Alternative objectives in allocating care to the elderly people in Durham County

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ALTERNATIVE OBJECTIVES IN ALLOCATING CARE TO THE ELDERLY PEOPLE IN DURHAM COUNTY

BY

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ABSTRACT

This thesis consists of three chapters. Chapter one reviews the general provision of care for the elderly with an account of national and regional planning policy. Section one of this chapter is concerned with national planning policy and section two relates to the norms of care and geographical background of Durham County.

Chapter two is a review of some previous studies in which mathematical programming was used to assist health care planning for the community in general and care for elderly people in particular. Several different models produced by other researchers are described.

Chapter three develops a model, on similar lines to some of those previously discussed, and applies this to conditions in Durham County using relevant local data. Alternative formulations are found to be necessary in order to obtain feasible solutions and these are worked out and their results compared.

C O N T E N T S

CHAPTER 1

SECTION ONE

1.1 INTRODUCTION

This chapter consists of two sections. Section one reviews the general provision of care for the elderly with some account of national planning policies[25]. Section two is devoted to the social and geographical background of care for the elderly people in Durham County[24].

1.2 THE SERVICES AS A WHOLE

The target of health and personal social services is the health care and social support of the community as fully as possible. The people's expectation for care will grow as knowledge advances and skills improve and the services are able to do more. Standards of need tend to be relative and what is reasonable at any given time depends on what the country can afford and its willingness to pay for as well as on professional assessments of need. As a result, there always exists a gap between the provided services and the demand made upon them. So it will be difficult to decide how far a particular demand should be met and how much service should be provided. The choices are particularly hard when there can only be a slow rate of growth in resources.

In the last few years there has been particular concern about standards of care for the elderly and physically handicapped. Pressure for improvements and expansion of services come from the public and the Department of Health and Personal Social Services itself.

The expansion of resources in this period has been particularly large in the community care services which aim to help people (especially elderly) to live an independent life in their own homes as long as possible.

Residential homes and hospitals would then admit only those who are temporarily or permanently unable to manage at home or who need services which it would be too expensive to provide to them at home.

1.3 SERVICES USED BY THE ELDERLY

Old people are the major users of most of the services provided by the Department of Health and Personal Social Services. The primary care and acute hospital services are very important to them. Those services which are mainly or entirely used by the elderly will have to meet a particularly sharp increase in demand. Social and environmental changes such as smaller housing units and increased job mobility have tended to reduce the ability of younger people to care for elderly in a family environment.

Many of the services used by the elderly are used also by physically handicapped people in other age groups. So the availability of resources like home nursing and residential accommodation would not be fully used by elderly people, although they are meant to meet the elderly's needs. The services like aids and adaptations are particularly produced for physically handicapped people from different age groups but that does not mean that the elderly who are in need of these sort of services cannot use them.

The elderly patient group can be divided into different categories according to their illness and state of health. This categorization differs from area to area and varies from 6 to 36 categories. But in general they can be, like any other group of patient, divided into two sub-groups (i) those who are living in the community with different modes of services provided to them by family doctors and social workers (ii) those who cannot manage to live in the community any further and have to be placed in either special places or in the hospitals. One may argue that as soon as an elderly patient is admitted to a hospital he or she

must be treated under the categories of his or her relevant sickness,for example if he is admitted for surgical treatment he should be treated as one of the members of surgical category patient. But in most of the cases the elderly who are admitted in the hospitals must be met with a special sort of treatment, i.e. geriatric hospitals and beds.

1.4 SERVICES FOR THE ELDERLY LIVING AT HOME

About 95% of all elderly people are living in the community and family doctors meet most of their services of which the elderly are major users and which are

(i) Home helps

(ii) Meals

(iii) Home Nursing and health visiting

(iv) Day Centres

(v) Chiropody

1.5 SERVICES FOR THE ELDERLY NOT LIVING AT HOME

The needs of the remaining 5% of the elderly people who cannot be served in the community are mainly met with the following services and facilities

(i) Residential facilities

(ii) Hospital facilities

(iii) Special Hospitals for the elderly with mental illness.

1.6 PRIMARY CARE

The services mentioned above like Home help, Home nursing, Health visiting and Chiropody, are an integral part of primary care services for the elderly patient groups. All these services have an important role in preventing illness, maintaining health, and keeping elderly people out of hospitals.

1.7 IMMEDIATE AIMS

The number of population aged 65 and over is growing. This naturally will place an increasing strain on most of the health and personal social services.

The main emphasis is thus on the development of the domiciliary services and on the promotion of a more active approach towards the treatment of the elderly in hospital. But those who cannot continue to live independently in the community, even with the support of all available health and social services, will need long term residential or hospital care. This need is noticeably high for the elderly client aged 75 and over.

The objectives suggested by the government for the near future were [25] :-

- to encourage the development of primary health care teams in order to,
  - (a) improve the preventive and curative services in the community,
  - (b) allow for the increased work load which will result from the greater number of old people,
  - (c) to remedy persistent shortages of personnel in localities where they occur, by encouraging a better distribution of manpower,
- to prevent pharmaceutical costs from rising unduly, and secure better value from expenditure on drugs,
- to give priority to preventive measures services.

The above objectives will not be met fully unless restrictions on the available resources can be removed ; realistically achievement of the objectives will have to be phased according to the degree of priorities assigned to each of them.

In order to develop the emphasis on the community care there must be a growth on the services for the elderly although there exist some constraints on the Health and Personal Social Services as a whole. For this purpose an overall growth by about 3% a year has been suggested by the Department of Health and Personal Social Services on the current expenditure between 1976 and 1980. This would increase the expenditure to £620 m in 1980 from £550 m in 1976 (25).

A high percentage yearly increase has been permitted in the primary care service's expenditure which is the indication of its degree of priorities and it might be because of presence of elderly people who are the main users of these services[25].

If we assume, as we have mentioned, that the main objective and aim of the government is to increase the amount of health care in society in general and for elderly in particular, then the government's planning policy has to be designed in such a way that the demographic changes, especially the steadily rising numbers of elderly people, will be taken into account.

1.8 PLANNING POLICY AND FUTURE PROJECTION

For the first time the Department of Health and Social Services attempted to establish rational and systematic priorities throughout the health and social services. The main purpose was to plan in the balance of health care in the community in the context of economic limitations and scarcity of resources. The next purpose was to find the best way to allocate adequate care to the patients, especially the elderly, and also physically handicapped in other age groups.

Good management can save money. There must be a pressure and responsibility on management in all parts of the services in the Department of Health and Personal Social Services to ensure that it carries out its own activities efficiently and economically. For example, it has been

recognized that the acute hospital services face serious problems like waiting lists, the need to introduce new methods of treatment and the growing number of elderly clients. Now the challenge here is how to make the pattern of existing provision of care more efficient and how to make the best use of available resources with the current demands.

1.9 GENERAL PRIORITIES AND ECONOMIC BACKGROUND

The government's present policy is to constraint the public expenditure in the national economic interest.

Personal Social Services capital expenditure is projected to level out at £44 m which would be supplemented by joint finance capital. This should enable some development in services for the elderly and younger physically handicapped (25).

The average rate of increase for the services used mainly by the elderly including hospital geriatric provision, home nursing, residential homes, day care, home helps and meals is 3.2 percent a year over the 1976 to 1980. It is also suggested that unless the targets for meeting the needs for elderly are met, there must be a deliberate decision to give priority over the development of general and acute hospital services. Phasing out the pay-beds from NHS hospitals will increase the number of acute beds available to NHS patients and the scope for using acute beds for the elderly will be increased. The growth in acute services will pose serious problems that can only happen due to lack of community services.

The planners and the responsible authorities are trying to find the best way for the development of the services to the level of national guidelines and trying to find a way to implement them over the next few years in order to meet the urgent needs. The needs may arise from the increasing number of elderly people, or from the introduction of new policies, due to past negligence or to the pressures for new and improved techniques for the provision of health care and treatment.

The services used by the elderly clients have been listed in the beginning of this chapter. An acceptable standard of care to the elderly people has been defined according to governmental guidelines. However, as will be shown later, the available resources in the national scale are below the guidelines and in some cases are very far from the target.

1.10 THE GOVERNMENT'S GUIDELINES ON SERVICES FOR THE ELDERLY[25]

(a) Home Helps : In 1974 there were about 41,000 full-time equivalent home helps, i.e. 6 per 1000 elderly. The guideline is for a ratio of 12 per 1000 elderly people.

(b) Meals : About 600,000 meals were served each week through the meals-on-wheels services and day centres and clubs. The guideline is for 200 per week per 1,000 elderly - about 1,300,000 overall per week.

(c) Home Nursing : Over half the time of home nurses is thought to be spent on the elderly. In 1974 there were about 11,000 home nurses in all, somewhat less than 1 per 4000 total population. The guideline is for 1 per 2,500 - 4,000 according to local needs.

(d) Day Centres : In 1974 there were about 23,000 day centre places available to the elderly and younger physically handicapped. About half of these are used by elderly people giving about 2 places per 1,000 elderly. The guideline is 3-4 places per 1,000.

(e) Chiropody : Chiropody Services do a great deal to prevent immobility, and elderly people are the clients who nearly receive all of this service. In 1974 there were about 14,000 full-time equivalent chiropodists, something like 1 per 5,000 elderly. The guideline is 0.25 per 1,000. Social workers and voluntary

effort also play an important role in meeting the needs of the elderly. Another element on old people's ability to continue to manage in the community is their housing conditions, which have an effect on the quality of their lives.

(f) Residential Facilities : In 1974 there were about 125,000 local authority places available for elderly people and for the younger physically handicapped, i.e. about 18.5 places per 1,000 elderly. The national guideline is 25 places per 1,000 elderly.

(g) Hospital Facilities : Elderly people of 65 and over are occupying over 50% of all hospital beds. Although the hospital beds, like surgical beds, are not set specially aside for them, they are occupied proportionally more by elderly patients. For medical conditions old people are admitted to general medical beds, or to beds designated for geriatric medicine. In 1974 there were 8.57 beds per 1,000 elderly specifically designated as "geratric". The guideline is 10 per 1,000 elderly. It has been estimated that over 80% of patients admitted to geriatric beds remain there for less than three months. Most geriatric departments now include day hospitals and out-patients clinics as well as in-patient facilities.

(h) Facilities for Elderly People with Mental Infirmity : About 2.5 per 1,000 elderly who are

about 16,000 are staying in mental illness hospitals, because of severe mental infirmity. The guidelines are 2.5 to 3 beds in local hospital units and 2 to 3 day hospital places per 1,000 elderly. There are 650,000 elderly with varying degrees of mental infirmity related to their old age living at home or with

others or relatives, or in various types of local authority and private residential accommodation.

1.11 DOMICILIARY SERVICES

The pressure on residential accommodation and hospitals never can be eased, unless a considerable expansion of domiciliary services is done. The following increases has been suggested by the HPSS authorities on the expenditures in order to meet with the required expansion in domiciliary services:

Home nursing and health visiting by 6% a year.

Chiropody services by 3% a year.

Home help and meals 2% a year.

Some of these growth rates may exceed the annual increase in the elderly population, and can be the cause of some improvements in the standard and scope of provision of services.

