th century to the modern pavement (Toolis, 2005). The first layer of occupation above the natural soil contained silty clay deposits associated with medieval domestic activity between the 13th century and 15th century (Toolis, 2005). This layer of occupation have been interpreted as backland, possibly associated with neighbouring structures, and contained pottery, animal bones, and leather fragments dating from the 13th to the 15th century (Toolis, 2005: 13). This domestic debris suggested the area was associated with either burgage plots or an early Medieval religious community at St. Giles (Toolis, 2005: 29; Collard et al., 2006).

The fourth phase of occupation observed at the Parliament House excavation was a layer of silt with graves containing 96 inhumation burials in rows (Toolis, 2005). The burials were supine and aligned west to east, consistent with medieval Christian burial practices. One mass grave was excavated containing six adult individuals hypothesised to have been victims of disease (Toolis, 2005). Although no grave goods were recovered to assist with dating the burials, late-Medieval pottery was found in the grave soil (Toolis, 2005). Consistent with other medieval cemeteries, many of the graves in the lower part of the level were truncated by subsequent grave cuts and disarticulated remains were found in the grave backfills (Toolis, 2005: 30). A sandstone cobble surface covered the graves from the fourth

phase, representing a 17th to 19th century market described in historical documents as the "Meal Market of the former churchyard of St. Giles" (Toolis, 2005 1).

Post-excavation skeletal analysis identified a minimum number of 95 individuals, 55 adults and 40 non-adults (Melikian, 2005: 1). Preservation of the skeletons was described as moderate for a majority of the individuals (Melikian, 2005: 11). Stable isotope analysis of this population has indicated that the individuals interred in this portion of St. Giles' burial ground were residents of the Edinburgh region during childhood and ate protein-rich diets consistent with Medieval lay populations (Melikian and Evans, 2008). The skeletal collection is currently stored at AOC Archaeology's Edinburgh location (Toolis, per comm.).

Historical Context

Previous archaeological excavations at Edinburgh's Castle Rock have demonstrated that humans have used the current location of Edinburgh Castle as a settlement site since the Bronze Age (Driscoll and Yeoman, 1997). Driscoll and Yeoman (1997) excavated Bronze, Iron, and Roman age domestic occupation layers without archaeologically identifying the boundaries of the settlement (Table A.1). Debate still remains over the size, importance, and defensive capabilities of prehistoric and early-Medieval populations living in Edinburgh (Driscoll and Yeoman, 1997; Toolis, 2005).

Table A.1: Phases of Occupation excavated at Edinburgh's Castle Rock (Driscoll and Yeoman, 1997).

Phase	Date	Description
1	900 BC – 200 BC	Pits, cobbled surfaces, soil hearths, stone drain, and pottery associated with settlement activity.
2	200 BC – 100 AD	Three round timber houses, paved surfaces. Settlement activity.
3 & 4	100 AD – 1000 AD	Midden layer containing ash and hearth sweepings, animal bone, matted vegetable matter (possible thatching), Iron Age and Roman pottery; site occupied, but dwellings not at this location.
5	c. 1000 AD – 1325 AD	Cobbled pathway associated with casual, open-air iron-working.
6	1325 AD – 1400 AD	Blacksmith's workshop. All features found and well preserved including scrap iron.
7	1400 AD – 1550 AD	Workshop demolished and covered with soil to level ground. Soil possibly imported from elsewhere with a jumble of 15th and 16th century artefacts.
8	1550 AD – 1675 AD	Previously undocumented earthwork defences found. Two phases of rampart construction.
9	1675 AD – 1745 AD	Defensive ditches filled. Artillery defences and bomb shelter constructed.
10	1745 AD – 1800 AD	Demolished artillery defences to build modern Cartshed. Part of military reorganisation following Jacobite rebellion.

Roman-era occupation was identified at Castle Rock, but no evidence of this settlement extended to the Parliament House site (Toolis, 2005: 3). The first written

evidence of settlement in the Edinburgh region comes from a 7th century Welsh poem which tells of a people from north of Bamburgh, possibly the Picts or the Scots, who launched an attack from *Din Eidyn* against the Northumbrian kingdom of Deira (Mackie, 1978; Lowe, 1999; Toolis, 2005). The offensive effort of the northern Gododdin kingdom was not successful and their warriors were defeated at the Battle of Catraeth (Lowe, 1999: 12 - 6). Some historians believe the defeat at Catraeth began the Northumbrian occupation and rule over Lothian and Edinburgh in the 7th century (Mackie, 1978; Toolis, 2005). Reference in an Iona annal from 638 AD described the conquest of *Etin*, which could refer to the events of Northumbrian expansion to Edinburgh (Mackie, 1978; Toolis, 2005).

Bede's description of the northern border of the Northumbrian kingdom in the 8th century did not specifically describe a significant settlement at Edinburgh (Bede, 2008). He described an early-Medieval monastic community, Abercorn, as located in the general area of modern Edinburgh which was violently reclaimed by the Picts from the Northumbrians after the death of King Ecgfrith in 685: "Many of the English were either slain by the sword or enslaved or escaped by flight from Pictish territory; among these latter was Trumwine, a reverend man of God who had been made bishop over them and who retired with his companions from the monastery of Abercorn, which was in English territory but close to the firth which divides the lands of the English from that of the Picts" (Bede, 2008: 222). Bede also described a city called Giudi, "half way along the eastern branch," of a long arm of the sea which was inhabited by Picts from the north (Bede, 2008: 22). Although previous historians are uncertain of the exact location of Giudi, they have hypothesised it to be Edinburgh, Stirling, or the Roman fort at Cramond (Bede, 2008: 365). During the 8th century, Edinburgh appears to have been located along a contested border between the Pictish kingdoms to the north and the Northumbrian kingdom to the south.

Documentary references to Edinburgh during the decline of the Northumbrian kingdom are sparse. Lees (1889) describes a church in Edinburgh, belonging to the monestary at Lindisfarne, in 834 (Toolis, 2005: 4). The *Historia de Sancto Cuthberto* claimed the lands of Tyningham to the east of Edinburgh as part of Lindisfarne's property in the 9th century (South, 2002: 47). The *Chronicles of Clonmacnoise* described the Wessex King Athelstane's destruction as far north as Edinburgh in his 934 war against the Scots (Rollason, 2003; Toolis, 2005: 3). According to *The Old Scottish Chronicle*, Indulf, the Scoto-Pictish King from 954 to 962 AD, laid siege to

oppidum Eden until it was abandoned by the Angles (Mackie, 1978; Toolis, 2005). Researchers have inferred from these documentary references that a settlement at Edinburgh was associated with Northumbrian political and religious authority in the 9th century and became a fortified settlement in the 10th century as Northumbria fragmented and the Vikings raided the eastern coast of Britain (Rollason, 2003; Toolis, 2005). Archaeological evidence from Edinburgh Castle suggested a "thriving and wealthy communities occupying this key defensive site into the early medieval period" (Toolis, 2005: 3). This evidence supports the hypothesis that there was an Anglian *burgh* at this location which was conquered by the Scots during the decline of Northumbria in the 10th century.

Edinburgh appeared to remain a minor town throughout the 11th century as Scottish royal power grew and was consolidated under the Canmore Kings (Mackie, 1978). These Kings have been credited with building a 'new' Norman town at Edinburgh and was founded as a *burgh* in 1130 (Mackie, 1978; Collard et al., 2006). A *burgh* was defined by Medieval society as a stronghold in a central geographic location, such as a hill, a ford, or a road junction, which already was a settlement before defences were built and became a centre of trade as well as a seat of military power (Mackie, 1978: 52).

Excavations within St. Giles' Cathedral, between 1981 and 1993, identified two archaeological strata below the Choir Aisle (Collard et al., 2006). A large platform of clay was discovered beneath the church foundation, which appeared to have been constructed to alleviate the steep incline of bedrock from the High Street to Cowgate, and created a more gradual slope to the south of the church (Collard et al., 2006). Below this clay deposit on the east and south foundations of the church were two flat stone slabs with mortar between them which alone could not be interpreted due to a lack of additional datable materials and the inability to excavate the feature further (Collard et al., 2006). Collard and Lawson (2006) suggested these strata represented a planned construction of Edinburgh with the stone slabs marking the mid-point of the 'new' town and the clay platform forming additional space along the High Street for the parish church.

Immediately below the east wall of the Cathedral, aligned north-west to south-east, was a ditch approximately 3 m deep which was not associated or correlated with construction phases or alignments within the medieval cathedral (Collard et al., 2006). A majority of the earliest human burials encountered in the east and south-east

portions of the cathedral excavations were aligned perpendicular to this ditch feature (Collard et al., 2006). This ditch has been hypothesised to represent the alignment of an original Norman church built on the site, with associated burials to the west, dating from the first foundation of the town in the early 12th century (Collard et al., 2006).

Edinburgh's position as the capital city of Scotland and the administrative centre of the kingdom was a gradual progression from population centre to royal burgh (Mackie, 1978). In 1329, Edinburgh was granted a 'feu-farme charters' which created a similar tax payment relationship between the citizens and the King as in England; the townspeople paid an annual fee in lieu of the usual dues and customs of feudal subjects which involved the employment of royal officers (Mackie, 1978: 78). Although the city was defined as a royal burgh in the 13th century, the Scottish royal government also maintained administrative functions in other Scottish cities, such as Dunbarton, Stirling, and Berwick, until the 16th century (Mackie, 1978). James IV (1488 – 1513) worked to improve the function of the government and established regular meetings of Parliament and the judiciary council in Edinburgh between 1503 and 1511 (Mackie, 1978: 117 - 8). The decentralised nature of the Scottish political authority was largely a conscious effort of the Kings to maintain mobility when confronted with a more dominant military force from England to their south (Mackie, 1978; McNamee, 2006).

Edinburgh was extensively damaged and occupied by the English army during conflicts in the 14th and 15th centuries. The residents of Edinburgh experienced one siege associated with the Scottish Wars of Independence in the 14th century; England's Edward III ravaged Edinburgh in the 'Burnt Candlemas' of 1356 (Mackie, 1978: 81). Despite the destruction these wars brought to the rural populations of southern Scotland, Edinburgh continued to grow and developed its port at Leith (Mackie, 1978: 85). In August 1385, an English army under King Richard II's command invaded Scotland as retaliation for the Franco-Scottish alliance army's raid of Northumberland the previous month; the English army burned Edinburgh as well as Dryburgh and Melrose abbeys (Sadler, 2006). The English army occupied Edinburgh in 1482 "theoretically to depose James [III, 1460 – 1488], but … the main outcome of the expedition was that the English recovered Berwick [upon-Tweed]" (Mackie, 1978: 92). Edinburgh was also sacked in 1544 by the Earl of Hereford, as part of Henry VIII's "rough wooing" (Morgan, 2001: 293).

The extent of medieval defensive architecture constructed around Edinburgh to protect the city remains under investigation. Recent excavations along Flodden Wall, believed to have been a Medieval defensive wall extended and refortified following the battle at Flodden Hill in 1513, demonstrated the wall was originally built in the late 16th century and subsequently modified in the 18th and 19th centuries (Lawson and Reed, 2003). This excavation indicated Edinburgh's medieval defences were less extensive than previous historical sources have suggested (Mackie, 1978).

St. Giles' Cathedral functioned as the parish church and burial ground for the city of Edinburgh throughout the Medieval period (Collard et al., 2006). The original building was a Romanesque church, constructed during the reign of either Alexander I (1107-24) or David I (1124-53), and is believed to have been a simple nave or a two-cell structure which now lies below the east end of the current cathedral (Collard et al., 2006). The earliest documentary evidence is dated to 1178, although the archaeological evidence from the Choir aisle suggests that there was occupation at this site before the construction of the Cathedral (Collard et al., 2006). Previous archaeological excavations also identified various phases of expansion after the stone church's construction in the 12th century (Collard et al., 2006). St. Giles Cathedral was burned during Richard II's 1385 attack on Edinburgh (Mackie, 1978; Collard et al., 2006). The architectural plans for reconstruction, dating from 1387, are the earliest surviving documentary sources for building work at the cathedral (Collard et al., 2006). These plans described an aisled nave with five bays which closely resembles the current structure (Collard et al., 2006).