1.12 ELDERLY POPULATION PROJECTION

There are now more than 6½ million people aged 65 and over in England and they comprise about 14 percent of the total population. Since 1961 the total population has grown by 7%, but the elderly over 65's have increased by over 25%. This trend will continue until 1981. By 1980 nearly 15% of the population will be 65 or over. The number of over 75's who are the heaviest users of health and personal social services, is expected to rise by half a million over ten years from 2.3 m to 2.8 m.

TABLE 1 : The growth of elderly population has been projected by the Office of Population Censuses and surveys based on the estimated mid-1974 population.

Age Groups	1973	1979	1985	% Change 1971-1973	% Change 1973-1979	% Change 1973-1985
Elderly 65-74	4.1 m	4.3 m	4.1 m	+ 4	+ 5	- 1
Elderly 75 +	2.3 m	2.5 m	2.8 m	+ 3	+ 9	+25
Total	6.4 m	6.8 m	6.9 m	+ 1	+ 6	8

The expected increase in the elderly is particularly important as they make heavy demands on hospitals and residential homes and on most social work, primary health, and community care services.

The population growth in the country between 1968/69 and 1974/75 was 0.2% a year on average but expenditure on the services grow at the rate of 4% per year in real terms. The expansion has been made possible by the above steady growth in the resources used by the services within this period. The most rapidly expanding services have been residential, day care and domiciliary services which are used mainly by the elderly.

1.13 PRIORITIES AND SUGGESTIONS

The main objective in care for elderly people is helping them to remain in the community as long as possible. This cannot be achieved without expansion in all sectors of cares, including provision of suitable housing and encouragement of greater activity by the elderly and even sometimes by their employment if possible. High priority must be given to examining ways of making better use of hospital provision. This includes examination of the relationship between general and geriatric medicine, and the interface between geriatric medicine and other specialities.

Few areas have enough geriatric beds in general hospitals with immediate access to diagnostic and re-habilitation facilities, and with provision for old people presenting as acute medical emergencies to be directly admitted under the care of a geriatric physician. The existence of an acute geriatric service will increase the turnover and reduce waiting lists. The demand for long-stay care and blocking of general medical, general surgical and orthopaedic beds will also lessen.

The departmental policy is to have at least 50% of geriatric beds in the general hospitals but the present level is much below this. Nearly 1/5 of all health districts have no geriatric beds in general hospitals, so

one of the major priorities that must be considered by the health authorities is the provision of geriatric bed services in the general hospital with a faster rate of growth.

The pattern of provision of health services may prevent care being given to those who are in real need. This may result in misuse of the residential and hospital facilities. Inadequate domiciliary services cause misuse of hospital beds and unnecessary demand for residential places. Most local authorities have waiting lists for admission to residential homes, and in many instances can admit only emergency cases. It has been noticed by the health authority that late discharge or inaccurate discharge of the patients in the hospital will cause a block in the hospital beds. This can be overcome if the residential or domiciliary care or suitable housing were available[5].

Local social structure and the physical environment are the two important factors that have a considerable influence on the amount of residential accommodation needed by elderly pe_ le. A greater demand can be noted for this sort of service in localities with mor. old people living in unsatisfactory conditions like being alone, far from relations, friends and shops, etc. Provision of sheldered housing may reduce this need.

It will be very difficult to judge how much more residential provision is needed on a national scale. About three-quarters of the residential places are taken up by elderly people of over 75 years old[25]. If the aim is to keep pace with the increased number of over 75's and approach the stated guidelines, even without allowing for any replacement of unsatisfactory ex-workhouse or other adapted premises then a national increase of 2500 or more places per year for the elderly would be necessary.

There should be considerable scope in the coming years also for converting general medical and surgical beds into geriatric beds, and the

NHS private beds which become available to NHS patients should increase the scope for such a transfer. Some private beds might be suitable, but whether or not the actual beds are so converted
Authorities should ensure that increases in their NHS bed stock from private beds, should be largely used for the benefit of the geriatric sector.

Day hospitals are very important in modern geriatric service, therefore an increase of 500 beds per year in general hospitals and 500 in community hospitals has been suggested. If this programme cannot be achieved or if slow progress is observed, use of the capital on improvement of existing long-stay geriatric units is the next alternative.

The increase of 3% a year on current expenditure will need better and more control, particular attention should be given to the following services in order to meet with different aspects of priorities.

(a) The rapid development of health and social service, domiciliary services, especially home nursing, health visiting, meals, home help services and general social work support,

(b) The acute geriatric units in the general hospitals should be developed to enable the doctors a fast replacement of old long-stay geriatric hospitals by the provision in community hospitals. This cannot be done except by having an immediate access to full diagnostic, and rehabilitation facilties.

(c) The development of local authority residential homes.

(d) The development of special in-patient, and day hospital units for the elderly severely mentally infirm in community hospitals as part of the district psychiatric service.

A low cost solution, without damaging the standards of care, must be adopted. It can be done by new developments or by substitution in

existing services. Another concern is the review of the level of provision in all services, with a view to finding particular elements which can be reduced in current circumstances. This review does not cover the general administration costs, and the general and acute hospital services costs. Good and efficient administration makes a major contribution to the standard and cost effectiveness of care and treatment given directly to the community.

1.14 SUMMARY

Details have been given in this section of the services available to the elderly and the national guidelines suggested for levels of each service ; it has also been shown that the projected increase in the numbers of elderly, and so in the demand for services, will conflict with restraints imposted on government expenditure. There will therefore be increased emphasis on using efficient methods of resource allocation in administering care, and on mathematical models to aid this process. The rest of this thesis is concerned with such models ; in Chapter 2 some categories of model are described, and in Chapter 3 a particular model of social service provision to the elderly in Durham County is derived and some results obtained. As an introduction to this, the next section of this chapter gives some details on the present conditions in Durham.

SECTION TWO

2.1 INTRODUCTION

Since the care for elderly in Durham County is our concern, we now try to give a picture of the situation of elderly people in Durham County along with a brief description of the area. An account is also given of national guidelines and priorities as set out in a publication by the Durham Area Health Authority (DAHA), STRATEGIC PLAN 1977-1986. It covers the area service by the Authority, its population, resources and health indices projected for the health services for this 10-year period.

2.2 GEOGRAPHY

The area served by the Authority covers 244,000 hectares (610,000 acres) and has an overall population density of 2.5 persons per hectare (610,000). Darlington with a population of 86,000 is the largest town. Other towns with a population greater than 20,000 are, Durham City, Chester-Le-Street, Seaham and the new towns of Peterlee and Newton Aycliffe.

The relative distribution of the population is as follows :

TABLE 2 :

Persons Per Hectares	% Distribution of Population and Hectares								Durham Area Health Authority	
	HEALTH DISTRICT									
	Durham		N.W.Durham		S.W.Durham		Darlington			
	Popn.	Hect.	Popn.	Hect.	Popn.	Hect.	Popn.	Hect.	Popn.	Hect.
Over 20	32	7	19	2	15	1	75	3	34	3
1-20	67	77	74	44	78	29	15	12	64	31
Less than 1	1	16	7	54	7	70	10	85	5	66
	100	100	100	100	100	100	100	100	100	100

The last column of the table (Durham Area Health Authority) shows that 5 percent of the population live in remote rural settlements scattered over two thirds of the land, 61% live in small towns and villages and over one third (34%) live in larger towns.

With reference to the other columns, it is obvious that flexibility in planning is required, for example, the type of health service for Durham Health District will need some modification to suit the needs of population of the rural part of Darlington and S.W.Durham.

The following table shows the population of area from 1961 to 1971 and projected population for 1981.

TABLE 3 : Durham C.C.Planning Dept (22.7.76)

Age Group (Years)	Census, 1961		Census, 1971		Projection, 1981	
	Number	%	Number	%	Number	%
0- 4	49,612	8.2	47,872	7.9	40,982	6.8
5-14	98,758	16.3	98,700	16.3	90,127	14.9
15-19	42,802	7.0	42,721	7.0	48,423	8.0
20-64	350,521	57.7	340,771	56.1	335,768	55.7
65-74	43,679	7.2	51,491	8.5	55,265	9.2
75-79	12,807		13,932			
80-84	6,571	3.6	7,666	4.2	32,506	5.4
85-	2,732		4,011			
All Ages	607,482	100	607,164	100	603,071	100

Although it is predicted that the number of population will decrease by some 4,000 (from 71-81) it is interesting to notice that the number of elderly people (65 & over) will show an increase of some 11,000, so it is

suggested that geriatric work should increase both absolutely and relatively and that the efforts to help the elderly people should be reinforced.

As can be seen from Table 2 , Durham Area Health Authority is divided into 4 Health Districts known as (i) Durham, (ii) North West Durham (N.W.Durham), (iii) South West Durham (S.W.Durham), (iv) Darlington.

2.3 DURHAM HEALTH DISTRICT

Geography : The Durham Health district is the most urban of the 4 districts. It covers the 3 local government districts of (i) Durham, (ii) Chester-le-Street, (iii) Easington and comprises 39,897 hectares with 25,000 persons living in areas with more than 30 persons per hectare.

2.3.1 Age Structure 1961-1981

The following table gives a clear picture of the number of population in different age groups.

TABLE 4 :

Age Group (Years)	Census, 1961		Census, 1971		Projection, 1981	
	Number	%	Number	%	Number	%
0- 4	19,979	8.6	19,382	8.1	16,196	6.9
5-14	38,253	16.6	40,065	16.8	25,849	15.2
15-19	16,673	7.2	17,136	7.2	19,119	8.1
20-64	133,018	57.6	133,951	56.0	132,627	56.4
65-74	15,831	6.8	19,341	8.1	19,967	8.5
75-79	4,380		4,962			
80-84	(7,478) 2,161	3.2	(8,999) 2,721	3.8	11,564	4.9
85 +	937		1,316			
All Ages	231,232	100	238,874	100	235,322	100

Although the total population is expected to show a decrease of about 2% by 1981 over 1971 the number of elderly will increase considerably, especially elderly people of 75 and over whose numbers will go up by 50%.

2.3.2 Provision for the Elderly

Table 8 shows the provision of services for the elderly in Durham. In addition, there are 94 privately financed places and 27 day care places in residential homes.

The hospital bed provision in Durham is low. At present, Easington L.G.D., with the lowest socio-economic status, is served to a large extent by the Sunderland and Hartlepool hospitals.

2.4 NORTH WEST DURHAM HEALTH DISTRICT

Geography : West Durham Health district covers only one local government district of Derwentside. It comprises 27,092 hectares with about 90,000 population. Over half of the district contains only one person per hectare and around 7,000 persons are living in such a rural area.

Age Structure, 1961-1981 : The age structure has changed markedly with an absolute increase in the geriatric workload.

TABLE 5 :

Age Group (Years)	Census, 1961		Census, 1971		Projection, 1981	
	Number	%	Number	%	Number	%
0- 4	7,687	7.7	7,045	7.7	5,812	6.5
5-14	15,998	16.0	14,055	15.3	13,018	14.6
15-19	7,383	7.4	6,290	6.8	6,705	7.5
20-64	58,038	58.1	52,080	56.5	48,517	54.6
65-74	7,092	7.1	8,500	9.2	9,315	10.5
75-79	2,155		2,250			
80-84	1,127	3.7	1,175	4.5	5,544	6.2
84 +	395		685			
All Ages	99,875	100	92,080	100	88,911	99.9

The health district undertakes the hospital care of almost 90% of its own residents in general specialties and over 90% in geriatrics.

2.4.1 Provision for the Elderly

In addition to the services shown in Table 8, there are 26 privately financed places and 9 day care places in residential homes.

Because of poor socio-economic status of elderly in N.W.Durham district there are longer durations of stay in the hospital and heavy demands on all services. There are 164 geriatric beds which is an average of 13.0 per 1,000, where 193 is the average daily demand.

The following are the suggested solutions to overcome the problems and difficulties related to the elderly population :

(i) an active and forward geriatric service with day hospital and assessment unit,

(ii) improved community services with an emphasis on prolonging the independence of the elderly in their own homes,

(iii) improved geriatric staffing ratios,

(iv) joint care planning with social services.

2.5 SOUTH WEST DURHAM HEALTH DISTRICT

Geography : The S.W. Durham Health district covers two local government districts of Sedgefield and Wear Valley. It comprises 72,482 hectares. The majority of people, about 120,000, live in small towns and villages where the population density varies from 1-20 persons per hectare.

Age Structure,1961-1981 : The following table shows the population in S.W.Durham district in different age groups. The population prediction for 1981 shows an overall increase of persons from 1961 census. The increase is dominated by the elderly age groups.

TABLE 6 :

Age Group (Years)	Census, 1961		Census, 1971		Projection, 1981	
	Number	%	Number	%	Number	%
0- 4	12,302	7.9	11,965	7.8	10,953	7.0
5-14	25,522	16.5	24,832	16.2	23,781	15.1
15-19	10,668	6.9	10,942	7.1	12,592	8.0
20-64	89,146	57.6	86,299	56.1	87,538	55.6
65-74	11,350	7.3	13,032	8.5	14,308	9.1
75-79	3,382		3,712			
80-84	1,743	3.8	1,942	4.4	8,273	5.3
85 +	738		1,052			
All Ages	154,851	100	153,776	100.1	157,445	100.1

The health district undertakes hospital care for almost 70% of its own population in general specialties and 70% of geriatrics are coped with locally. S.W.Durham appears to have less of a waiting list problem than the other districts.

2.5.1 Provision for the Elderly

In addition to the services shown in Table 7 there are 18 day care places in residential homes. The percentage occupancy for geriatric beds during 1975 was 75.6 where there were no patients on the waiting list for geriatrics services at 31.12.75.

To overcome the difficulty related to care for the elderly, improvement to the following services is suggested during the strategic plan 1977-1986:

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(i) An active and forward looking geriatric service is required with emphasis on prolonging the independence of the elderly in

their own homes.

(ii) Multipurpose community clinics backed by a motor caravan are proposed.

(iii) Out-patient psychiatry and out-patient clinics should be considered for Stanhope Health Centre to reduce travelling from the dales.

2.6 DARLINGTON HEALTH DISTRICT

Geography : The Darlington Health district covers the local government districts of Darlington and Teesdale. It comprises 104,169 hectares with an overall population of about 121,000. The majority of the population, 86,000 live in the former Darlington C.B.

Age Structure, 1961-1981 : Like other districts, the overall population in this period have a decline but there is a noticeable increase in the number of 65 and older age groups.

TABLE 7 :

Age Group (Years)	Census, 1961		Census, 1971		Projection, 1981	
	Number	%	Number	%	Number	%
0- 4	9,644	7.0	9,480	7.7	8,021	6.6
5-14	18,985	15.6	19,748	16.1	17,479	14.4
15-19	8,078	6.6	8,353	6.8	10,007	8.2
20-64	70,319	58.0	68,441	56.0	67,085	55.3
65-74	9,406	7.7	10,618	8.7	11,675	9.6
75-79	2,890		3,008			
80-84	1,540	4.2	1,828	4.7	7,125	5.9
85 +	662		958			
All Ages	121,524	100	122,434	100	121,392	100

The health district cares for 75% of its own residents in general specialties, 95% in geriatrics and 82% in rehabilitation.

2.6.1 Provision for the Elderly

In addition to the services shown in Table 8, there are 12 privately financed places and 18 day care places in residential homes. Geriatric provision overall appears satisfactory.

2.7 PRESENT STATE OF SERVICES[24]

The services used by the elderly clients in Durham County are more or less similar to those listed and briefly described in the section one of this chapter.

The Area Health Authority's guidelines are exactly the same as the national guideline dictated by the Department of Health and Social Services in 1976. The availability of resources and standard of the services are listed below :

(a) Home Helps : In 1977 there were about 855 full-time equivalent (F.T.E) home helps, i.e. 9.7 per 1,000 elderly;the guideline is for a ratio of 12 per 1,000 elderly.

(b) Meals : About 519,907 meals were served each year through the meals-on-wheels services, i.e. 113.9 per 1,000 elderly;the guideline is for 200 per week per 1,000 elderly or about 912,915 overall per year ; 17,556 per week.

(c) Home Nursing : Over half the time of home nurses is thought to be spent on the elderly. In 1977 there were about 71.3 home nurses (½ F.T.E), somewhat more than 0.8 per 1,000 total elderly population ; the guideline is 2 per 1,000 elderly people (this local guideline differs with the national guideline of 1 per 2500-4000).

(d) Day Centres : In 1977 there were about 200 day centre places available for elderly clients somewhat like 2.3 places per 1000

elderly ; the guideline is 3-4 places per 1000.

(e) Chiropody : Elderly clients are the main users of this vital service to them. The level of resources of this service is far below the national guideline. The importance of the service and attention of the local authorities towards it can be noticed from their continuous discussions mentioned in their minutes of meetings from 1977 until the present. In 1977 there were about 14.8 F.T.E. chiropodists something like 0.17 per 1000 elderly ; the guideline is 0.25 per 1000.

(f) Residential Facilities : In 1977 there were about 1654 local authority residential places for elderly people, i.e. about 18.8 places per 1000 elderly. The guideline is 25 places per 1000 elderly.

(g) Hospital Beds : The situation of hospital beds in Durham County on the whole is satisfactory for the elderly as far as the number of beds designated to them is concerned. In 1977, 910 hospital beds were available, i.e. 10.4 beds for 1000 elderly where the guideline is 10 beds per 1000 elderly.

(h) Units of Accommodation : In 1977 there were 12,281 units of accommodation like warden-served flats and houses available to the elderly clients, i.e. 139.9 places for 1000 elderly. The national guidelines have not been circulated so far and nothing is mentioned from the Local Authority for an accepted target.

Other services like aids, occupational therapy, craft instructors, Technical Officer services for Deaf and Blind, etc., are also the services being provided by the Area Health Authority.

A full picture of the services provided to the four health districts in Durham County and the available resources in each district is shown in Table 8.

2.8 THE ECONOMIC PRESSURES AND RESOURCE ASSUMPTION

The National Health Service is in a period of severe financial restraint and with the introduction of the Resource Allocation Working Party Criteria the indications are that Durham Area Health Authority can at the best expect only to mark time regarding its revenue allocation. For 1976/77 all the indications pointed to the allocation being less than the existing level of expenditure. To keep expenditure within the sum allocated, savings must be made, and development of any part of the service must be financed by savings from other parts of the service.

The White Paper published in 1977 on Public Health Expenditure to 1980 indicates that the growth of public expenditure within years 1974 to 1977 has been nearly 20% in volume, while output has grown by only 2%. The ratio of public expenditure to gross domestic product has grown from 50% to 60%. The paper indicates that there will not be an overall growth in public expenditure up to 1980 beyond the level envisaged for 1976/77.

Information regarding future capital resources is limited. The Resource Allocation Working Party has recommended that capital should be allocated on the basis of existing contractual commitments for major schemes, forming a first charge on the programme, with the balance distributed according to the weighted population of each region.

In the first section of this chapter we talked about the importance and role of primary care in helping to relieve the pressures on the hospital and residential places services by caring for more people in the community. There is no doubt that the Durham Area Health Authority can not be exempted from the DHSS's policy, so in Durham County like other parts of the country priority is given to the treatment of elderly clients to help them to remain in the community as long as possible. In order to achieve this target the community health care (i.e. Home Helps, Meals-on Wheels,Chiropody,Home Nursing,Day Care,etc) must have more weight.

TABLE 8 : Services for the Elderly Population Aged 65 Years and Older, by Health and Local Government Districts.

Population estimate, 1981, Durham County Council Planning Dept.

Elderly Population Services Provided	DHSS Target Level of Provision 1976	N.W.Durham Health District	Durham Health District	S.W.Durham Health District	D'ton Health District	Durham A.H.A.
Estimated Population of 65 &Older in 1981		14,859	31,531	22,581	18,800	87,771
Total No.of Units of Acc.	Awaiting D.D.E. Housing Circular	1,623	5,682	3,796	1,780	12,281
Rate/1000 65+		109.2	180.2	168.1	94.7	139.9
Warden-serv. flats & houses(incl. above)		629	4,066	3,323	401	8,419
Rate/1000 65+		42.3	128.9	147.1	21.3	95.9
No.of Home Help W.T.E.	12/1000 elderly	172	351	205	127	855
Rate/1000 65+		11.6	11.1	9.1	6.7	9.7
No.of Meals (Meals-on-Wheels,Lunch. Clubs)	200/1000 per week	817	6,256	1,460	1,464	9,998
Rate/1000, 65+/week		55.0	198.4	64.6	77.9	113.9
Day Places, Hospital or Social Services	3-4 places /1000 elderly	50 Soc. Serv.	50 Soc. Serv.+25 Hosp=75+	50 Soc. Serv.pls	25 Hosp. places	200
		3.4	2.4	2.2	1.3	2.3
Home Nurses ½ W.T.E.= work for	2/1000 elderly	10 (20)	27.8 (55.5)	19.5 (39)	14 (28)	71.3(142.5)
Rate/1000,65+		0.7	0.9	0.9	0.7	0.8
Chiropodists W.T.E	0.25/1000 elderly	-	-	-	-	14.8
Rate/1000,65+		-	-	-	-	0.17
Hospital Beds	10/1000	225	228	226	231	910
Rate/1000,65+		15.1	7.2	10.0	12.3	10.4
Residential Places(L.A.)	25/1000	256	559	405	434	1,654
		17.2	17.7	17.9	23.1	18.8

Source of Data: D.H.S.S. Target levels of provision "priorities for Health and Social Services", H.M.S.O., 1976/77.

CHAPTER 2

2.1 INTRODUCTION

In this chapter different ways of approaching health care planning are discussed. Measures of efficiency in the field of social services and the cost-benefit approach are described and some description given of a mathematical programming approach, especially the "Balance of Care" model.

2.2 SUMMARY

Although health and welfare services have their own particular status and are distinguishable from other services in the public and private sectors, nevertheless there are lots of similarities with other organizations. For example, the problem of allocation of ambulances is very similar to the problem of allocation of bus services in a private or public sector organization, the difficulties faced by the staff in the laundry in a hospital are the same as in a private laundry or the problem of random arrivals of patients at a hospital and the scheduling of reception arrangements is very similar to the problem a bank manager has with queues at the counters at his branch at peak hours. The difference is likely to be in measuring the output of the system.

If a decision is going to be taken on a particular problem in an area related to the welfare of the patients a variety of benefit measures have to be considered. Many different groups of client make demands on same services. For example, the home help service is used by the elderly, physically handicapped and maternity cases while home nursing is used by virtually all client groups. At some stage in the planning process the conflicting claims of different client groups for services must be resolved. Taking an overview of the HPSS system is no easy task when the inter-relationships of different client groups and services have to be considered.