Burials occurred inside St. Giles' Cathedral for the wealthy and privileged citizens of Scotland, while burials occurred outside the church in the adjacent cemetery for the general lay population of Edinburgh (Collard et al., 2006; Melikian and Evans, 2008). "The church originally stood at the top of a substantial open plot stretching down to the Cowgate valley, containing the house and garden of the Vicar (later the Provost) in the lower part and the parish cemetery immediately to the south of the kirk" (Collard et al., 2006: 5). Due to lack of space, the cemetery was extended twice in the 15th century into the Provost's garden, first in 1477 and again in 1496 (Collard et al., 2006: 5). The cemetery extension of 1496 comprised the northern portion of the Provost's garden which later became part of the Parliament House complex (Toolis, 2005). This garden was used as a cemetery by St. Giles' Cathedral until Queen Mary opened the Greyfriars lands outside of the city centre for public

burials in 1562 (Collard et al., 2006: 5). St. Giles' parish records state that the last burial in its adjacent cemetery was in 1566, with the one exception of John Knox who was executed on the High Street in 1572 and buried at St. Giles (Toolis, 2005: 4).

The portion of the St. Giles' parish cemetery uncovered by the Parliament House excavations represented individuals who resided in Edinburgh during the late-15th century and the early 16th century (Melikian and Evans, 2008). Historical records indicated burial occurred in this location between 1496 and 1566 (Toolis, 2005). Although Medieval Edinburgh experienced violence associated with war, the population interred at Parliament House only experienced one episode of siege; the Earl of Hereford's siege of 1544 (Mackie, 1978). This single event would not have produced chronic health changes associated with a conflict-zone lifestyle. The Parliament House population was hypothesised to have experienced a stable, urban lifestyle consistent with other late-Medieval urban populations in Britain.

A.2.4 Whithorn Priory, Dumfries and Galloway

Whithorn Priory (NT 444 402) is located approximately 5 km north of the southern coast of the modern county of Dumfries and Galloway in Scotland (Figure A.7). Whithorn was a vibrant town of continuous religious significance throughout the early- and late-Medieval periods. The local populations in and around the town of Whithorn supported both the monastic community and the secular aristocratic land owners through various changes in political authority. "There appear to have been changes of foci for burial, with areas within the monastery falling in and out of use as cemeteries" (McComish and Petts, 2008: 77). The cemetery population interred along the southern side of the Priory consisted of the general lay population of Whithorn from approximately 1250 AD until 1600 AD. This population lived after the final violent event of the Scottish conquest of Galloway in 1235 and were consistently economically supported by the needs of the monastic community and pilgrims associated with the cult of St. Ninian. Their daily lives would have reflected a typical medieval town lifestyle without the nutritional or economic disruptions associated with the border troubles.
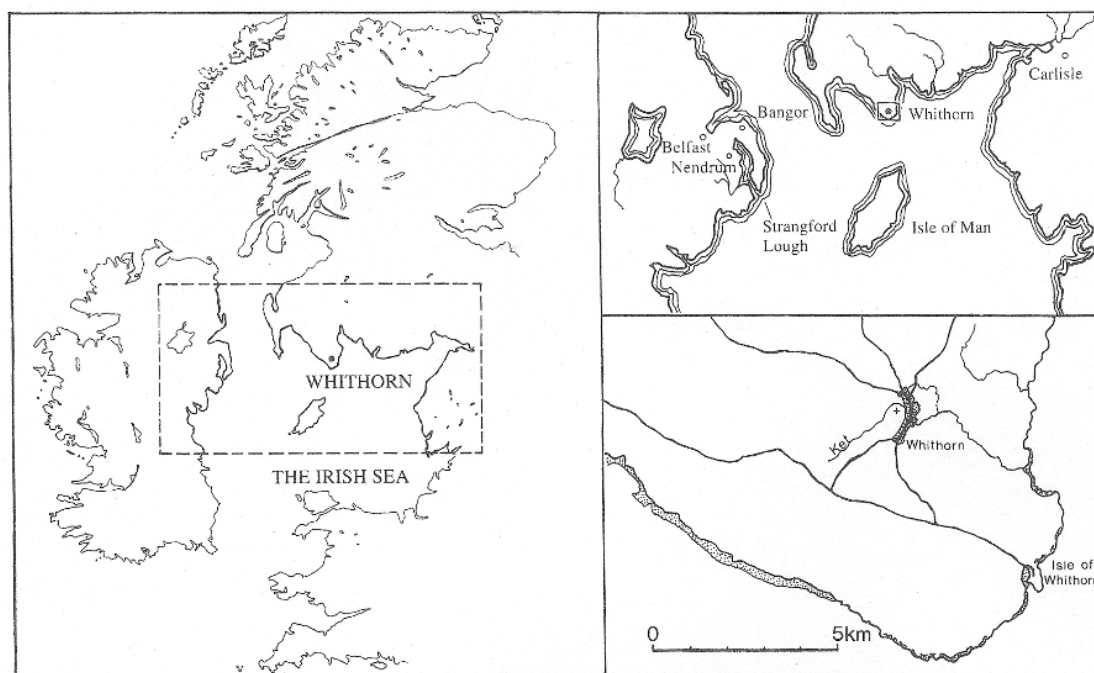
Figure A.7: Location of Whithorn Priory on the Irish Sea Coast (left); in relation to Carlisle (top right); and its proximity to the harbour on the Isle of Whithorn (bottom right) (Hill, 1997: 5).

Archaeological excavations were conducted between 1984 and 1991 by the Whithorn Trust, in association with a proposed construction project, on Glebe Field which lies south-east of the standing Medieval Priory church ruins (Hill, 1997). These excavations uncovered six broad phases of occupation which improved the interpretation of the spatial relationship between Whithorn's monastic and lay communities during the early- and late-Medieval periods (Table A.2).

Table A.2: Phases of occupation at Glebe Field associated with Whithorn Priory (Hill, 1997).

Phase	Dates	Description
Period I	Late 5th/Early 6th C – 7th C	*Monasterium* established under St. Ninia.
Period II	7th C – c. 840 AD	*Monasterium* modified with Northumbrian material culture and a Northumbrian bishopric established. Destroyed by fire around 840 AD.
Period III	c. 840 AD – early 11th C	Northumbrian Minster rebuilt with Scandinavian and Irish material culture.
Period IV	early 11th C – c. 1250 AD	New Celtic settlement built over the Minster. Settlement burned and abandoned. Surrounding swampland drained naturally during this period.
Period V	c. 1250 AD – 1600 AD	Separation of the monastic and the lay communities with construction of a planned Medieval town adjacent to the Priory. Lay burials on south side of Priory.
Period VI	1600 AD – present	Cessation of activity and reversion to agricultural use.

The strata beneath Glebe Field consisted of layers of structural remains covered by waterborne silt which, in turn, were cut by human-made drains; these layers indicate that cycles of human occupation, flooding, and natural drainage

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occurred throughout the Medieval period on Glebe Field (Hill, 1997). Hill's (1997) excavations of Glebe Field is the latest in a series of five excavations undertaken on the Priory hill since the 1880s (Hill, 1997). The four previous excavations primarily explored the Priory ruins, the crypt to the east, and the post-Reformation kirkland to the north of the ruins (Hill, 1997). These previous excavations contributed greatly to our understanding of the scope and function of the early Medieval *monasterium* at Whithorn (Hill, 1997).

The early-Medieval occupation strata excavated by Hill (1997), included two phases of burials, a Northumbrian boundary wall, and a Norse settlement. The hill on which the Priory was constructed was surrounded by water on three sides before 1250 AD (Hill, 1997). The field drained naturally before the late Medieval burials began in this section of the parish cemetery (Hill, 1997). Hill's excavations "revealed a densely-populated medieval graveyard in the northern part of the field disturbing deep early medieval deposits" (1997: 11). Although there were three temporally separate phases of burial at Whithorn (Table A.3), the late-Medieval burials from Period V/1-3 consisted of individuals from the general Whithorn population during the period of the border troubles (Hill, 1997). The early-Medieval burials were assessed to be from a highly select group, predominately males, from only the monastic community (Cardy, 1997). Therefore, only the skeletons excavated from the late-Medieval phase were included in this study as a comparative population for the conflict-zone populations.

Table A.3: Temporal differences in burial phases at Whithorn Priory (Cardy, 1997; Hill, 1997).

Burial Phases	Date
Period I	500 – 700 AD
Periods II and III/1	700 – 900 AD
Period V/1-3	1250 – 1450 AD

Excavations from the late-medieval cemetery phase uncovered 1651 graves containing 1605 articulated skeletons, of which 1553 were excavated intact (Hill, 1997: 253). The graves were aligned east-west and were densely packed in the centre of the graveyard with subsequent burials intercutting previous graves. Many skeletons were described as truncated by the cutting of later graves (Cardy, 1997: 519). Hill (1997: 255) recognised foetal, neonate, and infant remains were under-represented in the cemetery and suggested these individuals were interred in an unexcavated portion of the cemetery.

Demographic data were collected from all 1605 skeletons during excavation; 1093 individuals were determined to be adults and 512 were determined to be non-adults at the time of their death (Cardy, 1997: 519). However, only the 1553 lifted skeletons were fully analysed during post-excavation osteological work (Cardy, 1997: 520). Preservation and completeness of the skeletons was an issue highlighted by post-excavation analysis. Only 19% of the individuals were described as in 'moderately good or better condition" (Cardy, 1997: 519). A large portion of the skeletal material from Whithorn was reburied after post-excavation analysis (Pickin, per comm.). The remaining portion of the collection that is available for analysis is currently stored at Stranraer Museum in Dumfries and Galloway (Pickin, per comm.).

Historical Context

Archaeological excavations from 1957 to 1967 reportedly uncovered Roman cremation burials and material culture to the west of the late-Medieval crypts and beneath the remains of the Priory quire (Hill, 1997: 10). The results of this previous excavation have yet to be published and could shed much light on Roman occupation and early-Medieval urban development at Whithorn.

The location of the town of Whithorn has been noted to be unusual for Galloway; other towns in this region are at "nodes of communication and trade, and are either sited by natural harbours and landing places, or linked to the sea by navigable rivers" (Hill, 1997: 7). Whithorn, however, is sited within the eastern end of the Ket basin, which was originally "an inhospitable, watery place of lochans and bogs, subject to severe seasonal flooding" (Hill, 1997: 7). This location is virtually invisible in the surrounding topography. Whithorn's position of invisibility is similar to Celtic early monastic foundations built in marginal environments (Hill, 1997; Ewart, 2001; Wright, 2004; Daniels, 2007).

The first excavation at Whithorn, conducted by William Galloway in the 1880s, uncovered the *Latinus* stone, which remains the only contemporary written evidence of the Christian community from the Early Medieval period (Hill, 1997: 9). Occupation patterns from the 5th to the 7th centuries suggest that Irish Celtic culture influenced Whithorn in the post-Roman era. The houses were small wattle buildings with double walls which were comparable with buildings from contemporary Northern Irish sites (Cramp, 1994). Pottery and glass found during archaeological excavations demonstrate a connection with the early-Medieval Irish Sea trade (Cramp,

1994). Early-Medieval burial practices were also similar to Irish cemeteries with specially marked graves surrounded by later burials oriented around the first grave (Cramp, 1994). "This suggests whatever ethnic group maintained a religious presence here in the sixth/seventh centuries there was a close link with Ireland, or that there were close similarities between monastic organization in the British west and Ireland" (Cramp, 1994: 16).