In the previous chapter the Health and Personal Social Services system within the U.K was more or less described but it seems to be useful here to give a brief discussion of the decision making process. England is divided into 14 regions which in turn are sub-divided into areas (90 in total) and these areas are divided into districts (a total of 205). (Durham Area Health Authority consist of 4 districts). Each management level has considerable autonomy. At a national level, the Department of Health and Social Security has the responsibility for setting guidelines and priorities. It is not in a position to determine the precise pattern of care but in many respects must respond to the patterns of care chosen by decision makers at a more local level. The DHSS must take a long-term view of the changes in demand for services which will arise from demographic changes, increased expectations of clients, or developments in forms of care, and must co-ordinate the developments in different parts of the system.

The DHSS has issued guidance to the field via a number of policy documents [24,]. Quantitative guidance has normally been given in the form of norms of service provision such as doctors/1000 population, beds/1000 population, costs/day in hospital, costs/patient, visit/week, meals/week, etc. However, the DHSS does not claim that these norms should be implemented rigidly because there is a limited analytical basis for many of the norms.

2.3 COST-BENEFIT ANALYSIS

As there will not always be enough resources to satisfy the community's desires for things that improve the quality of life, the necessity for choice and hence the consideration of priorities is certain. The choice of planning process in the medical field is important because it is concerned with large groups of potential patients at some future date.

One of the important and increasingly widespread approaches to the problems of planning medical care is Cost-Benefit Analysis (22).

Cost-Benefit Analysis, as a technique is mainly used by planners and economists in the public sector in order to enable them to provide services only if their benefits outweigh their costs. It aims to take account of all social costs and benefits so as to obtain the best decision for the community as a whole. It has been developed as a technique for the appraisal of policy options involving the allocation of resources between competing schemes where conventional techniques confined to the consideration of financial returns and cash outlays are thought to be too narrow.

Although Cost-Benefit Analysis is a traditional analytical tool, some scholars argue(9) that health and welfare in a society cannot be measured precisely by it, since it attempts to reduce all decisions to economic terms. Instead they recommend Cost Effectiveness Analysis which can be of more use in measuring the health benefits in a programme.

2.4 IS COST-BENEFIT ANALYSIS APPLICABLE TO HEALTH SERVICE POLICY ?

In principle, Cost-Benefit Analysis studies are appropriate wherever resource-allocation decisions have to be made ; and this leaves most of the field of human choice subject to Cost-Benefit Analysis. In practical terms the monetary benefits are not likely, in many cases, to outweight the costs ; hence, cost-benefit studies should be concentrated where the reward is likely to be the greatest (22).

Items which may specify situations in which the potential benefits from a cost-benefit study would be great are (i) sizeable amounts of scarce resources are at stake, (ii) responsibility is fragmented, (iii) the objectives of the respective parties are at variance or unclear, and items which specify and ensure that the analyst would have something worthwhile to

consider may be listed as (i) there exist acceptable alternatives of a radically different kind, (ii) the technology underlying each alternative is well understood, (iii) the results of the analysis are not wanted in an impossibly short time.

There are plenty of problems arising in the health services which are subject to cost-benefit analysis[22]. Leaving aside the many choices that have to be made which are not peculiar to health services as such (e.g. in the general fields of catering, domestic services, engineering and building), there are important decisions concerning different types, places and times of treatment for a particular condition, and priorities for treatment within a particular condition and between conditions or patients. Each of these generates needs for similar types of data, and, even conceptually, they are not so dissimilar as they appear at first sight. They give rise to the need for more fundamental studies, concerned to make clear certain common problems, such as the notion of cost that is appropriate for a particular content of choice and how the effectiveness of a health care system can be measured.

2.5 REQUIREMENTS FOR MODEL BUILDING

In studying problems concerned with the planning of services using operational research techniques, the requirements for constructing a model may be listed as follows :

(i) Definition of a set of client groups,

(ii) Definition of the type of services being considered,

(iii) Estimate of the effect of a particular service or group of services on a particular client group,

(iv) Some measure or measure of overall utility related to the effect of provided services,

(v) Definition of the resource constraints operating,

(vi) Definition of the type of decision to be made e.g. minimizing cost to provide adequate care, maximizing utility subject to restricted cost, etc.

In the following sections an account will be given of several published studies on models for the planning of care, described under each of these headings. The model used in the present work is described in Chapter 3 in the same way. The studies analysed in the next section are :

(i) The use of a strategic planning model for Health and Personal Social Services : R.J.Gibbs,

(ii) The Balance of Care Project : Modelling the Allocation of Health and Personal Social Services : I.L.Coverdale and S.M. Negrine,

(iii) Care of the Elderly : R.Wager,

(iv) A Generalized Cost-Effectiveness Model for Health Planning : G. W. Torrance,

(v) Balance of Care; A. G. McDonald and E.M.L.Beale,

(vi) A Role for O.R. in Health Care Planning and Management Teams : R. M. Burton.

2.5.1 Client Groups

This is the first step in the model building process and is one which can be carried out in various ways. G.W. Torrance introduces the term health index, and classifies the whole population in terms of it. The index is regarded as a function of 3 health states, x_1, x_2, x_3, assessing physical, emotional and social components respectively. If h represents the index value, then $h = f(x_1, x_2, x_3)$.

The health index is measured on a linear interval scale, standardized at a value of one for the healthy state ($h_1 = 1$) and zero for the death state ($h_n = 0$). A state of health varies from perfect health to a

total absence of function (death). The index value for a state is measured in such a way that it represents the average utility of the state over a specified time period (t), independent of prognosis and financial considerations. In the study the assessment of states was made by professional workers, e.g. doctors, social workers.

R.M.Burton in a study carried out by a multidisciplinary team concerned with the care for the elderly people in Durham County in North Carolina in the U.S.A, argues that at the early stage of the research the team agreed to first develop a set of patient state definition which would reflect the patient's ability to function independently with respect to five dimensions known as (i) physical health (ii) mental health (iii) social resources (iv) economic resources, and (v) activities of daily living. Patients were then rated on a scale of 1 to 6 on each of these five dimensions according to the degree of impairment in each. Here 1 represents no impairment and 6 represents severe impairment. In total there would be $6^5 = 7776$ possible patient states but in most of the cases these were reduced from six possible states on each scale to two (impaired and unimpaired) which gives $2^5 = 32$ states.

For classifying individuals into patient states a lengthy questionnaire was developed and initially applied to over 1200 subjects related to the status of individuals.

R. Wager,in a study commissioned by Essex County Council, answers the question of "Is it possible to assess the state of the potential clientele in a fairly objective way that will be useful for operational purposes ?" by categorizing the clients attributes according to 14 components as follows :

(a) Sensory perceptions

1 - Defective sight

2 - Defective hearing

	3 - Difficulties with speech communication
(b) Intellectual processes	4 - Mental confusion and instability
	5 - Difficulties with dressing
(c) Personal care	6 - Difficulties with washing
	7 - Incontinence
	8 - Falls and giddiness
	9 - Mobility indoors
(d) Physical mobility and absence of stability	10 - Mobility outdoors
	11 - Bathing
	12 - Negotiating stairs and steps
	13 - Housing cleaning
(e) Domestic duties	14 - Meal preparation

When the population concerned was assessed under these headings by social workers, the above components (categories) turned out to be scattered into 5 groups as shown above (a to e). A new key concept called "Index of Incapacity" is argued and that is the scores from zero upwards assigned to each category and grouping them again in terms of incapacity, as shown in Table 1.

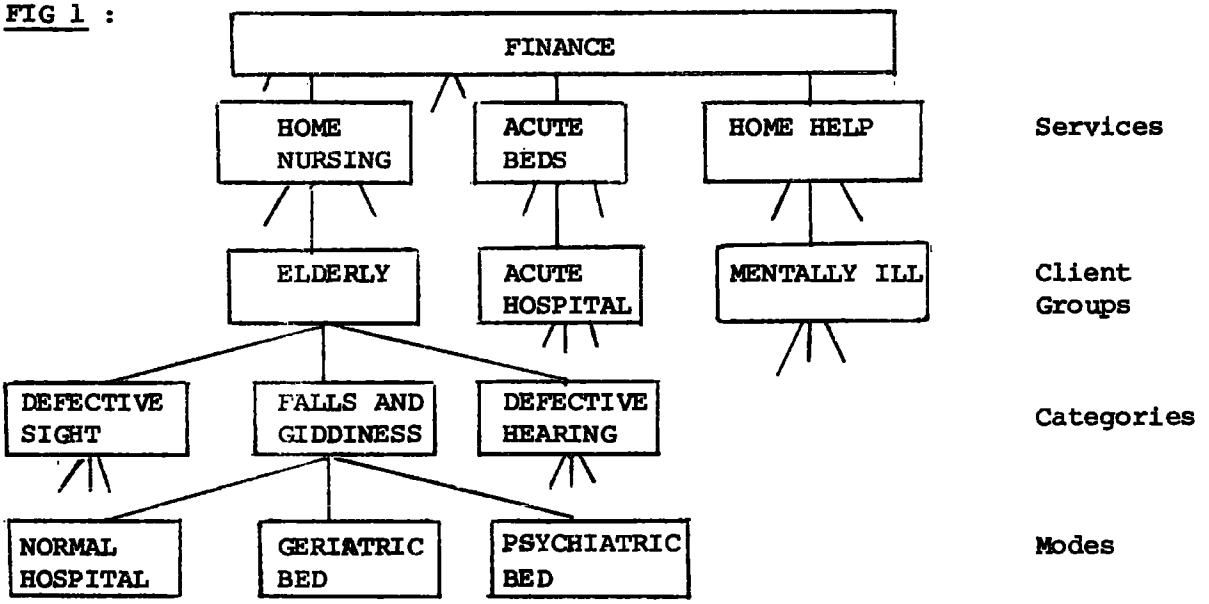
TABLE 1 :

Score	% of Population surveyed falling in each group
Score 0 = no incapacity	4
Score 1 to 5 = slight incapacity	24
Score 6 to 8 = moderate incapacity	23
Score 9 to 15 = substantial incapacity	37
Score 16 & over= severe incapacity	12

The right-handside column of the table shows the percentage of the applicants in each component applying for places in the local authority's welfare homes.

I. L. Coverdale, in a study known as Balance of Care,defines the client groups which are divided into categories ; of those clients who make similar demands on services, e.g. complete dependency cases form a category within the "elderly client group or in other words "where the question of health is concerned", the community can be divided into different groups of patients and then each group can be subdivided into categories according to their state of health. The following figure is self explanatory for the above definition :

FIG 1 :



A. G. McDonald gives the same definition as I. L. Coverdale to the client groups and argues that the same patient might be represented in more than one category. For example, an elderly patient might also appear in a surgical category and a mentally ill category. Therefore the categories must be defined in such a way that the resources required to care for the same patient under different categories are not counted twice. In other words they are discrete and additive.