The early-Medieval transition from a Celtic monastic community to a Northumbrian town remains difficult for researchers to describe. Whithorn was one of the last and the most western acquisitions of the Northumbrian kingdom, but the exact date and method of Northumbria's conquest remains uncertain (Cramp, 1994). The earliest documentary references to Whithorn that survive are Northumbrian and link the monastic community at Whithorn to the Northumbrian religious centres at Hexham, Lindisfarne, and York (Bede, 2008). Bede described Whithorn as part of Northumbria at two different dates; in 565, when Bishop Ninia was head of the monastic community, Bede described Whithorn as "in the kingdom of Bernicia" (Bede, 2008: 115), and in 731 Bede described Whithorn as the fourth bishopric in Northumbria (Bede, 2008: 289).

Archaeological evidence suggests the Northumbrians gained physical control over Whithorn in the late 7th century and it experienced a cultural change in response to this conquest (Hill, 1997: 17 - 8). Place names and artistic evidence suggested the Northumbrian conquest was less of a military conquest and more of a political change resulting in a greater influence of Northumbrian culture throughout Galloway (Cramp, 1994; Hill, 1997). "At Whithorn there are no crosses (architectural sculpture) of the common Northumbrian type, but regional types of grave markers and crosses" (Cramp, 1994: 17). Craig (1991) described a stylistic barrier at the Cree River, which runs north of Wigtown Bay to the east of Whithorn, beyond which Northumbrian art made little impact.

Excavations conducted from 1949 to 1953 explored both the ruins of the late-Medieval Priory and the Isle of Whithorn, located five km south of the town, with the aim of identifying Ninian's original church, 'Candida Casa', as described by Bede (Hill, 1997; Bede, 2008). This research project proved the chapel on the Isle, previously believed to have been an early-Medieval building, as a 13th century construction (Hill, 1997). It also reassessed building evidence on the eastern side of the Priory hill, near the crypts, as Northumbrian constructions (Hill, 1997).

Further excavations between 1992 and 1996 in Fey Field, southwest of the standing cathedral ruins and to the north of Glebe Field, identified various phases of human settlements, industry, and burials adjacent to Priory Hill from the 6th to the 14th centuries (McComish and Petts, 2008). The importance of this excavation lies in its contradiction of the nature and the extent of functional changes and expansion surrounding the Northumbrian minster. Early Medieval ditches identified in Hill's excavations as 8th century constructions at Glebe Field were interpreted as Northumbrian modifications to the Celtic spatial organisation, and a shift of activity to the west of the monastic complex (Hill, 1997: 181). These early Medieval ditches were also identified in the Fey Field excavation, but these were dated to the 6th century, which suggests the Northumbrian influence on the spatial organisation of the community may have been less than previously expected (McComish and Petts, 2008).

The Fey Field excavation also identified another area adjacent to the monastic community which was used for burial. Burials in Fey Field were uncovered from the southern half of the north-south trench adjacent to the current nave ruins, which indicated monastic use of this space for interment from the 6th to 12th century (McComish and Petts, 2008: 76). Burial in this area declined during both the early 7th century and the 11th and 12th centuries with intermittent structural phases; this is in contrast to the burial phases described at Glebe Field in Table 3.3 (Hill, 1997; McComish and Petts, 2008). The post-excavation analysis of skeletal material from Fey Field indicated a more representative population of males, females, and non-adult individuals buried in this location (Tucker, 2008). This demographic difference between the Fey Field and Glebe Field early-Medieval burials could highlight a difference in burial locations for the lay and monastic populations, or could simply be a function of differential preservation (Cardy, 1997; Tucker, 2008).

Early-Medieval miracle texts describe St. Ninian's shrine at Whithorn as a place of miraculous healing during the 8th century, at the height of the Northumbrian kingdom's expansion and influence (Hill, 1997). Pilgrimage and worship at the tomb and of the relics of St. Ninian were described as two distinct locations at Whithorn throughout the early- and late-Medieval periods. The tomb was believed to heal sickness via an overnight vigil inside the tomb by the ill individual (Hill, 1997). Archaeological evidence of medicinal herbs and a possible surgeon's knife in Northumbrian strata at Whithorn lend support to the interpretation of the early

Medieval *monasterium*'s role as an infirmary, as well as a religious community, from the 700s AD (Hill, 1997: 20).

Records of the bishops of Whithorn ceased around 835 and archaeological evidence from the late 830s and early 840s at Whithorn show the Northumbrian minster was destroyed by fire (Hill, 1997). The cause of this fire remains unknown, but coincided with a dynastic conflict and civil war within the Northumbrian kingdom and with Viking raiding of the Irish monastic communities along the Irish Sea coast, and within central Scotland of Picts and Scots settlements (Hill, 1997). Although there are no records of Viking raids in Galloway, the raids in Scotland prompted a cohesive union of the Picts and Scots under the first King of Scotland, Kenneth, in 841 AD. Northumbrian records stated Kenneth raided the borders and burned Melrose and Dunbar in response to the Northumbrian kings' support for Kenneth's Pictish opponents (Hill, 1997: 21). Whether Whithorn was burned by Viking or Scottish raiders or by Northumbrian civil war, this destruction marked the beginning of a period of instability in Northumbria which did not affect Whithorn for long.

The *monesterium* was rebuilt soon after the fire with a more Scandinavian and Irish material culture style, which indicated Whithorn was no longer part of the Northumbrian kingdom and maintained a more stable socio-political independence from the Scots and the Brits (Hill, 1997). Hill's (1997) Glebe Field excavation uncovered 9th century coinage which continued to the last Northumbrian issues which demonstrated Whithorn was a valuable economic centre in the Solway area throughout the 9th century Northumbrian decline and the rise of Scandinavian influence in Galloway. "After that the disturbed conditions during the Scandinavian wars in Northumbria may have weakened the marketing as well as the ecclesiastical links. The importance of the Whithorn evidence is that it shows the continued care for and the renovation of the church range throughout the obscure period of the ninth century, and provides a context for the continuance beyond that of ecclesiastical organization in the region which had once more turned its back on the Northumbrian east and looked to the west coast of Britain, and to Wales." (Cramp, 1994: 18)

The political and religious organisation of Whithorn in the 10th and 11th centuries remains uncertain. "The site is indefensible and its security probably relied on its obscure location, and protection of local people and, perhaps, on mercenary settlers in the later ninth/tenth centuries" (Hill, 1997: 25). A new settlement with a

Celtic building tradition and material culture was constructed over the *monesterium* in the early 11th century (Hill, 1997).

The late-Medieval Whithorn Priory was part of the Premonstratensians monastic order (Hill, 1997). Called White Canons, this monastic order was derived from a monastic revival on the Continent whose aims were to reinstate the austere simplicity of early Christian monastic life (Dilworth, 1994). The White Canons came to Scotland during the 1150s, during the reign of David I (1124-1153), when there was a royal movement to expand the monastic presence in Scotland by the royal family, and established themselves at Dryburgh (Dilworth, 1994). By the 1220s, six additional Premonstatensian monasteries had been founded by the Dryburgh community; one of these was the Whithorn Priory (Dilworth, 1994).

The priory of Whithorn was centred around a large cathedral complex that included monastic cloisters for the religious community, and a large nave and burial ground which functioned as a house of worship and cemetery for the lay townspeople (Hill, 1997). Excavations from 1957 to 1967 to the west of the late Medieval crypts and beneath the remains of the quire, uncovered the 13th and 14th century graves of Whithorn's bishops and Priors as well as the early-Medieval graves and the possible Roman cremation cemetery (Hill, 1997: 10). Tabraham's excavations in 1975 explored land north of the Priory remains and have identified the northern sections of the cloisters (Hill, 1997: 10). Tabraham's excavations in 1972 identified the late-Medieval burial ground to the south of the Priory both within Glebe Field and on land to the immediate west of the field (Hill, 1997: 10).

During the 12th and 13th centuries, Dumfries and Galloway was dominated by the Lords of Galloway and the local populations saw themselves as a different ethnicity and a separate political entity from the Scots (Hill, 1997). "This fiercely independent family struggled to resist the incorporation of the region to the increasingly powerful Kingdom of Scotland for more than 100 years" (Hill, 1997: 5). Galloway became part of greater Scotland in 1234 but, after a short-lived rebellion by the local people under the leadership of Thomas, the last male heir of the Lords of Galloway. This "brutally suppressed" rising of the people by Alexander II was the last political and economic instability experienced by the people of Whithorn until the town's economic decline in the 16th century following the Protestant Reformation in Scotland (Hill, 1997; Ewart, 2001: 84).

The Priory of Whithorn held large parcels of land in Galloway which it administered as a secular barony. "A barony had various duties and privileges: to have a mill, to fix prices, to regulate land management and so on. Its trading centre was the burgh of barony with privileges of having a court, a market and an annual fair. The prior was the superior of the barony, the baron who ruled local life." (Dilworth, 1994: 10) The earliest town charter which survives dates from 1451, but reconfirms the privileges granted in the town's three previous charters issued by Robert I (1326 AD), Edward Bruce (c. 1310 AD), and Alexander III (1249 – 86 AD) respectively. These charters all describe Whithorn as a vill or free burgh with a weekly market and an annual fair around St. Ninian's Day (Dilworth, 1994). These charters also confirmed that the grant of the town to the Priory was its source of income (Hill, 1997). "The settlement existed, in part, to serve the cult, which, in turn, generated the economic activity that maintained the community" (Hill, 1997: 25).

The Priory also relied upon the shipping port at the Isle of Whithorn for economic support. The relationship between the town of Whithorn, the Priory, and the Isle of Whithorn was so interconnected that early maps confused the two locations and recorded Whithorn as located on the coast (Hill, 1997). "A place-name indicated that the bishop possessed a large farm on the landward side of the bay in the ninth/tenth century, while artefacts and commodities excavated at Whithorn attest marine trade from the early-sixth century if not before, which presumably passed through the Isle. The Isle was owned by the Priory in the late middle ages and royal charter of 1491-2 granted the priory the customs of the goods carried in its own ships, which were listed as leather, wool, skins, cloth and fish in a charter of confirmation of 1499." (Hill, 1997: 5-6)

Pilgrimage to the relics of St. Ninian also brought economic prosperity to Whithorn in the medieval period. It was one of four pilgrimage destinations in Scotland during the late-Medieval period (Dilworth, 1994). The shrine attracted religious tourists from throughout Scotland and from abroad (Dilworth, 1995), and late Medieval royalty were active patrons of Whithorn's Priory: "Queen Margaret, wife of James III, came with six of her ladies in 1473-4, James IV and his queen came often, at times even annually, and he gifted a new reliquary for the saint's bones. Letters of James IV and James V refer often to pilgrims to the shrine at Whithorn" (Dilworth, 1994: 11).

Despite Whithorn's geographic proximity to the Anglo-Scottish border, the wars associated with border contention from the 10th to the 16th century did not directly affect the lay populations in western Galloway. Although other monastic communities in eastern Galloway, such as Dundrennan and Sweetheart Abbeys, reported property damage and claimed tax exemption from England's King Edward I, damage was not recorded at Whithorn and the town was not attacked during the Scottish Wars of Independence (Hill, 1997; Ewart, 2001: 84; McNamee, 2006). The greatest impact of the late-Medieval border troubles was experienced by the severance of administrative connections between Whithorn Priory and the Premonstratensian communities in England. Religious administrative documents from Whithorn described a close, communal relationship between southern Scottish and northern English monastic houses during the early centuries of the Medieval period, which was later dissolved by the international political conflict between the two kingdoms (Dilworth, 1994: 4).