At the end of 1973 the major areas of health care and the number of client groups of patient into which each has been sub-divided into

different categories were as follows :

(i) Surgical (16 categories)

(ii) Maternity (10 categories)

(iii) Patients of general practitioners (2 categories)

(iv) Mentally ill (34 categories)

(v) Mentally handicapped (36 categories)

(vi) Children

(vii) Medical Patients

(viii) Elderly (34 categories)

Since then there has been definitely some revision in all the groups and their associated categories. Table 2 shows the elderly client group's categories introduced by McDonald and R.J.Gibbs.

Notes: 1. Good housing is defined as having an inside W.C. and hot water.

2. Very severe = handicap 1-3

Severe = " 4-5

Appreciable = " 6

Minor = " 7-8

None = No disability, handicap or impairment.

2.5.2 Definition of Type of Service

After defining the groups of patients and analysing the appropriate categories within these groups, the next step is to consider what can be done for these people. For this purpose there should be a full knowledge of available services that a society can provide to each individual.

The types of care available have been described in the previous chapter. However, their precise specification differs a little from one

TABLE 2 : Description of Category

Category	Housing[1]	Lives Alone	Physical Handicap[2]	Dementia[3]
1	Poor	Yes	Very severe	Severe/Moderate
2	Good	Yes	" "	" "
3	Poor	No	" "	" "
4	Good	No	" "	" "
5	Poor	Yes	Severe/Appreciable/Minor/	Severe/Moderate
6	Good	Yes	" " " None	" "
7	Poor	No	" " " "	" "
8	Good	No	" " " "	" "
9	Poor	Yes	Very severe	Mild
10	Good	Yes	" "	"
11	Poor	No	" "	"
12	Good	No	" "	"
13	Poor	Yes	Severe/Appreciable	Mild
14	Good	Yes	" "	"
15	Poor	No	" "	"
16	Good	No	" "	"
17	Poor	Yes	Minor/None	Mild
18	Good	Yes	" "	"
19	Poor	No	" "	"
20	Good	No	" "	"
21	Poor	Yes	Very severe	None
22	Good	Yes	" "	"
23	Poor	No	" "	"
24	Good	No	" "	"
25	Poor	Yes	Severe/Appreciable	None
26	Good	Yes	" "	"
27	Poor	No	" "	"
28	Good	No	" "	"
29	Poor	Yes	Minor	None
30	Good	Yes	"	"
31	Poor	No	"	"
32	Good	No	"	"
33	Poor/Good	Yes/No	None	None

model to another. One common feature is the assignment of modes of services, that is a set of services, e.g. both "Meals on Wheels" and "Home Helps", which may be supplied to a particular client. Therefore for each category of patient, suitable alternative modes of care must be defined. This is a very important task and needs the help and cooperation of experts and social workers to set the modes and desirable services in order to achieve a standard and acceptable relief to the clients.

R.J.Gibbs, I.L.Coverdale, and I.J.McDonald, have been separately dealing with the development of a model known as Balance of Care which is particularly concerned with policies which involve a shift in the balance between hospital and residential care on one hand and care by community on the other hand ; all agree that such a shift become feasible for a wide range of client groups because of technological changes in the delivery of care.

The Balance of Care model relates the aggregate provision of services to the way in which they are rationed in the field. R.J.Gibbs expresses the rationing in terms of three groups of variables described below :

(i) "Cover", the numbers of patients who receive treatment, broken down first by client groups (e.g. surgical, mentally ill, elderly disabled) and second by categories within client groups.

(ii)"Modes", the alternative forms of treatment that may be given (e.g. day surgery followed by home nurse visiting, surgery accompanied by an in-patient stay in a hospital).

(iii)"Standards", the average amounts of resources used per patient in a given mode (e.g. five home nurse visits).

Some modes of care which can be used alone or in combination by

elderly clients are as follows:

1. Geriatric wards
2. Psychiatric wards
3. Residential home with day care(i.e. day centre, psychiatric or geriatric day hospital)
4. Residential home without day care
5. Special housing with day care
6. Special housing without day care
7. Own housing with day care
8. Own housing without day care

The pattern of care has been described by I.L.Coverdale in terms of :

(i)"Coverage", the ratio of the number of client receiving care to the number of potential clients in a category.

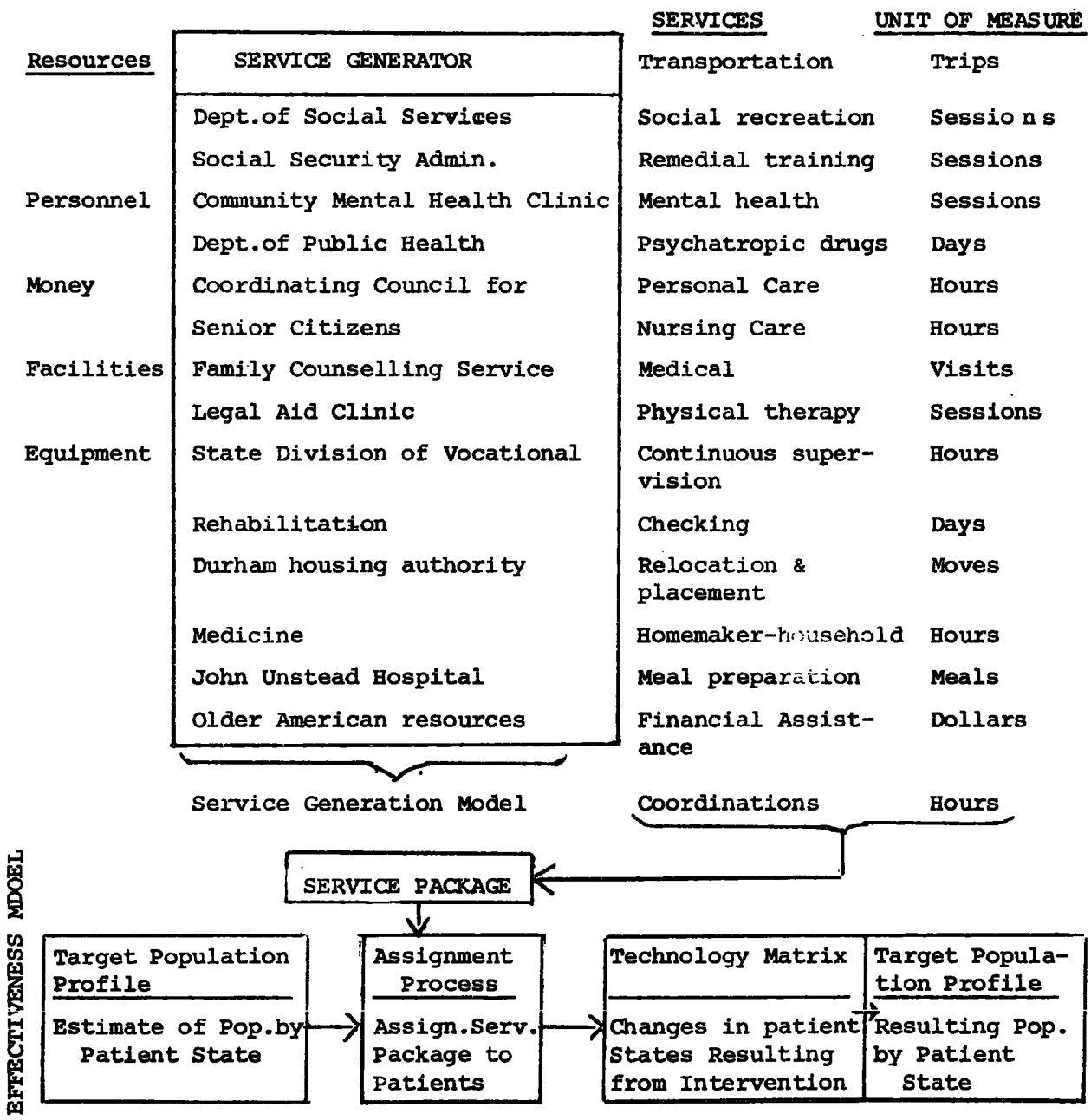
(ii)"Model Balance", the number of clients in different modes of care.

(iii)"Quotas", in the Balance of Care model, services are regarded as being reducible or irreducible. Those which are irreducible must, by the nature of the service, be allocated to clients either at fixed levels or not at all ; for example, a fraction of residential places can not be allocated to a client. For each reducible service its quota, for a particular client group, is the ratio of the allocation of the service to that required if desirable levels of services were to be reached.

The definition of a set of services was given by Burton and his research team working in Durham County in the U.S.A. at their first stage of survey. It was one of the key assumptions that services must be defined so that quantities of services could be observed and measured.

The following Fig. shows a sample of different sorts of services provided to elderly people by different organizations which could be assigned to elderly patients in a form of service package.

FIG 2:



Since these organizations consume resources and generate services, it is possible to state the relationship between costs and services generated, so the services must be defined in a measurable term, e.g. number of trips, number of hours of personal care, etc.

The total set of services produced is allocated among the individuals in the target population. The particular set of services assigned to a particular individual is defined as a service package. For example, a particular individual may receive a service package consisting of 5 hours nursing, 6 hours of personal care per week, etc. The notion of a service package completes the conceptual part of this model dealing with the generation of services.

R. Wager tries to answer the question "Are domiciliary care and residential care really feasible alternatives for the elderly ?". His survey was restricted to a particular set of elderly people in Essex namely those already receiving domiciliary care. He finds that there was a range of moderate incapacity to which either domiciliary care or residential care could be appropriate responses. He actually does not discuss the problem of allocations of a particular set of services to an individual, but reaches a conclusion of a yes answer to the above question.

Allocation of services to any one of the categories of patients, say elderly, will not be an easy job if some resources are scarce. On the basis of this assumption McDonald suggests that it is therefore adequate to provide patients in a specific category with one of several alternative packages of care. Table 3 shows the alternative requirements for one category of elderly patients. Collection of such data for each category along with its associated costs, is difficult but estimates based on professional judgement have been used as the basis of the model.

The amount and the form of care provided to a particular patient is not always the only solution for his relief of pain or discomfort. There

are always other alternatives which can be allocated to a patient instead of former type of care that can be mutually accepted by the patient and care takers. For example, a patient can either stay in hospital full-term or be discharged early under the care of district nurses. For most of the studies and models the alternative form of care for some categories of patient is the basic concept.

TABLE 3 : Scheme showing alternative requirements for resources and alternative care options, for a category of elderly patients. The category relates to those with good housing who live with others very severely handicapped, and with severe/moderate dementia (Category 4 from Table 1).

RESOURCE	ALTERNATIVE CARE OPTIONS							
Location								
Psychiatric Bed	X							
Geriatric Bed		X						
Special Housing Place			X	X	X			
Own Home						X	X	X
Community Support								
District Nurse (Visit per week)			2	2	5	2	2	5
Part-time Domestic Help (hours per week)			2	2	3	3	3	4
Meals Delivered to Patient's Home (No. per week)			1	1	4	1	1	4
Atten. at Psychiatric Hospital (Times per week)			3			3		
Atten. at Geriatric Hospital (Times per week)				3			3	

2.5.3 Effect of Services on Client Group

After defining the client group and the appropriate services available to them, we can specify how these services may affect the individuals and so what will be the effectiveness of a care programme.

G. W. Torrance introduces the matrix d_{jk} (y) the number of man days changed from health state j to health state k during year (y). He argues that when health index values have been determined for all relevant health states, it is a relatively straightforward calculation to determine the effectiveness (E) of a programme measured in health-days (index-days). From an analysis of the programme, determine $d_{jk}(y)$. Since the matrix of state changes is skew-symmetric $\left[d_{jk}(y) = -d_{jk}(y) \right]$ let $D_{jk}(y) = \max \left[0, d_{jk}(y) \right]$. Then the number of man-days in the same health state contributes nothing to the effectiveness E(y), the health effectiveness of the programme in year (y) measured in health days can be calculated as in the next section.

The effect of service packages on the client group has also been studied by Burton and his research team; as is shown in the lower portion of Fig.2. It represents the concept of estimating the impact, a particular set of service packages will have on target population. Beginning with the known or estimated status of the members of the target population, the available service package are assigned to individuals. The Technology Matrix, or impact function, is a summary statement which indicates the probability distribution on the patient's new state, given his current state and a specific service package. The changes in the target population can be predicted as a function of the service packages available, which in turn is a function of the service generation system chosen and, ultimately, the cost of producing the service.

In each of these two models, the effect of any specified service on any specified client state is assumed known ; the other models are based on the idea that numbers of alternative 'packages' of care are equally effective.

2.5.4 Utility Function

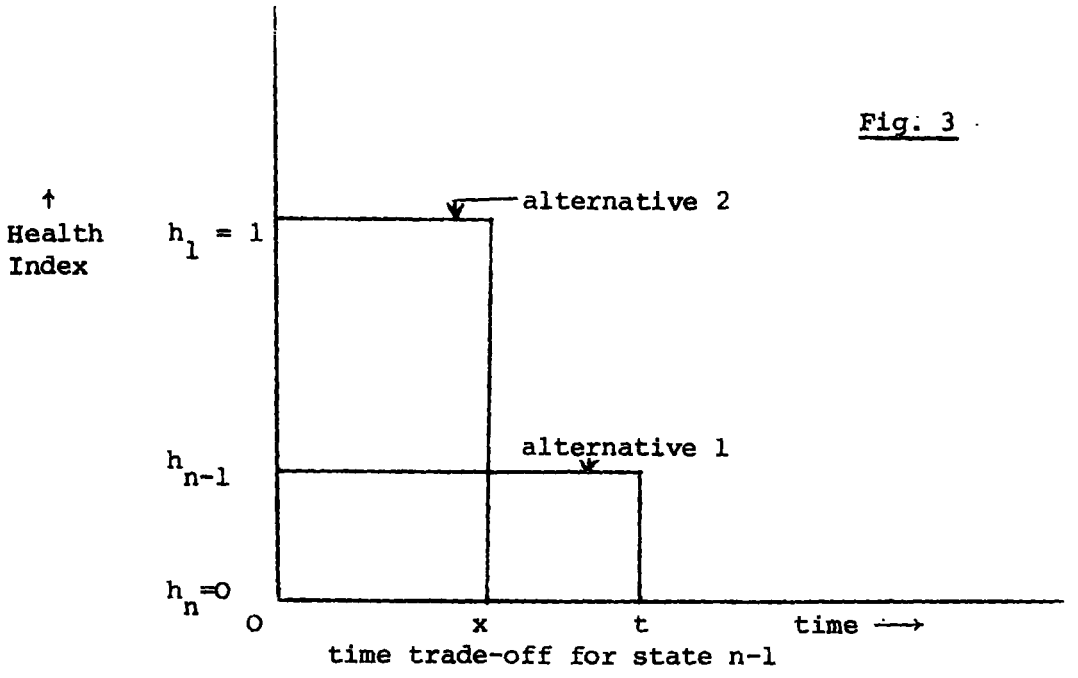
The demand for health care services frequently exceeds the supply (7) since there is no market price regulator. The inevitable result is that services have to be rationed by one means or another. The rationing can be seen in terms of answers to three questions, (i) who gets treatment ? (ii) what form of treatment ? (iii) at what intensity ?

TORRANCE argues that in order to be able to calculate and determine the effectiveness (E) of a programme, we must first produce a "health index" for all relevant health states. The index at a particular health state is the utility of that state as perceived by society.

The first step for the measurement of health index is the determination of the time period of interest (t) for each state ; if several states have identical time periods, they can be grouped together for convenience. The procedure for measuring a group of states begin by asking the subject to preference rank the states, assuming the same time period t for each state and assuming the identical prognoses. Let i = 1,2,3,---n-1,n represent the preference ranking for a particular respondent (i = 1 and i = n are perfect healthy states and dead states respectively. The utilities for this respondent are then measured by various techniques.

One of the techniques for measuring the required utility is called timetrade-off method. The following figure shows the application of this method to state n -1

Fig. 3



time trade-off for state n-1

Here the respondent is asked to choose one of the two alternatives. Alternative one is, state n-1 for the time t followed by death, and alternative two is state 1 (healthy) for time $x < t$ followed by death. The respondent's indifference point is located by varying the time x. The average utility for state n-1 over time period t (h_{n-1}) is determined by equating the utilities of the two alternatives.

Utility of alternative 1 = utility of alternative 2 or

$$h_{n-1}t = h_1 x + h_n(t-x)$$

$$\therefore \quad h_{n-1} = {}^{x}/_{t} \quad \because \quad h_n = 0 \quad \& \quad h_1 = 1$$

For any state i other than n-1 the alternative becomes

alternative 1 —— state i for time t followed by healthy

alternative 2 —— state i + 1 for time $x < t$ followed by healthy.

Again, x is varied to determine the indifference point at which the required utility is

$$h_i = 1 - {}^{x}/_{t}\,(1 - h_{i+1})$$

Let E(y) be the health effectiveness of the programme in year (y), measured in health days and representing the change in health utility in year (y) caused by the programme. Therefore the health effectiveness can be found as presented by TORRANCE, from

$$E(y) = \sum_{j=1} \sum_{k=1} D_{jk}(y)\ (h_k - h_j) \qquad (1)$$

h_k & h_j are the utilities of state k and state j respectively.

Let E be the present value or the change in health utility (health effectiveness) for all years affected by the programme. Therefore it can be calculated from

$$E = \sum_{y=1}^{\infty} \frac{E(y)}{(1+r)^y} \qquad (2)$$

where r is an annual rate for discounting the future change into present time.

Substitution for E(y) from (1) yields the following formula for the programme health effectiveness

$$E = \sum_{y=1}^{\infty} (1+r)^{-y} \cdot \sum_{j=1}^{n} \sum_{k=1}^{n} D_{jk}(y)\ (h_k - h_j)$$

R.M.Burton and his research team have the same view of a utility measure. One of the points they agreed upon at the first stage of their research on the care for elderly people was that"It was not necessary to define a specific utility measure on the patient states, but the patient states must be defined so as to accommodate a variety of utility measures."

On the basis that the objective cannot be satisfactorily quantified and the final output can not be reliably meaured, different forms of utility functions have been constructed by some other researchers to tackle this problem more precisely in order to proceed with intermediate or surrogate output measures.

R.J.Gibbs in a comprehensive description of background to the balance of care study in the U.K. produces a model which does offer the DHSS the opportunity to use intermediate outputs (cover and standards as previously defined in page 35) as surrogate measures.

The adoption of a model in which services are rationed will lead to an analysis of the values which HPSS decision-makers place on different allocations of services. I.L. Coverdale says that it is not possible to use the subjective judgement techniques of utility theory to assess these values, as a representative group of decision-makers could not be assembled. Instead he suggests that adopting a model which is able to explore how the pattern of care will change as service levels change, can be of practical help to a planner considering service levels. This suggestion is therefore to calculate the parameters of a general utility function from the decisions which have actually been made in running the service in the immediate past.

The principle assumption in the model by R.J.Gibbs is that the service, in rationing its resources, attempts to maximize a utility function of its own involving cover, modes and standards, subject to certain constraints. The parameters of the utility functions can be inferred from observations of the service's past behaviour. Utility is thus measured in terms of "inferred worth".

The mathematical form of the model is summarized below :

MAXIMIZE

$$\sum_{i} g_i(d_i) + \sum_{i}\sum_{l}\sum_{k} h_{ilk}(U_{ilk})X_{il} - \sum_{i}\sum_{l}\sum_{k} C_k U_{ilk} X_{il}$$

subject to

$$\sum_{l} X_{il} - d_i = 0 \quad \text{for all } i$$

$$\sum_{i}\sum_{l} U_{ilk} X_{il} \leq B_k \quad \text{for all } k$$

where

i is the category of patient (as in Table 2)

l is the mode of care (as in Table 3.)

k is a resource

X_{il} is the number of patients in category i allocated to mode l

d_i is the number of patients category i to receive treatment (i.e.cover); d_i will in general be less than D_i the total number of patient in this category.

U_{ilk} is the standard (amount of resource allocated per patient) for resource k used in mode l for category i. Again u_{ilk} will in general be less than the ideal standard U_{ilk}.

C_k is the unit cost of resource k

B_k is the availability of resource k.

π_i is a constant (to be determined).

U_{ilk} is the corresponding ideal standard.

F_{ik} is similarly the elasticity of the actual allocation of resource k to each patient in category i with respect to the opportunity cost of the resource.

The h_{ilk} (u_{ilk}) function is defined so that at the value $u_{ilk}=U_{ilk}$ the function vanishes and its slope equates to the corresponding direct marginal resource cost C_k. Thus at ideal standards $u_{ilk}= U_{ilk}$ the contribution to inferred worth of treating extra patients is represented purely by the functions $g_i(d_i)$ and because of the inclusion of direct resource cost in the objective function, the model will not generate standards greater than ideals. Therefore the model represents decisions being taken, in the field, on cover, modes and standards in terms of trade-off between the different terms of a utility function.

A G McDonald proposes the same mathematical model. He first introduces it using cover and cost only, as

$$\text{MAX} \quad \sum_i g_i(d_i) - \sum_i \sum_l \sum_k C_k \, u_{ilk} \, x_{il}$$

$$\text{subject to} \quad \sum_l x_{il} - d_i = 0 \qquad \text{for all } i$$

$$\sum_i \sum_l u_{ilk} \, x_{il} \leq B_{NK} \quad \text{for all } k$$

$$D_{Li} \leq d_i \leq D_{ui} \qquad \text{for all } i$$

where

B_{NK} is the new amount of resource available.

D_{ui} is the upper bound demand from patients in category i.

D_{Li} is the lower bound demand from patients in category i.

Here the number of patients receiving care is variable (d_i) but the new amount of resources is changed and denoted by B_{NK}. Further there are also defined an absolute lower bound and upper bound (D_{Li} & D_{ui}) on the demand from patient in category i.

He then reaches exactly the same model introduced by Gibbs by adding the bounded constraints for the u_{ilk} to the model, (12).

I.L.Coverdale's approach to the maximization of utility or inferred worth function is defined in a slightly different way from Gibbs and McDonald's although based on the same concept. His model is the maximization of,

$$\sum_j \sum_k b_{jk}\, h_{jk}\,(g_{jk}) + \sum_i D_i g_i\,(p_i) - \sum_j \sum_k C_k\, a_{jk}$$

subject to

$$\sum_l x_{il} = D_i p_i \qquad \text{for all } i$$

$$\sum_{i\varepsilon j} \sum_l u_{ilk}\, x_{il} = b_{jk} \qquad \text{for all } j \text{ \& } k$$

$$\sum_j a_{jk} \leq A_k \qquad \text{for all } k$$

$$q_{jk} \cdot b_{jk} = a_{jk} \qquad \text{for all } j \text{ \& } k$$

where

i is categories of patients.

j is groups of client.

k is services (resources).

l is the mode within a category.

a_{jk} is the amount of service k used by client group j.

b_{jk} is the amount of service k to reach desirable service levels in client group j.