> "The White Canons had a unique arrangement, that of the circaria or circuit, where by the monasteries in a region met together and appointed a Visitor to carry out visitations [inspections] within the circuit. Originally, the five monasteries in the south of Scotland formed a circuit with seven houses in the north of England. The wars between Scotland and England put an end to this."(Dilworth, 1994: 7)

Although the Protestant Reformation in Scotland was less abrupt than in England, the gradual reduction of power and influence of the monastic communities produced the same effect of abandoned monasteries and derelict cathedrals. Whithorn's economy collapsed gradually with the contraction of the Priory and the Scottish parliament's ban of pilgrimages to religious relics. Whithorn's economy shrank, "from serving the needs of a dwindling community of monks to those of a landlord in residence. Despite the fact that the abbey as a monastic institution came to an end with the Reformation of 1560, some of the monks continued to live there alongside successive commendators" (Ewart, 2001: 85).

Although a settlement remained in the town, its population was greatly reduced and its Catholic parish traditions changed. The nave was transformed into a parish church and a square tower was constructed on its western end in 1610 (Hill, 1997). Although burials most likely continued around the parish church, Glebe Field

was no longer used for that purpose. Archaeological deposits above the graves contained only a few early post-Medieval coins and pottery, along with features indicative of agricultural activity (Hill, 1997). Over time, the cathedral was ruined and only the walls of the nave still stand. A Victorian-style parish church was constructed on the northern side of the Medieval cathedral complex in 1822 which still functions as Whithorn's parish church (Hill, 1997).

A.2.5 Neighbouring Populations Summary

These four skeletal populations from neighbouring regions of northern England and southern Scotland were hypothesised to have experienced a typical medieval lifestyle. Historical and archaeological evidence suggest that their nutritional resources were not diminished during periods of border conflict associated with military raids, military occupations, or border reiving. These populations should demonstrate the same demographic and palaeopathological profiles as other medieval British populations (Roberts and Cox, 2003).

Appendix B:

Recording Form Templates

Infant Skeletal Recording Form

Excavation Site: _____   Observer: _____

Skeleton # _____   Date: _____

Inventory

Cranium

	Right	Left
Frontal		
Parietal		
Temporal		
Occipital		
Sphenoid		
Zygomatic		
Nasal		
Lacrimal		
Ethmoid		
Maxilla		

Vertebrae

	Complete	Bodies	Arc
Cervical			
Thorasic			
Lumbar			

Ribs

Complete	Heads	Ends	Fragments

Hands / Feet

Carpals	R	L	Tarsals	R	L
Navicular			Calcaneus		
Lunate			Talus		
Triquetral			Cuboid		
Pisiform			Navicular		
Trapezium			1st Cuneiform		
Trapezoid			2nd Cuneiform		
Capitate			3rd Cuneiform		
Hamate			Metatarsals		
Metacarpals					

# of Phalanges:

General Summary

% Preserved: _____   Estimated Stature: _____

Bone Condition: _____   Estimated Body Mass: _____

Age Estimation: _____

Pathological Lesions Observed

Cribra Orbitalia   Porotic Hyprostosis   Enamel Hypoplasia   Dental Disease

Metabolic Disease   Joint Disease   Infection   Trauma

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Infant Skeletal Recording Form

Excavation Site: _____   Observer: _____

Skeleton # _____   Date: _____

Age Estimation   Notes:

Epiphyseal Fusion	State	Age Range
Metopic suture		
Mental symphysis		
Lateral to basilar		
Lateral to squamous		
Basilar suture		
C halves of arch		
C arch-vert. body		
C vert. sup. rim		
C vert. inf. rim		
T halves of arch		
T arch-vert. body		
T vert sup. rim		
T vert. inf. rim		
L halves of arch		
L arch-vert. body		
L vert. sup. rim		
L vert. inf. rim		
S1-S2		
S3-S5		
Scapula coracoid		
Scapula glen.cavity		
Scapula acromion		
Scapula inf. angle		
Scapula med. border		
Prox humerus		
Distal humerus		
Humerus epicondyle		
Prox radius		
Distal radius		
Prox ulna		
Distal ulna		
Ilium to pubis		
Ischium to pubis		
Ischium to ilium		
Ischial tubercle		
Iliac crest		
Prox femur		
Greater trochanter		
Lesser trochanter		
Distal femur		
Prox tibia		
Distal tibia		
Prox fibula		
Distal fibula		
Dentition	Score	Age Range
Dental Eruption		
Dental Attrition		
Metrics	in mm	Age Range
Scapula length		
Scapula width		
Humerus length		
Clavicle length		
Radius length		
Ulna length		
Femur length		
Tibia length		
Fibula length		
Ilium width		

Infant Skeletal Recording Form

Excavation Site: _____   Observer: _____

Skeleton # _____   Date: _____

Dental Inventory

Dental Notes:

MAXILLARY

BUCCAL   BUCCAL

OCCLUSAL   OCCLUSAL

LINGUAL   LINGUAL

Right   51   52   53   54   55 | 56   57   58   59   60   Left

          70   69   68   67   66 | 65   64   63   62   61

LINGUAL   LINGUAL

OCCLUSAL   OCCLUSAL

BUCCAL   BUCCAL

MANDIBULAR

Abscesses   Tooth   Internal/External Drain

Other Dental Defects   Tooth   Description

Key

NP	not present	PU	pulp exposed - jaw not present
/	lost postmortem	●	caries
B	broken postmortem	○	abscess
X	lost antemortem	—	calculus
R	root only	…	dental enamel defects
U	unerupted		
E	erupting		
PE	partially erupted		

Infant Skeletal Recording Form

Excavation Site: _____　　　Observer: _____

Skeleton # _____　　　Date: _____

Pathological Lesions

See attached notes page for detailed descriptions

Non-Specific Infection

Cribra Orbitalia:	Signs Present	Signs Absent	Not available
Porotic Hyperostosis:	Signs Present	Signs Absent	Not available
Endocranial Surface:	Signs Present	Signs Absent	Not available
Maxillary sinusitis:	Signs Present	Signs Absent	Not available
Rib Lesions:	Signs Present	Signs Absent	Not available

Degenerative Joint Disease

**See separate sheet for spinal joint disease if present in several vertebra

Joint　Location　　　Description: porosity, osteophyte, eburnation, shape/contour change, fusion, erosion, ossification

Trauma

Fractures: Bone/Location　Type　Simple/Compound　Deformity　Complications

Dislocations: Joint/Location　　　Changes to joint surface　　congenital or traumatic

Soft Tissue Injury: Location on bone　　　Description

Metabolic Disease

Signs of:　Rickets　　Scurvy　　Anaemia

Photo Record

Photo Ref. No.	Description

Infant Skeletal Recording Form

Excavation Site: _____   Observer: _____

Skeleton # _____   Date: _____

Additional Pathology Notes:

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Juvenile Skeletal Recording Form

Excavation Site: _____ Observer: _____

Skeleton # _____ Date: _____

Inventory

Cranium

	Right	Left
Frontal		
Parietal		
Temporal		
Occipital		
Sphenoid		
Zygomatic		
Nasal		
Lacrimal		
Ethmoid		
Maxilla		

Vertebrae

	Complete	Bodies	Arc
Cervical			
Thorasic			
Lumbar			

Ribs

Complete	Heads	Ends	Fragments

Hands / Feet

Carpals	R	L	Tarsals	R	L
Navicular			Calcaneus		
Lunate			Talus		
Triquetral			Cuboid		
Pisiform			Navicular		
Trapezium			1st Cuneiform		
Trapezoid			2nd Cuneiform		
Capitate			3rd Cuneiform		
Hamate			Metatarsals		
Metacarpals					

# of Phalanges:

General Summary

% Preserved: _____ Estimated Stature: _____

Bone Condition: _____ Estimated Body Mass: _____

Age Estimation: _____

Pathological Lesions Observed

Cribra Orbitalia   Porotic Hyprostosis   Enamel Hypoplasia   Dental Disease

Metabolic Disease   Joint Disease   Infection   Trauma

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Juvenile Skeletal Recording Form

Excavation Site: _____   Observer: _____

Skeleton # _____   Date: _____

Age Estimation

Epiphyseal Fusion	State	Age Range
Metopic suture		
Mental symphysis		
Lateral to basilar		
Lateral to squamous		
Basilar suture		
C halves of arch		
C arch-vert. body		
C vert. sup. rim		
C vert. inf. rim		
T halves of arch		
T arch-vert. body		
T vert sup. rim		
T vert. inf. rim		
L halves of arch		
L arch-vert. body		
L vert. sup. rim		
L vert. inf. rim		
S1-S2		
S3-S5		
Scapula coracoid		
Scapula glen.cavity		
Scapula acromion		
Scapula inf. angle		
Scapula med. border		
Prox humerus		
Distal humerus		
Humerus epicondyle		
Prox radius		
Distal radius		
Prox ulna		
Distal ulna		
Ilium to pubis		
Ischium to pubis		
Ischium to ilium		
Ischial tubercle		
Iliac crest		
Prox femur		
Greater trochanter		
Lesser trochanter		
Distal femur		
Prox tibia		
Distal tibia		
Prox fibula		
Distal fibula		

Dentition	Score	Age Range
Dental Eruption		
Dental Attrition (Brothwell)		
Dental Attrition (Lovejoy)		

Metrics	mm	Age Range
Scapula length		
Scapula width		
Humerus length		
Clavicle length		
Radius length		
Ulna length		
Femur length		
Tibia length		
Fibula length		
Ilium length		

Adult Metrics

Clavicle max length _____

Glenoid cavity width _____

Max. hum length _____

Hum. head diameter _____

Max. Radius Length _____

Radial head diameter _____

Max Ulna Length _____

Max. Femur Length _____

Fem. bicondylar length _____

Fem. head A-P breadth _____

Fem. head P-D diameter _____

Fem. bicondylar width _____

Fem. Sub-Troch A-P diameter _____

Fem. Sub-Troch M-L diameter _____

Max. Tibia Length _____

Tibia NutFor A-P diameter _____

Tibia NutForM-L diameter _____

Max. Fibula Length _____

Bi-iliac pelvic breadth _____

Age Estimation:

Notes:

Juvenile Skeletal Recording Form

Excavation Site: _____   Observer: _____

Skeleton # _____   Date: _____

Dental Inventory

Permanent Dentition   Deciduous Dentition

MAXILLARY

BUCCAL

OCCLUSAL

OCCLUSAL

LINGUAL

Right | 1 2 3 4 5 6 7 8 | 9 10 11 12 13 14 15 16 | Left

32 31 30 29 28 27 26 25 | 24 23 22 21 20 19 18 17

OCCLUSAL

LINGUAL

OCCLUSAL

BUCCAL

MANDIBULAR

MAXILLARY

BUCCAL | BUCCAL

OCCLUSAL | OCCLUSAL

LINGUAL | LINGUAL

Right | 51 52 53 54 55 | 56 57 58 59 60 | Left

70 69 68 67 66 | 65 64 63 62 61

LINGUAL | LINGUAL

OCCLUSAL | OCCLUSAL

BUCCAL | BUCCAL

MANDIBULAR

Key

NP	not present	R	root only	PU	pulp exposed - jaw not	— calculus
/	lost postmortem	U	unerupted		present	… dental enamel defects
B	broken postmortem	E	erupting	●	caries	
X	lost antemortem	PE	partially erupted	○	abscess	

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Juvenile Skeletal Recording Form

Excavation Site: _____   Observer: _____

Skeleton # _____   Date: _____

Dental Notes:

Abscesses   Tooth   Internal/External Drain

Other Dental Defects   Tooth   Description

Pathological Lesions
See attached notes page for detailed descriptions

Non-Specific Infection
Cribra Orbitalia: Signs Present   Signs Absent   Not available
Porotic Hyperostosis: Signs Present   Signs Absent   Not available
Endocranial Surface: Signs Present   Signs Absent   Not available
Maxillary sinusitis: Signs Present   Signs Absent   Not available
Rib Lesions: Signs Present   Signs Absent   Not available

Degenerative Joint Disease
**See separate sheet for spinal joint disease if present in several vertebra
Joint   Location   Description: porosity, osteophyte, eburnation, shape/contour change, fusion, erosion, ossification

Trauma
Fractures: Bone/Location   Type   Simple/Compound   Deformity   Complications

Dislocations: Joint/Location   Changes to joint surface   congenital or traumatic

Soft Tissue Injury: Location on bone   Description

Metabolic Disease
Signs of: Rickets   Scurvy   Anemia

Juvenile Skeletal Recording Form

Excavation Site: _____   Observer: _____

Skeleton # _____   Date: _____

Photo Record

Photo Ref. No.	Description

Additional Pathology Notes:

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Juvenile Skeletal Recording Form

Excavation Site: _____   Observer: _____

Skeleton # _____   Date: _____

Additional Pathology Notes:

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Adult Skeletal Recording Form

Excavation Site: _____   Observer: _____

Skeleton # _____   Date: _____

Inventory

Cranium

	Right	Left
Frontal		
Parietal		
Temporal		
Occipital		
Sphenoid		
Zygomatic		
Nasal		
Lacrimal		
Ethmoid		
Maxilla		

Vertebrae

	Complete	Bodies	Arc
Cervical			
Thorasic			
Lumbar			

Ribs

Complete	Heads	Ends	Fragments

Hands / Feet

Carpals	R	L	Tarsals	R	L
Scaphoid			Calcaneus		
Lunate			Talus		
Triquetral			Cuboid		
Pisiform			Navicular		
Trapezium			1st Cuneiform		
Trapezoid			2nd Cuneiform		
Capitate			3rd Cuneiform		
Hamate			Metatarsals		
Metacarpals					

Key   # of Phalanges: ___

■ = present and complete   ▦ = present and fragmented

General Summary

Preservation: _____   Estimated Stature: _____

Bone Condition: _____   Estimated Body Mass: _____

Age Estimation: _____   Platymeric: _____

Sex Estimation: _____   Platycnemic: _____

Pathological Lesions Observed

Cribra Orbitalia   Porotic Hyprostosis   Enamel Hypoplasia   Dental Disease

Metabolic Disease   Joint Disease   Infection   Trauma

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Adult Skeletal Recording Form

Excavation Site: _____   Observer: _____

Skeleton # _____   Date: _____

AGE ESTIMATION	Score	Age Estimation
Skull – Dental Eruption		
Skull – Dental Attrition (Brothwell)		
Skull – Dental Attrition (Lovejoy)		
Skull – Cranial Suture Closure		
Pelvis – Pubic Symphysis		
Pelvis – Auricular Surface		
Pelvis – Sacrum Fusion		
Other – Sternal Rib Ends		
Other – Medial Clavicle Fusion		
TOTAL		

SEX ESTIMATION	Score/Notes	F	?F	?	?M	M	N/A
Skull – Forehead							
Skull – Bossing							
Skull – Supraorbital ridges							
Skull – Oribital Rims							
Skull – Post. zygomatic arch							
Skull – Nuchal Crest							
Skull – Mastoid Process							
Mandible – Mental Eminence							
Mandible – Ramus Flexure							
Pelvis – Sciatic notch							
Pelvis – Subpubic angle							
Pelvis – Subpubic concavity							
Pelvis – Pubic bone width							
Pelvis – Ischio-pubic ramus							
Pelvis – Ventral Arc							
Pelvis – Obturator foramen							
Pelvis – Pelvic inlet/outlet							
Pelvis – Acetabulum							
Pelvis – Sacrum segments							
Pelvis – Sacrum morphology							
Metrics (See details below)							
TOTAL							

Metrics

Clavicle max length _____

Glenoid cavity width _____

Max. Hum length _____

Hum. head diameter _____

Max. Radius Length _____

Radial head diameter _____

Max Ulna Length _____

Max. Femur Length _____

Fem. bicondylar length _____

Fem. head A-P breadth _____

Fem. head P-D diameter _____

Fem. bicondylar width _____

Fem. Sub-Troch A-P diameter _____

Fem. Sub-Troch M-L diameter _____

Max. Tibia Length _____

Tibia NutFor A-P diameter _____

Tibia NutForM-L diameter _____

Max. Fibula Length _____

Bi-iliac pelvic breadth _____

Adult Skeletal Recording Form

Excavation Site: _____   Observer: _____

Skeleton # _____   Date: _____

Dental Inventory

Notes:

MAXILLARY
BUCCAL
OCCLUSAL   OCCLUSAL
OCCLUSAL
LINGUAL

Right   1   2   3   4   5   6   7   8 | 9   10 11 12 13 14 15 16   Left
        32 31 30 29 28 27 26 25 | 24 23 22 21 20 19 18 17

LINGUAL
OCCLUSAL   OCCLUSAL
OCCLUSAL
BUCCAL
MANDIBULAR

Abscesses   Tooth   Internal/External Drain

Other Dental Defects   Tooth   Description

Key
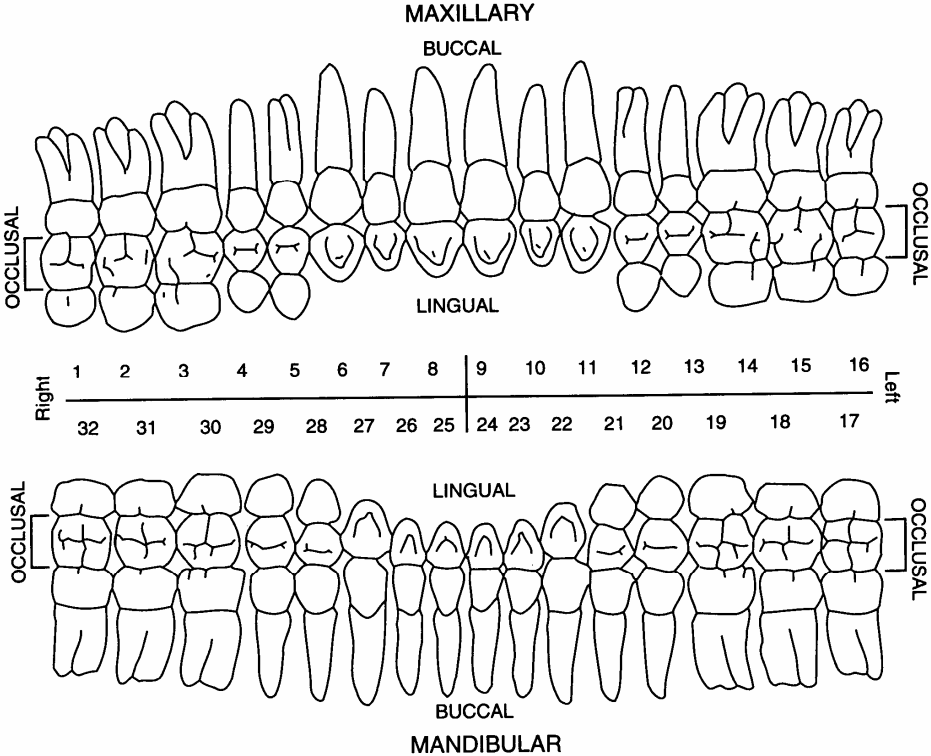
NP	not present	R	root only	PU	pulp exposed, jaw	—	calculus
/	lost postmortem	U	unerupted		not present	…	enamel defects
B	broken postmortem	E	erupting	●	caries lesion		
X	lost antemortem	PE	partially erupted	○	abscess		

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Adult Skeletal Recording Form

Excavation Site: _____   Observer: _____

Skeleton # _____   Date: _____

Pathological Lesions

See attached notes page for detailed descriptions

Non-Specific Infection

Cribra Orbitalia:	Signs Present	Signs Absent	Not available
Porotic Hyperostosis:	Signs Present	Signs Absent	Not available
Maxillary sinusitis:	Signs Present	Signs Absent	Not available
Rib Lesions:	Signs Present	Signs Absent	Not available
Endocranial Surface:	Signs Present	Signs Absent	Not available

Degenerative Joint Disease

**See separate sheet for spinal joint disease if present in several vertebra

Joint   Location   Description

porosity, osteophyte, eburnation, shape/contour change, fusion, erosion, ossification

Trauma

Fractures

Bone/Location   Type   Simple/Compound   Deformity   Complications

Dislocations

Joint/Location   Changes to joint surface   congenital or traumatic

Soft Tissue Injury

Location on bone   Description

Metabolic Disease

Signs of: Rickets   Scurvy   Anemia

Description of bone changes:

Photo Record

Photo Ref. No.	Description

Adult Skeletal Recording Form

Excavation Site: _____   Observer: _____

Skeleton # _____   Date: _____

Additional Pathology Notes:

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Adult Skeletal Recording Form

Excavation Site: _____   Observer: _____

Skeleton # _____   Date: _____

SPINAL JOINT DISEASE

Changes
OP osteophytes
PO porosity
SN Schmorls nodes
EB eburnation

Body
1 superior body
2 inferior body

Left
3 superior facet
4 inferior facet
5 transverse process
6 costal facet

Right
7 superior facet
8 inferior facet
9 transverse process
10 costal facet

Vert.	1	2	3	4	5	6	7	8	9	10
C1										
C2										
C3										
C4										
C5										
C6										
C7										
T1										
T2										
T3										
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T6										
T7										
T8										
T9										
T10										
T11										
T12										
L1										
L2										
L3										
L4										
L5										
S1										

Appendix C

Example Recording Form

Adult Skeletal Recording Form

Excavation Site: Parliament House
Skeleton # 66

Observer: TDT
Date: Feb 26, 08

Inventory
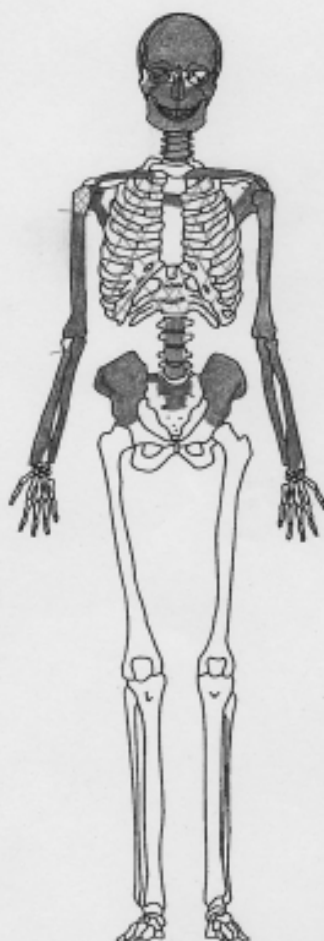
Cranium

	Right	Left
Frontal	✓	✓
Parietal	✓	✓
Temporal	✓	✓
Occipital	✓	✓
Sphenoid	1/2	1/2
Zygomatic	1/2	✓
Nasal	—	—
Lacrimal	—	✓
Ethmoid	—	—
Maxilla	3/4	3/4

Vertebrae

	Complete	Bodies	Arc
Cervical	3	3	2 (halves)
Thoracic	—	11	7
Lumbar	—	5	5

Ribs

Complete	Heads	Ends	Fragments
—	17 (re+vice)	6	40

Hands / Feet

Carpals	R	L	Tarsals	R	L
Navicular			Calcaneus		
Lunate			Talus		
Triquetral			Cuboid		
Pisiform			Navicular		
Trapezium			1st Cuneiform		
Trapezoid			2nd Cuneiform		
Capitate			3rd Cuneiform		
Hamate			Metatarsals		
Metacarpals					

# of Phalanges: Hands None   Feet None

Key
■ = present and complete ▨ = present and fragmented

General Summary

Preservation: Good (25-50%)
Bone Condition: Fair PMBreaks Erosion
Age Estimation: 30-35
Sex Estimation: F

Estimated Stature: 161.09 cm ± 4.3
Estimated Body Mass: N/A
Platymeric: N/A
Platycnemic: N/A

Pathological Lesions Observed

Cribra Orbitalia   Porotic Hyprostosis   (Enamel Hypoplasia)   (Dental Disease)
Metabolic Disease   Joint Disease   (Infection)   (Trauma)

1

Adult Skeletal Recording Form

Excavation Site: Parliament House   Observer: TUT.
Skeleton # 66   Date: Feb 26, 08

AGE ESTIMATION	Score	Age Estimation
Skull – Dental Eruption	M3 X	Adult
Skull – Dental Attrition (Brothwell)		25 - 35
Skull – Dental Attrition (Lovejoy)	F / F	30 - 35
Skull – Cranial Suture Closure	Frag	—
Pelvis – Pubic Symphysis	—	—
Pelvis – Auricular Surface	2	25 - 29
Pelvis – Sacrum Fusion	F	> 27
Other – Sternal Rib Ends		
Other – Medial Clavicle Fusion	F	> 30
TOTAL		30 - 35

5-10mm rim, spicules in notches.