C_K is the unit cost of service k.

q_{jk} is the quota of service k in client group j (this will be fixed at 1.0 for irreducible services).

x_{il} is the number of clients from the ith category in the lth mode of care.

A_k is the availability of service k.

D_i is the number of potential clients in category i.

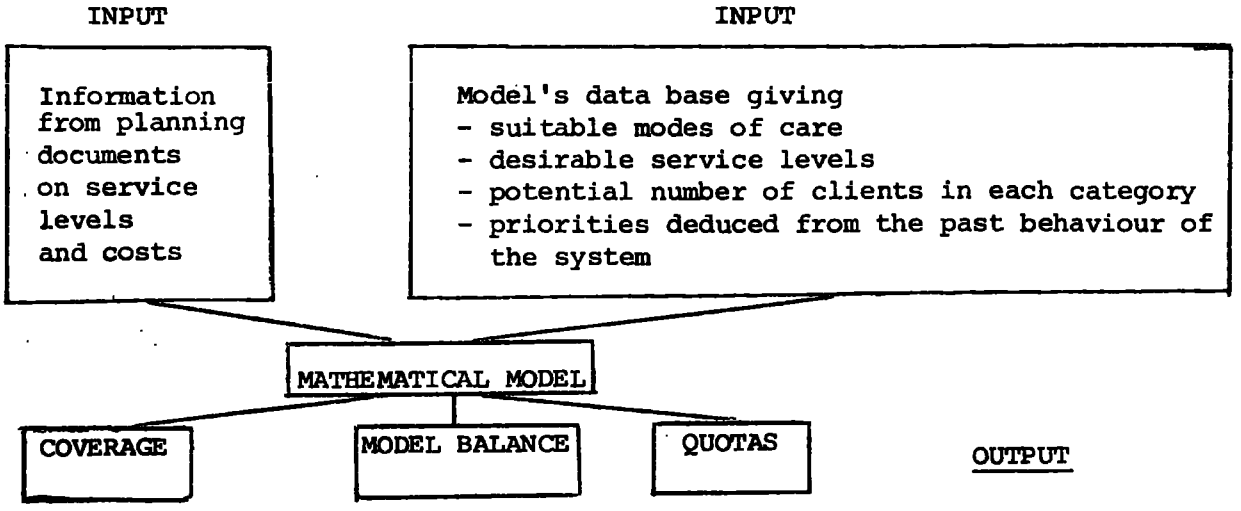
p_i is the coverage in category i, i.e. $p_i = d_i/D_i$ in previous notation.

u_{ilk} is the desirable level of service k to be given to a client of the ith category in the lth mode.

Again h and g will be calibrated to reflect the behaviour of the system of Utility function(curve) but, whereas utility curves are ordinarily used in normative models, here they are used in a predictive role. The g functions reflect the worth of caring for clients at desirable service levels and the h functions are negative reflecting the penalty of falling short of these levels.

The input and output of this model is shown below :

FIG. 2



2.6 CONSTRAINTS AND RESOURCES - COSTS

Any attempt to model the health care problem must include the limit to some resources, since under periodical conditions it is inevitable that there must be a restriction on the use of resources.

Demand has to be estimated anyhow, although it is not a simple job, especially for the elderly and those who receive some domiciliary care. Future demand can be obtained by considering the current demand in proportion to population trend.

Availability of resources, such as the home visits by nurses, number of hospital beds, residential places, meals-on-wheels, etc, can be obtained from DHSS records (24). Most of the resources can be used by more than one category of patient.

For each resource a short-term and a long-term marginal unit cost should be estimated where it is assumed that they are linear (12). Some assumptions usually related to the resources are (i) that resource use for each case should be independent of resource availability - thus maintaining standards ; (ii) that resource costs are linear with respect to the amount available ; and (iii) that potential demand is not less than present demand.

After the main constraints are developed in a health care model, usually resource constraints and demand constraints, then it is easy to add extra refinement to the model. For example in the model introduced by Coverdale he suggests a set of lower bound and upper bound constraints to the resource constraints and McDonald suggests a set of constraints for the demand constraints of his model as well. These are given in the next section.

2.7 DECISIONS

As was mentioned earlier the stated objectives of the government and health care planners are general ones to give relief of pain to the

community and in particular to help elderly to remain in the community as long as possible. However, the health model must specify a quantitative objective, e.g. maximizing the health utility subject to the service constraints which are positively associated to cost or alternatively providing adequate care to each individual while trying to minimize the relevant cost, or some combination of these.

In the case of the model developed by Torrance, the criterion is to maximize the total effectiveness for the given constraints, thus maximizing the increase in health utility for society. The model is formulated as follows :

$$\text{MAXIMIZE} \quad \sum_{i=1}^{n} e_i x_i$$

$$\text{Subject to} \quad \sum_{i=1}^{n} c_i x_i \leq c$$

$$\sum_{i \in I_j} x_i \leq 1 \quad j = 1, 2 \text{ -----}$$

$$x_i = 0, 1 \quad i = 1, 2 \text{ -----} n$$

where

$x_i = 1$ implies that ith programme is in the solution (accepted).

$x_i = 0$ implies that ith programme is not accepted.

e_i is the effectiveness of the ith programme.

c_i is the cost of ith programme.

c is the total budget available.

I_j is the jth set of mutually exclusive programmes.

The addition of extra constraints is easily possible, for example if it is desired to individually constrain the number of hospital bed-days to no more than the total number available B then the constraints are

$$\sum_{i=1}^{n} b_i x_i \leq B$$

where b_i is the amount of resource (bed) used by the ith programme.

This model has been used and tested on three different health-care programmes. The model takes a society-wide view of costs. However, it is sufficiently flexible that other cost definitions could be readily substituted if desired.

The next model to be described is cost minimization model introduced by McDonald. This model will be very useful as it is going to be applied in a modified form in the next chapter to the health care for elderly in Durham County.

McDonald argues that there are so many combinations of the alternative resource uses for each patient that are applied in practice, and since the aim is to reduce the area of decision, we must search for the "best" combination of alternatives or to find the best allocation of alternative use of resources to different categories. Most of the time the best allocation of services to categories will not be accepted by the authorities even if it reduces the cost of the plan, because the best allocation of alternatives in minimizing the cost, does not always guarantee the maximum health for the community. But as the author argues the cost minimization sort of objective is very easy to interpret. The model finds the minimum cost of allocation of resources to categories of patient to satisfy a given number of patients, (case-load).

The basic model is shown below :

$$\text{MINIMIZE} \quad \sum_{k} C_k \sum_{i} \sum_{l} u_{ilk}\, x_{il}$$

$$\text{Subject to} \quad \sum_{i} \sum_{l} u_{ilk}\, x_{il} \leq B_k \qquad \text{for all } k$$

$$\sum_{l} x_{il} \geq D_i \qquad \text{for all } i$$

$$x_{il} \geq 0$$

where

i is a category of patient.

l is an alternative set of resources uses per patient.

k is a resource.

x_{il} is the number of patients from category i to be allocated alternative l.

c_k is the given unit cost of resource k.

u_{ilk} is the given use of resource k per patient from category i under alternative l.

D_i is the given number patient under category i (case-load).

B_k is the given availability of resource k.

The model can be expanded in objective function and constraints as well. For example introduction of a new variable for calculation of short-term marginal cost. It permits resources to be increased up to given limits at additional capital cost. Any cost of preventive programmes can be included with the assumptions about the consequent decrease in the level of care.

Some data like estimates of demand, costs and resources available

are bound to error so some sensitivity analyses can be applied.

In order to achieve a satisfactory cover to the potential demand by the available resources two measures are introduced.

(i) RESOURCE USAGE FACTOR,

(ii) PERCENTAGE OF POTENTIAL DEMAND.

Resource Usage Factor is a hypothetical proportion of the "acceptable" use of some resources by each patient. Some of the resources (viz. hospitals and residential homes) are considered as irreducible, and some like district nurses. Part-time domestic help and meals can proportionally be reduced.

Percentage of Potential Demand can be achieved by assigning a general proportion of demand say θ to each demand constraints, so the model may turn to be

$$\text{MINIMIZE} \quad \sum_k C_k \sum_i \sum_l u_{ilk}\, x_{il}$$

$$\sum_l x_{il} \geq \theta D_i \qquad \text{for all } i$$

$$\sum_i \sum_l u_{ilk}\, x_{il} \leq B_k \qquad \text{for all irreducible } k$$

$$A \sum_i \sum_l u_{ilk}\, x_{il} \leq B_k \qquad \text{for all reducible } k$$

$$x_{il} \geq 0$$

where A & θ are parameters and are defined as

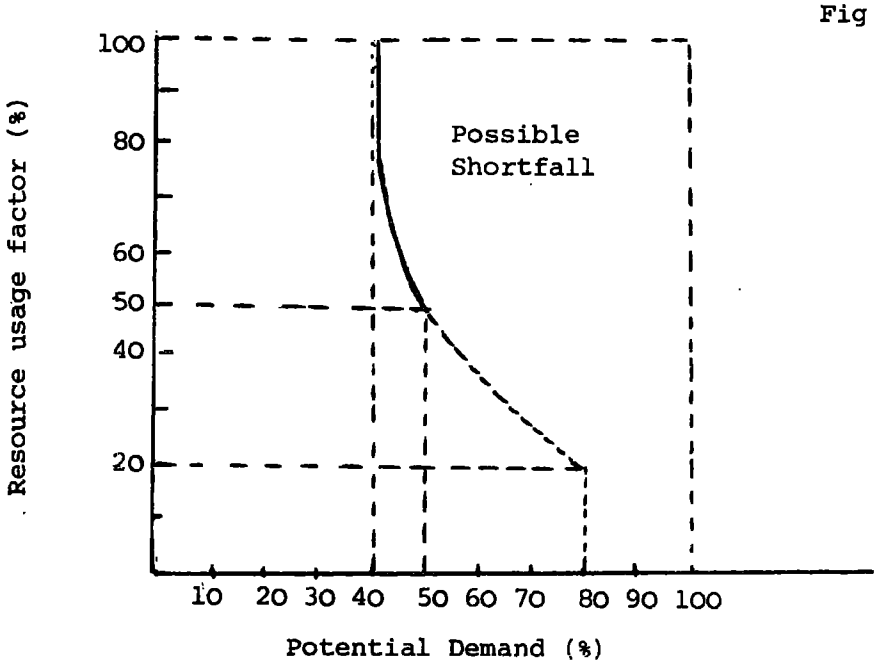
A General resource use reduction factor

θ General proportion of demand

If a general resource usage factor and a general proportion of demand are applied to all categories and appropriate resources, and to all categories in the elderly section of the model respectively, then the ideal situation is when both A's and θ's percentage are 100.

The relationship between the two measures is shown in the following figure :

Fig 3.



If we assume that the above figure shows the domiciliary care for the patients then the graph indicates that only 40% of potential demand can receive full care each, or 50% of potential demand can be considered with 50% of acceptable domiciliary care can be given to each patient or any other acceptable combination in between.