SEX ESTIMATION	Score/Notes	F	?F	?	?M	M	N/A
Skull – Forehead	tall + narrow		X				
Skull – Bossing	Frontal + Parietal	X					
Skull – Supraorbital ridges	2		X				
Skull – Oribital Rims	2		X				
Skull – Post. zygomatic arch	At EAM			X			
Skull – Nuchal Crest	3			X			
Skull – Mastoid Process	1	X					
Mandible – Mental Eminence	2		X				
Mandible – Ramus Flexure	None	X					
Pelvis – Sciatic notch	1	X					
Pelvis – Subpubic angle	—						X
Pelvis – Subpubic concavity	—						X
Pelvis – Pubic bone width	—						X
Pelvis – Ischio-pubic ramus	—						X
Pelvis – Ventral Arc	—						X
Pelvis – Obturator foramen	—						X
Pelvis – Pelvic inlet/outlet	—						X
Pelvis – Acetabulum	—						X
Pelvis – Sacrum segments	—						X
Pelvis – Sacrum morphology	—						X
Metrics (See details below)		X					
TOTAL		X					

Metrics

Clavicle max length	128.50	F	Fem. head P-D diameter	
Glenoid cavity width	23.40	F	Fem. bicondylar width	
Max. hum length	288		Fem. Sub-Troch A-P diameter	
Hum. head diameter	38.55	F	Fem. Sub-Troch M-L diameter	
Max. Radius Length	—		Max. Tibia Length	
Radial head diameter	19.24	F	Tibia NutFor A-P diameter	
Max Ulna Length	242		Tibia NutForM-L diameter	
Max. Femur Length	—		Max. Fibula Length	
Fem. bicondylar length	—		Bi-iliac pelvic breadth	
Fem. head A-P breadth	—			

2

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Excavation Site: Parliament House

Observer: JW.

Skeleton # 66

Date: Feb 26, 08

Dental Inventory

Notes:

#4 - Small C.L. on mesial crown/rootline. Enamel only affected. 2.96 x 1.85mm.

#16, 17, 32 - M3 not present, but room in aveolar bone for them. Occlusal surface of aveolar bone is porous. Possible either M3s never present, or lost antemortem with root shafts resorbed.

#19, 30 - Root shafts resorbed antemortem.

#28 - Small CL on buccal root/crown line. <1mm². Enamel only affected.

#29 - CL on mesial crown. Crown/root/Enamel/dentine affected. 1/4 tooth destroyed. 4.22 x 5.12 x 1.66 deep.

#31 - 2 C.L: one on occlusal crown. Enamel + dentine affected. 2.54 x 1.34mm. one on distal crown. Enamel/dentine/root affected. 3.85 x 2.77mm. 1/4 total tooth affected.

Broken off + missing →

MAXILLARY

BUCCAL

Abscess

OCCLUSAL

LINGUAL

OCCLUSAL

ax NP

Right 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 Left

-32 31 30 29 28 27 26 25 24 23 22 21 20 19 18 -17

NPorX

X

NPorX

OCCLUSAL

LINGUAL

OCCLUSAL

BUCCAL

MANDIBULAR

Abscesses	Tooth	Internal/External Drain

#14-15 - External triangular drain from disto-buccal #14 root shaft to middle of #15 root shaft. Drain opening and internal aveolar bone present is both porous and smooth lamellar osteophytes. 14's distal-buccal and distal-lingual root ends visibly destroyed/resorbed/remodeled into curved, smooth surfaces which model walls of abscess. 12.74 x 8.83mm.

Other Dental Defects	Tooth	Description

- Root shafts quite exposed on both max. + mand. incisors + canines. Possible periodontal disease. Calculus present on roots all supragingival.

Key

NP — not present

/ — lost postmortem

B — broken postmortem

X — lost antemortem

R — root only

U — unerupted

E — erupting

PE — partially erupted

PU — pulp exposed - jaw not present

• — caries

○ — abscess

— — calculus

... — enamel defects

23 teeth
13 w/EH
20 w/calc
5 CL/4 teeth
1 Abscess
P.D.
29 roots/2 AMTL
3

Adult Skeletal Recording Form

Excavation Site: _Parliament House._ Observer: _JM_

Skeleton # _66_ Date: _Feb. 26, 08._

Pathological Lesions
See attached notes page for detailed descriptions

Non-Specific Infection

Cribra Orbitalia:	Signs Present	(Signs Absent)	Not available
Porotic Hyperostosis:	Signs Present	(Signs Absent)	Not available
+ Maxillary sinusitis:	(Signs Present)	Signs Absent	Not available
Rib Lesions:	Signs Present	(Signs Absent)	Not available
* Endocranial Surface:	(Signs Present)	Signs Absent	Not available

Degenerative Joint Disease
**See separate sheet for spinal joint disease if present in several vertebra

Joint   Location   Description

porosity, osteophyte, eburnation, shape/contour change, fusion, erosion, ossification

R. Shoulder - Marg. of an glenoid cav - rest of scapula + clavicle articular surfaces missing. No signs on humeral head.

L. Wrist - Distal Radius has spicules present on articular surface

Trauma
Fractures

Bone/Location   Type   Simple/Compound   Deformity   Complications

Right Clavicle - Partial diaphyseal fracture on posterior midshaft. Simple. Well-healed. Shaft straightened more than left side. Porosity on superior cortical surface just lateral to fracture line: 16.80 × 8.10mm. Epiphyses missing.

Dislocations

Joint/Location   Changes to joint surface   congenital or traumatic

Soft Tissue Injury

Location on bone   Description

Metabolic Disease

Signs of: Rickets   Scurvy   Anemia

+ - Both R+L sinuses have porosity on floors. Left sinus also has lamellar newbone deposition lateral wall. ½ of both sinuses present to observe.

* - Slight vertical striations present on right frontal endocranial surface. Cortical thickening also visible on PM break. HFI.

Photo Record

Photo Ref. No.	Description
66 - 1	Box Label
66 - 2	HFI
66 - 3	Max Sinusitis
66 - 4	R + L Clavicles.

4

400

Appendix D:

Demographic Tables

Table D-1: Summary of age-at-death estimations based on epiphyseal fusion states (Scheurer and Black, 2000b).

Observation Location	Unfused	Fusing	Fused
Metopic suture	< 2 yrs	2 – 4 yrs	> 4 yrs
Mental symphysis	Neonate	0 – 1 yr	> 1 yr
Lateral parts to basilar	< 5 yrs	5 – 7 yrs	> 7 yrs
Lateral parts to squamous	< 1 yr	1 – 3 yrs	> 3 yrs
Basilar suture	< 11 yrs	11 – 18 yrs	> 16 – 18 yrs
Cervical halves of arches	< 2 yrs	2 yrs	> 2 yrs
Cervical arches to vertebral bodies	< 3 yrs	3 – 4 yrs	> 4 yrs
Cervical body superior rims	< 17 yrs	17 – 19 yrs	> 25 yrs
Cervical body inferior rims	< 17 yrs	17 – 19 yrs	> 25 yrs
Thoracic halves of arches	< 1 yr	1 -2 yrs	> 2 yrs
Thoracic arches to vertebral bodies	< 3 yrs	3 – 6 yrs	> 6 yrs
Thoracic body superior rims	< 14 yrs	14 – 25 yrs	> 25 yrs
Thoracic body inferior rims	< 14 yrs	14 – 25 yrs	> 25 yrs
Lumbar halves of arches	< 1 yr	1 yr (L1 – 4); 1 – 5 yrs (L5)	> 1 yr.
Lumbar arches to vertebral bodies	< 2 yrs	2 -4 yrs	> 4 yrs
Lumbar body superior rims	< 14 yrs	14 – 25 yrs	> 25 yrs
Lumbar body inferior rims	< 14 yrs	14 – 25 yrs	> 25 yrs
Sacral segments to ala	< 2 yrs	2 – 6 yrs	> 6 yrs
Sacral segments 1 to 2	< 27 yrs	20 – 27 yrs	> 25 yrs
Sacral segments 3 to 5	< 20 yrs	20 – 25 yrs	> 25 yrs
Scapula coracoid process	< 16 yrs	16 – 20 yrs	> 20 yrs
Scapula glen.cavity	< 14 yrs	14 – 20 yrs	> 20 yrs
Scapula acromion	< 18 yrs	18 – 20 yrs	> 20 yrs
Scapula inf. angle	< 19 yrs	19 – 23 yrs	> 23 yrs
Scapula med. border	< 19 yrs	19 – 23 yrs	> 23 yrs
Prox humerus	< 13 yrs	13 – 17 yrs (female); 16 – 20 yrs (male)	> 17 yrs (female) > 20 yrs (male)
Distal humerus	< 11 yrs	11 – 17 yrs	> 17 yrs (female) > 20 (male)
Humerus epicondyle	< 13 yrs	13 – 16 yrs	> 16 yrs
Prox radius	< 11 yrs	11 – 17 yrs	> 17 yrs
Distal radius	< 14 yrs	14 – 17 yrs (female); 16 – 20 yrs (male)	> 17 yrs (female); > 20 yrs (male)
Prox ulna	< 12 yrs	12 – 16 yrs	> 16 yrs
Distal ulna	< 15 yrs (female); < 17 yrs (male)	15 – 17 yrs (female); 17 – 20 yrs (male)	> 17 yrs (female); > 20 yrs (male)
Ilium to pubis	< 11 yrs	11 – 17 yrs	> 18 yrs
Ischium to pubis	< 3yrs	5 – 8 yrs	> 8 yrs
Ischium to ilium	< 11 yrs	11 – 17 yrs	> 18 yrs
Ischial tubercle	< 13 – 16 yrs	16 – 23 yrs	> 23 yrs
Iliac crest	< 15 yrs	15 – 22 yrs	> 23 yrs
Prox femur	< 12 yrs	12 – 19 yrs	> 19 yrs
Greater trochanter	< 14	14 – 18 yrs	> 18 yrs
Lesser trochanter	< 16 yrs	16 – 17 yrs	> 17 yrs
Distal femur	< 14 yrs	14 – 20 yrs	> 20 yrs
Prox tibia	< 13 yrs	13 – 19 yrs	> 19 yrs
Distal tibia	< 14 yrs	14 – 18 yrs	> 18 yrs
Prox fibula	< 12 yrs	12 – 17 yrs (females); 15 – 20 yrs (males)	> 17 yrs (females); > 20 yrs (males)
Distal fibula	< 12 yrs	12 – 15 yrs (females); 15 – 18 yrs (males)	> 15 yrs (females); > 18 yrs (males)

Metric Aging Estimates for Non-Adults (Schurer and Black, 2000b)

Scapula

Table 8.3 Fetal scapular dimensions (cm)

Age (weeks)	Scapular length	Scapular width	Length of spine
12	0.45	0.30	0.35
14	0.71	0.51	0.58
16	1.16	0.90	1.02
18	1.50	1.15	1.24
20	1.72	1.39	1.54
22	1.88	1.54	1.70
24	2.09	1.75	1.84
26	2.23	1.85	1.95
28	2.31	1.94	2.12
30	2.45	2.06	2.22
32	2.66	2.23	2.38
34	2.81	2.33	2.53
36	2.93	2.44	2.60
38	3.31	2.68	2.91
40	3.55	2.95	3.16

Scapular length: maximum distance between superior (upper medial) and inferior angles.
Scapular width: distance between the margin of the glenoid fossa and the medial end of the spine.
Length of spine: maximum distance between the medial end of the spine and the tip of the acromion process.
Adapted from Fazekas and Kósa (1978).

Table 8.6 Juvenile scapular dimensions (cm)

Age	n	Scapular length	n	Scapular width
Birth–6 months	1	3.93	7	3.11
6 months–1 year	15	4.92	16	3.70
1–2 years	19	6.04	19	4.33
2–3 years	10	6.78	8	5.98
3–4 years	5	6.39	5	5.60
4–5 years	3	8.10	3	5.68
5–6 years	3	9.17	3	6.18
6–7 years	6	9.73	7	6.61
7–8 years	1	9.40	2	6.33
8–9 years	1	11.70	1	8.25
9–10 years	2	12.00	2	7.73
10–11 years	1	12.10	2	8.73
11–12 years	1	12.10	1	8.20

Scapular length: distance between superior (upper medial) and inferior angles.
Scapular width: distance between margin of glenoid fossa and medial end of spine.
Adapted from Saunders et al. (1993a).

Clavicle:

Table 8.1 Fetal clavicular measurements

Age in weeks	Maximum clavicular length (mm)	
	Fazekas and Kósa*	Yarkoni et al.†
12	8.2	–
14	11.1	–
16	16.3	17.0
18	19.4	19.0
20	22.7	21.0
22	24.5	23.0
24	26.9	25.0
26	28.3	27.0
28	30.3	29.0
30	31.3	31.0
32	35.6	33.0
34	37.1	35.0
36	37.7	37.0
38	42.6	39.0
40	44.1	41.0

*Data derived from Fazekas and Kósa (1978) – dry bone.
†Data derived from Yarkoni et al. (1985) – ultrasound.

Table 8.2 Clavicular measurements from documented juveniles

Documented age	n	Maximum clavicular length (mm)	
		Mean	Range
Birth–6 months	11	44.4	38.8–54.5
7 months–1 year	9	54.1	48.0–60.9
1 year–1.5 years	11	59.5	54.3–66.0
1.5 years–2 years	4	63.0	61.4–64.6
2–3 years	13	66.5	58.5–72.6
3–4 years	7	73.4	69.1–77.0
4–5 years	8	74.4	65.3–82.0
5–6 years	2	75.9	74.7–77.0
6–7 years	4	86.5	85.4–88.8
7–8 years	1	89.5	–
8–9 years	3	89.0	78.5–98.7
9–10 years	0	–	–
10–11 years	2	103.7	103.0–104.0
11–12 years	2	105.0	104.5–105.0
12–13 years	3	106.4	102.5–111.3
13–14 years	2	118.6	117.0–120.1
14–15 years	2	118.5	113.5–123.5
15–16 years	3	137.7	127.0–154.0

Adapted from Black and Scheuer (1996b).

Metric Aging Estimates for Non-Adults (Schurer and Black, 2000b)

Humerus:

Table 9.2 Length and width of the fetal humeral diaphysis

Age (weeks)	Length (mm)	Distal width (mm)
12	8.8	1.9
14	12.4	2.2
16	19.5	4.7
18	25.8	6.1
20	31.8	7.8
22	34.5	8.3
24	37.6	9.3
26	39.9	9.9
28	44.2	10.9
30	45.8	11.9
32	50.4	12.5
34	53.1	13.6
36	55.5	14.4
38	61.3	15.7
40	64.9	16.8

Length: maximum length.
Width: maximum mediolateral width at distal end.
Adapted from Fazekas and Kósa (1978).

Table 9.6 Humeral length (mm) – 2 months–18 years

	Male			Female		
Age (years)	n	Mean	SD	n	Mean	SD
Diaphyseal length						
0.125	59	72.4	4.5	69	71.8	3.6
0.25	59	80.6	4.8	65	80.2	3.8
0.50	67	88.4	5.0	78	86.8	4.6
1.00	72	105.5	5.2	81	103.6	4.8
1.5	68	118.8	5.4	84	117.0	5.1
2.0	68	130.0	5.5	84	127.7	5.8
2.5	72	139.0	5.9	82	136.9	6.1
3.0	71	147.5	6.7	79	145.3	6.7
3.5	73	155.0	7.8	78	153.4	7.1
4.0	72	162.7	6.9	80	160.9	7.7
4.5	71	169.8	7.4	78	169.1	8.3
5.0	77	177.4	8.2	80	176.3	8.7
5.5	73	184.6	8.1	74	182.6	9.0
6.0	71	190.9	7.6	75	190.0	9.6
6.5	72	197.3	8.1	81	196.7	9.7
7.0	71	203.6	8.7	86	202.6	10.0
7.5	76	210.4	8.9	83	209.3	10.5
8.0	70	217.3	9.8	85	216.3	10.4
8.5	72	222.5	9.2	82	221.3	11.2
9.0	76	228.7	9.6	83	228.0	11.8
9.5	78	235.1	10.7	83	234.2	12.9
10.0	77	241.0	10.3	84	239.8	13.2
10.5	76	245.8	11.0	75	245.9	14.6
11.0	75	251.7	10.7	76	251.9	14.7
11.5	76	257.4	11.9	75	259.1	15.3
12.0	73	263.0	12.8	71	265.6	15.6
Total length including epiphyses						
10.0	76	258.3	11.2	83	256.1	14.6
10.5	76	263.7	11.6	75	262.9	16.1
11.0	75	270.0	11.5	76	269.6	16.4
11.5	77	276.3	12.7	75	278.5	17.3
12.0	76	282.0	13.8	75	287.5	18.2
12.5	67	289.2	13.1	65	294.0	17.7
13.0	69	296.6	15.3	69	301.0	17.5
13.5	69	305.0	16.6	62	305.7	17.4
14.0	69	313.3	16.8	64	311.7	16.1
14.5	64	321.4	17.6	42	314.9	17.1
15.0	60	329.0	16.7	57	315.6	17.0
15.5	52	336.5	16.5	12	323.2	19.6
16.0	60	341.0	14.5	40	316.5	18.5
16.5	38	343.4	15.3	3	–	–
17.0	50	347.1	14.6	18	315.4	17.3
18.0	28	350.6	15.6	4	–	–

Adapted from Maresh (1970).

Radius:

Table 9.7 Length of the fetal radial diaphysis

Age (weeks)	Length (mm)
12	6.7
14	10.1
16	17.2
18	21.5
20	26.2
22	28.9
24	31.6
26	33.4
28	35.6
30	38.1
32	40.8
34	43.3
36	45.7
38	48.8
40	51.8

Table 9.13 Radial length (mm) – 2 months–18 years

	Male			Female		
Age (years)	n	Mean	SD	n	Mean	SD
Diaphyseal length						
0.125	59	59.7	3.3	69	57.8	2.8
0.25	59	66.0	3.3	65	63.4	2.8
0.50	67	70.8	3.5	78	67.6	3.4
1.00	72	82.6	4.0	81	78.9	3.4
1.5	68	91.4	4.4	83	87.5	4.0
2.0	68	98.6	4.7	84	95.0	4.5
2.5	71	105.2	4.8	82	101.4	5.0
3.0	71	111.6	5.3	79	107.7	5.2
3.5	73	116.9	6.2	78	113.8	5.5
4.0	72	123.1	5.6	80	119.2	5.7
4.5	71	128.2	5.6	78	125.2	6.6
5.0	77	133.8	6.1	80	130.2	6.9
5.5	73	138.9	6.4	74	134.6	7.2
6.0	71	143.8	5.9	75	140.0	7.4
6.5	72	148.3	6.4	81	144.7	7.8
7.0	71	153.0	6.7	86	149.3	8.0
7.5	76	157.9	6.9	83	154.3	8.4
8.0	70	162.9	7.1	85	158.9	8.7
8.5	72	166.8	6.6	82	162.8	8.8
9.0	76	171.3	7.4	83	167.6	9.3
9.5	78	176.1	7.7	83	172.2	10.2
10.0	77	180.5	7.9	84	176.8	10.4
10.5	76	184.4	8.4	75	181.8	11.8
11.0	75	188.7	8.5	76	186.0	11.7
11.5	76	193.0	9.2	75	192.0	12.1
12.0	74	197.4	9.6	71	196.9	12.7
Total length including epiphyses						
10.0	76	193.0	8.1	83	189.3	11.4
10.5	76	197.7	8.9	75	195.0	13.0
11.0	75	202.6	8.9	76	200.0	13.0
11.5	77	207.3	9.7	75	206.7	13.5
12.0	77	212.3	10.3	75	213.5	14.2
12.5	71	218.0	10.2	67	218.8	14.2
13.0	73	223.7	11.8	70	223.6	13.1
13.5	73	230.2	12.9	63	227.8	12.7
14.0	75	236.9	13.5	64	231.4	11.8
14.5	69	242.8	14.1	42	233.5	11.7
15.0	61	248.7	13.4	57	234.5	11.7
15.5	52	255.0	12.8	12	237.4	15.2
16.0	61	257.7	11.7	40	235.0	11.8
16.5	38	259.8	11.3	3	–	–
17.0	50	261.8	11.2	18	233.8	11.8
18.0	28	263.2	12.8	4	–	–

Adapted from Maresh (1970).

Metric Aging Estimates for Non-Adults (Schurer and Black, 2000b)

Ulna:

Table 9.14 Length of the fetal ulnar diaphysis

Age (weeks)	Length (mm)
12	7.2
14	11.2
16	19.0
18	23.9
20	29.4
22	31.6
24	35.1
26	37.1
28	40.2
30	42.8
32	46.7
34	49.1
36	51.0
38	55.9
40	59.3

Length: maximum length.
  Adapted from Fazekas and Kósa (1978).

Table 9.18 Ulnar length (mm) – 2 months–18 years

		Male			Female	
Age (years)	n	Mean	SD	n	Mean	SD
Diaphyseal length						
0.125	59	67.0	3.5	69	65.3	3.1
0.25	59	73.8	3.4	65	71.2	3.1
0.50	67	79.1	3.7	78	75.7	3.8
1.00	71	92.6	4.4	81	89.0	4.0
1.5	68	102.3	4.6	83	98.9	4.4
2.0	68	109.7	4.9	84	107.1	4.8
2.5	71	116.6	5.2	82	113.8	5.2
3.0	71	123.4	5.6	79	120.6	5.4
3.5	73	129.1	6.4	78	127.2	5.7
4.0	72	135.6	5.6	80	133.1	5.8
4.5	71	141.0	5.6	78	139.3	6.6
5.0	77	147.0	6.1	80	144.6	7.1
5.5	73	152.6	6.7	74	149.1	7.2
6.0	71	157.5	6.2	75	154.9	7.4
6.5	72	162.2	6.8	81	159.9	7.9
7.0	71	167.3	7.0	86	164.8	8.3
7.5	76	172.2	7.4	83	170.1	8.5
8.0	70	177.3	7.4	85	174.9	8.7
8.5	72	181.6	7.1	82	179.1	8.8
9.0	76	186.4	7.9	83	184.3	9.5
9.5	78	191.7	8.3	83	189.7	10.4
10.0	77	196.2	8.5	84	194.4	10.6
10.5	76	200.4	8.8	75	200.0	12.4
11.0	75	205.1	9.2	76	204.7	12.0
11.5	76	209.8	9.9	75	211.3	13.1
12.0	74	214.5	10.2	70	216.4	13.3
Total length including epiphyses						
10.0	76	202.2	9.0	83	203.8	12.3
10.5	76	208.0	9.7	75	210.2	13.8
11.0	75	213.3	10.2	76	215.5	13.3
11.5	77	219.5	11.3	75	222.6	13.8
12.0	77	224.9	11.7	75	229.7	14.7
12.5	71	231.5	11.8	67	235.4	14.4
13.0	73	237.9	13.2	70	240.0	13.3
13.5	73	245.1	13.9	63	244.4	13.1
14.0	75	252.3	14.6	65	248.1	12.1
14.5	69	259.0	14.7	42	250.2	11.8
15.0	61	265.1	14.0	57	251.0	12.2
15.5	52	271.9	13.1	12	255.0	15.1
16.0	61	274.8	12.2	40	252.3	12.0
16.5	38	277.3	12.1	3	–	–
17.0	50	279.4	11.7	17	250.2	12.3
18.0	28	281.6	13.5	4	–	–

Adapted from Maresh (1970).

Femur:

Table 11.2 Length and width of the fetal femoral diaphysis

Age (weeks)	Length (mm)	Distal width (mm)
12	8.5	1.9
14	12.4	2.2
16	20.7	4.7
18	26.4	6.2
20	32.6	8.0
22	35.7	8.8
24	40.3	9.8
26	41.9	10.6
28	47.1	11.7
30	48.7	12.3
32	55.5	14.3
34	59.8	15.3
36	62.5	16.4
38	69.0	18.7
40	74.4	19.9

Length: maximum length.
Width: maximum mediolateral width at distal end.
  Adapted from Fazekas and Kósa (1978).

Table 11.6 Femoral length (mm) – 2 months–18 years

		Male			Female	
Age (years)	n	Mean	SD	n	Mean	SD
Diaphyseal length						
0.125	59	86.0	5.4	68	87.2	4.3
0.25	59	100.7	4.8	65	100.8	3.6
0.50	67	112.2	5.0	78	111.1	4.6
1.00	72	136.6	5.8	81	134.6	4.9
1.5	68	155.4	6.8	84	153.9	6.4
2.0	68	172.4	7.3	84	170.8	7.1
2.5	72	187.2	7.8	82	185.2	7.7
3.0	71	200.3	8.5	79	198.4	8.7
3.5	73	212.1	11.4	78	211.1	10.0
4.0	72	224.1	9.9	80	223.2	10.1
4.5	71	235.7	10.5	78	235.5	11.4
5.0	77	247.5	11.1	80	247.0	11.5
5.5	73	258.2	11.7	74	257.0	12.2
6.0	71	269.7	12.0	75	268.9	13.5
6.5	72	280.3	12.6	81	279.0	13.8
7.0	71	291.1	13.3	86	288.8	13.6
7.5	76	301.2	13.5	83	299.8	15.2
8.0	70	312.1	14.6	85	309.8	15.6
8.5	72	321.0	14.6	82	318.9	15.8
9.0	76	330.4	14.6	83	328.7	16.8
9.5	78	340.0	15.8	83	338.8	18.6
10.0	77	349.3	15.7	84	347.9	19.1
10.5	76	357.4	16.2	75	356.5	21.4
11.0	75	367.0	16.5	76	367.0	22.4
11.5	76	375.8	18.1	75	378.0	23.4
12.0	74	386.1	19.0	71	387.6	22.9
Total length including epiphyses						
10.0	76	385.1	17.0	83	382.8	21.1
10.5	76	394.2	17.9	75	392.6	23.7
11.0	75	405.2	17.9	76	403.5	24.8
11.5	77	414.8	19.4	75	415.4	25.2
12.0	77	425.6	20.6	74	427.9	25.2
12.5	71	437.1	19.6	67	437.9	23.9
13.0	73	447.4	21.5	69	447.2	24.1
13.5	73	458.4	24.0	63	453.1	22.0
14.0	75	470.8	24.1	64	459.9	22.5
14.5	69	478.9	25.2	41	464.5	20.8
15.0	61	489.0	23.5	57	464.4	21.4
15.5	52	498.5	23.4	12	471.5	26.0
16.0	60	502.8	22.8	40	466.7	24.0
16.5	38	504.5	24.9	3	–	–
17.0	50	508.9	23.2	18	462.9	26.2
18.0	28	511.7	24.4	4	–	–

Adapted from Maresh (1970).

Metric Aging Estimates for Non-Adults (Schurer and Black, 2000b)

Tibia: Fibula:

Table 11.8 Length of the fetal tibial diaphysis

Age (weeks)	Length (mm)
12	6.0
14	10.2
16	17.4
18	23.4
20	28.5
22	32.6
24	35.8
26	38.0
28	42.0
30	43.9
32	48.6
34	52.7
36	54.7
38	60.1
40	65.2

Length: maximum length.
Adapted from Fazekas and Kósa (1978).

Table 11.15 Length of the fetal fibular diaphysis

Age (weeks)	Length (mm)
12	6.0
14	9.9
16	16.7
18	22.6
20	27.8
22	31.1
24	34.3
26	36.5
28	40.0
30	42.8
32	46.8
34	50.5
36	51.6
38	57.6
40	62.0

Adapted from Fazekas and Kósa (1978).

Table 11.13 Tibial length (mm) – 2 months–18 years

	Male			Female		
Age (years)	n	Mean	SD	n	Mean	SD
Diaphyseal length						
0.125	59	70.8	5.4	69	70.3	4.6
0.25	58	81.9	5.3	65	80.8	4.6
0.50	67	91.0	5.2	78	88.9	5.3
1.00	72	110.3	5.2	81	108.5	4.8
1.5	68	126.1	6.0	84	124.0	5.6
2.0	68	140.1	6.5	84	138.2	6.5
2.5	72	152.5	6.8	82	150.1	7.0
3.0	72	163.5	7.7	79	161.1	8.2
3.5	73	172.8	9.8	78	171.2	8.7
4.0	72	182.8	9.0	80	180.8	9.5
4.5	71	191.8	9.2	78	190.9	10.5
5.0	77	201.4	9.9	80	199.9	11.4
5.5	73	210.3	10.7	74	207.9	12.5
6.0	71	218.9	10.0	75	217.4	12.6
6.5	72	227.8	11.6	81	226.3	13.6
7.0	71	236.2	11.8	86	234.1	14.1
7.5	76	244.2	12.4	83	243.2	15.0
8.0	70	253.3	12.9	85	251.7	15.6
8.5	72	260.6	12.3	82	259.1	15.6
9.0	76	268.7	13.4	83	265.5	17.1
9.5	78	276.9	14.4	83	276.6	18.7
10.0	77	284.9	14.2	84	284.3	19.3
10.5	76	292.0	15.1	75	292.4	21.4
11.0	75	298.8	15.0	76	300.8	21.2
11.5	76	306.8	16.5	75	310.5	21.4
12.0	73	315.9	17.0	71	318.2	21.7
Total length including epiphyses						
10.0	76	320.0	15.7	83	321.1	21.7
10.5	76	328.9	17.0	75	330.9	23.7
11.0	75	338.6	17.1	76	340.1	23.1
11.5	77	347.4	18.5	75	350.4	23.2
12.0	76	357.3	19.1	75	360.9	23.8
12.5	67	367.5	18.6	65	367.3	23.0
13.0	69	376.7	20.6	69	374.5	22.2
13.5	69	388.2	22.0	62	379.0	21.8
14.0	69	397.4	21.9	64	384.3	21.4
14.5	64	406.0	23.1	42	386.9	20.5
15.0	60	412.2	21.5	57	385.7	20.8
15.5	52	420.5	22.3	12	390.5	28.5
16.0	60	422.6	21.8	40	386.8	22.6
16.5	38	425.1	24.2	3	–	–
17.0	50	426.5	23.2	18	380.7	23.6
18.0	28	429.5	25.6	4	–	–

Adapted from Maresh (1970).

Table 11.17 Fibular length (mm) – 2 months–18 years

	Male			Female		
Age (years)	n	Mean	SD	n	Mean	SD
Diaphyseal length						
0.125	59	68.1	5.3	69	66.8	4.4
0.25	58	78.6	4.9	65	77.1	4.1
0.50	67	87.2	4.8	78	84.9	5.2
1.00	72	107.1	5.5	81	105.0	5.1
1.5	68	123.9	6.2	84	121.3	5.9
2.0	68	138.1	6.7	84	136.0	6.8
2.5	72	150.7	7.1	82	147.9	7.1
3.0	72	162.1	7.7	79	159.4	7.9
3.5	73	171.6	9.6	78	169.6	8.3
4.0	72	181.8	8.7	80	179.5	9.1
4.5	71	190.8	8.8	78	189.4	10.2
5.0	77	200.4	9.6	80	198.6	11.1
5.5	73	209.0	10.2	74	206.5	11.7
6.0	71	217.5	9.6	75	216.0	12.2
6.5	72	226.0	10.5	81	224.3	13.4
7.0	71	234.2	11.3	86	232.1	13.4
7.5	76	242.1	11.8	83	240.8	14.5
8.0	70	251.0	12.4	85	248.8	14.8
8.5	72	257.7	11.8	82	256.1	15.2
9.0	76	265.6	13.0	83	263.7	16.3
9.5	78	273.8	13.8	83	272.2	17.6
10.0	77	281.3	13.9	84	279.4	18.3
10.5	76	287.8	14.6	75	287.2	20.4
11.0	75	294.9	14.6	76	294.4	19.8
11.5	76	301.7	16.0	75	303.8	20.7
12.0	73	310.1	16.4	71	311.1	20.8
Total length including epiphyses						
10.0	76	310.4	15.2	83	307.9	19.5
10.5	76	318.0	16.2	75	316.7	21.8
11.0	75	326.2	15.9	76	324.7	21.5
11.5	77	334.0	17.6	74	334.6	22.1
12.0	76	342.8	18.0	75	344.6	22.7
12.5	67	351.9	16.8	65	351.0	22.2
13.0	69	360.2	19.8	69	358.5	21.9
13.5	69	371.1	21.4	62	363.4	21.4
14.0	69	380.3	21.3	64	367.9	20.6
14.5	64	388.5	22.5	42	368.9	21.5
15.0	60	395.3	21.5	57	370.2	20.0
15.5	52	404.4	22.1	12	375.7	25.8
16.0	60	406.3	21.7	40	372.4	21.5
16.5	38	408.6	22.8	3	–	–
17.0	50	410.4	22.6	18	366.8	24.2
18.0	28	412.8	24.2	4	–	–

Adapted from Maresh (1970).

Metric Aging Estimates for Non-Adults (Schurer and Black, 2000b)

Ilium:

Table 10.1 Dimensions of fetal ilium, ischium and pubis (in mm)

Age	Ilium		Ischium		Pubis
(weeks)	Length	Width	Length	Width	Length
12	4.8	3.2			
14	5.7	3.8			
16	9.7	7.8	3.1	2.2	
18	12.0	9.8	3.8	2.9	
20	15.6	12.6	5.5	3.5	3.6
22	16.5	14.2	6.4	4.3	4.5
24	18.3	15.6	7.5	5.6	5.5
26	19.6	17.1	8.7	6.0	6.0
28	21.3	19.1	9.7	6.6	6.6
30	22.1	20.1	10.3	7.6	8.0
32	25.1	22.2	12.1	8.1	9.9
34	26.8	24.6	13.2	9.3	12.4
36	28.7	26.0	16.2	10.4	14.1
38	32.1	28.5	17.2	11.6	15.0
40	34.5	30.4	18.5	12.4	16.6

Ilium length: max distance between the anterior to the posterior superior iliac spines.
Ilium width: max distance between the middle point of the iliac crest and the convexity of the acetabular extremity.
Ischium length: max distance between the convexity of the acetabular extremity and the tip of the ischial ramus.
Ischium width: max distance across the broad superior extremity.
Pubis length: max distance between the symphysis and the iliac articulation.
   Adapted from Fazekas and Kósa (1978).

Appendix E

Project Database

This database is available via the CD attached to the printed thesis. Please contact the author for additional copies.