If the resource level changes from current to future value, it may affect the pattern of care. The mathematical model could be used to investigate the optimum way of changing this pattern.

This situation has been fully explored by McDonald but the result of his approaches are not available but we try to tackle the problem in some modified approaches and discuss the results in the next chapter.

2.8 BALANCE OF CARE

Finally we look at the Balance of Care model produced by different researchers, (McDonald, Gibbs and Coverdale).

As mentioned ealier (page 35) the principal assumption in this model is that the service, in rationing the resources, attempts to maximize a utility function of its own involving cover, modes, and standards, subject to certain constraints. The objective finally used is a multiple one, containing not only positive utility but also the negative function

$$\sum_i \sum_l \sum_k c_k u_{ilk} x_{il}$$

thus including an element of cost minimization. Hence the objective in the Balance of Care model combines minimization of the costs associated with different resources, with maximization of amount of health delivered to the community.

The unknown parameters occuring in the utility function including the relative weighting of these two factors, can then be estimated from information on the past functioning of the system.

CHAPTER 3

3.1 SUMMARY

This chapter consists of three related sections. In the first section a complete review is given of the data and information regarding categories of elderly clients, services and resources available to them that were required to run the model. The alternatives and standards of care, and unit costs related to each service, are specified arbitrarily and are subject to alteration ; they have been developed making use of what information was available.

Section two describes the models produced to tackle the problem of cost minimization for the care given to elderly clients. To satisfy the feasibility condition it is necessary to alter the availability of resources, the demand variables, or the standards of care, in other words we must either give full care to part of demand, or provide less care, or be prepared for an extra cost for the shortage of resources to be covered. On this basis five approaches are made which will be described.

Section three gives the results related to each model ; results are picked up from the computer outputs and are organized in tabulated form for quick interpretation. Finally, some conclusions are drawn about the value of this approach.

3.2 INPUT DATA FOR MODEL

3.2.1 Sources of Information

The model that we are going to develop is a model appropriate to planning care for the elderly people in Durham County in 1981.

Data on the categories of elderly clients ; services provided to them ; alternative of care and standards ; and availability of resources were derived from three different sources of information. (ii) Durham Area Health Authority Strategic Plan 1977 ∿1986 (25). (ii) Durham County Council Social Services Department, position statement 1978 (27). (iii) A census carried out in 1978 which specified all the services being supplied at that time to all clients currently referred to the Social Service Department, and defined categories of such clients.

3.2.2 Categories of Elderly Clients

The categories of elderly client used in the Durham County census mentioned above were defined as follows :

1. Completely dependent elderly clients including psycho-geriatric patients.
2. Elderly clients with at least three physical handicapped.
3. Elderly blind or partially sighted clients.
4. Elderly clients with impaired hearing.
5. Elderly clients unable to bathe and/or use the toilet unaided.
6. Elderly clients unable to clean their houses and/or go out of their houses unaided.
7. Elderly clients unable to cook adequately unaided.
8. Frail elderly clients.
9. Other elderly clients (demanding social services).

These categories differ slightly from those used in the Balance of Care study. They were produced after a pilot study of Durham Social Service files. Since quantitative information was available under local

conditions using these categories, they are the ones which have been taken as the basis for the model to be used.

The census included 1613 clients in the above categories. These were of course only the clients currently being dealt with. The total number receiving services in 1978 was 12.21 per 1000 total population (29). The distribution of the current figures among the different categories is as shown in Table 1.

TABLE 1 : Distribution of elderly clients in 1978 Durham Census between categories.

Categories	1	2	3	4	5	6	7	8	9
% of Elderly Clients	14.07	11.78	18.72	3.97	2.42	7.81	1.24	23.43	16.55

From these figures the estimated numbers in these categories requiring services in 1981 (assuming same distribution) are as shown in Table 2, based on the total number of population (603071) projected in 1981 (Chapter I Table 3) and the same proportions as given above. In fact the number of 12.21 per 1000 population dealt with in 1978 has increased from 8.31 per 1000 in 1974 and so it might be taken as even higher in 1981, thus the values given are conservative. Therefore, for example, the estimated number of elderly people in Category 1 in 1981 is

603071 x (12.21/1000) x (14.07/100) = 1036.

TABLE 2 : Total potential demand $\equiv \sum_{i} D_i = 7363$

Categories	1	2	3	4	5	6	7	8	9
Projected Case Loads (D_i's)	1036	867	1378	292	179	575	92	1725	1219

3.2.3 Services, Alternatives, Standards

(i) Services: The services provided to the elderly people by the Social Services Department in Durham County were obtained mainly from the literature related to the 1978 census, and some were confirmed verbally by the authorities in the Social Services Dept., at County Hall. The census included the following services :

1. Homes for the elderly - long stay.
2. Homes for the elderly - short stay.
3. Sheltered housing.
4. Day centres.
5. Day care within homes for the elderly.
6. Home helps.
7. Meals-on-Wheels.
8. Adaptations structural alterations.
9. Aids.
10. Telephones - Rentals.
11. Telephones - Installations.
12. Domiciliary health service, e.g. health visitor, chiropody.

13. Occupational therapy.

14. Craft instructors.

15. Technical officer services - Blind.

16. Technical Officer services - Deaf.

17. Hospital based social work.

Two more services which are not included in the above services, but have been given in other literatures (27,29) are :

1. Hospital beds.

2. Residential places.

The above services could be divided into three different groups (a) locations (b) community support and (c) services which are once and for all.

(a) Locations : Before providing any support and services to the elderly clients, they must be located in one of the following places :

1. Hospitals.

2. Houses for the elderly,long-stay.

3. Houses for the elderly, short-stay.

4. Sheltered housing.

5. Own homes.

(b) Community Support : Suitable support in the form of the following services can be assigned to the elderly clients according to their state of health :

1. District health visits.

2. Chiropody services.

3. Home helps.

4. Meals.

5. Attendance at geriatric hospital.

6. Attendance at day place hospital for occupational therapy, etc.

7. Day centres.

(c) Services provided once and for all :

1. Telephones - Rentals.

2. Telephones - Installations.

3. Adaptation, structural alterations.

4. Aids.

5. Bus concessions, etc.

All the services available can be used by more than one category of patient. The services we are going to use in the model exclude the services mentioned in (c).

(ii) Alternatives: Available services will be provided singly or in a combination of 2 or more as an alternative package usually on the basis of mutual agreement and understanding between social workers, and each individual. It all depends on the state of the elderly client and the location he is in.

In this study it is assumed that at least some services will be scarce and that it is therefore adequate to provide the elderly clients in a specific category with one of several alternative packages of care.

Definition of different sorts of alternatives is not an easy job to do. In a discussion with one of the authorities in Social Services Department, he ironically argued that the number of alternative package of services can be equal to the number of individuals ? But as we categorize the elderly client into groups with similar states and requirements, their variety of needs have also to be combined in the form of alternative packages.

Six definitions of alternative resource uses for each elderly client category have been selected on the basis of the results of the 1978 Durham Census which listed the different modes of care delivered to 1613 elderly patients in Durham County. The 6 alternatives for each category

have been adopted because they have the highest frequency of use for clients in that category. The assumption is, as with the Balance of Care model, that the alternatives are equally desirable.

It may well be that the process for obtaining the possible alternatives of care is not entirely satisfactory nor free from error. Many studies in great depth need to be done to verify the inductive data on resource uses with actual uses deduced from observation. However, these alternatives are the best available under local conditions.

The alternative resource requirements for the 9 categories of elderly clients are shown in Tables 5 - 13.

(iii) Standards : The form of care is a rating of the services involved, while the standards of care are expressed in terms of the amount of each service received each week, for example, for an elderly client with at least three physical handicaps (category 2), we may put him at his/her own home and furnish him/her with two district health visits per week, three hours of home helps per week, four numbers of meals per week and take him/her to the day centres every other week (alternative 6). Although some of the standards were based on the information obtained from the literature, for example, the average number of hours of home help service per week client per week is 4.45 (27,29), most of the standards were based on general impressions rather than on objective data.

The standards (u_{ilk}) which are the technological coefficients of the resource constraints of the model are listed in Tables 5 - 13. Standards like alternatives can be varied and tested in the model to evaluate the consequences.

3.2.4 Costs

The marginal unit costs were fixed for each resource on the assumption that they are linear. In other words, the total cost of a resource resource is assumed to be proportional to the amount of resource after allowing a fixed cost.

The information regarding the cost of services like home helps and meals-on-wheels were obtained from the literature (Social Services, Durham County Structural Plan, Technical Paper, No.6) after considering a reasonable rate of inflation from 1974 until 1981. The costs for the other services are fixed on an arbitrary basis.

The value used for unit cost (C_k) of each service (resource) are shown in the table below:

TABLE 3 :

No	Services	Unit	Unit Cost (C_k) £
1	District health visits	Hrs/visits per week	5.00
2	Chiropody	Hrs/visits per week	6.00
3	Home helps	Hrs per week	1.20
4	Meals	Number/times per week	0.60
5	Geriatric Hospital	Attendance per week	10.00
6	Day Place Hospital	" "	7.00
7	Day Centres	" "	4.00

Costs for the services listed in (a) are regarded as being fixed and considered as overhead costs. Thus the model deals only with costs of services in (b), as listed above.

3.2.5 Resources Available

The total amount of services in terms of its appropriate unit delivered to the total elderly demand is called the availability of that resource. In other words when we have a service known as Chiropody Service, provided to the elderly clients, we must obtain or calculate the total hours available for this service assuming that a chiropodist can give his useful services to each patient within an hour including the time consumed for his going and coming to the patients.

As we have 7 forms of services provided to the elderly clients (excluding housing and accommodation services) therefore we have obtained the availability of 7 resources related to these services from the different literatures like Durham Area Health Authority Strategic Plan 1977 ∿ 1986 ([25]) and Durham County Council Social Services Department, position statement 1978 ([27]).

For the resources which are in terms of hours available per week, an average of 40 hours per week per social worker has been calculated (ignoring overtimes versus leaves).

If k is a resource, then B_k will be the available resource k. The following table shows the availability of resources(B_k's) used.

TABLE 4 : (Services numbered as in Table 3)

Ref: Table 8, Chapter I

No	Resources	Unit	Availability
1	B_1	Visit/hrs per week	5700
2	B_2	" "	592
3	B_3	Hrs per week	34200
4	B_4	Number per week	9998
5	B_5	Attendance per week	9923
6	B_6	Bed/attendance per week	1400
7	B_7	Place/attendance per week	1050

Availability of resources mentioned in (a) are regarded as fixed.

TABLE 5 : Scheme showing alternative requirements for resources and alternative care options, for Category 1 related to those who are completely Dependent elderly clients including Psycho-Geriatric patients.

$D_1 = 1036$

Resources	Alternative Care Options					
Location	1	2	3	4	5	6
1 - Hospital	X					
2 - Houses for elderly-Long stay		X				
3 - Houses for elderly-Short stay						
4 - Sheltered Housing			X	X		
5 - Own Home					X	X
Community Support						
1 - District health visitors			1	1	2	2
2 - Chiropody services	1	1				1
3 - Home helps			3	4	3	3
4 - Meals-on-Wheels			1	2	3	2
5 - Attendance at Geriatric Hos.	7					
6 - Attendance at day place Hos.		7				1
7 - Day centre			2	1	2	

TABLE 6 : Scheme showing alternative requirement for resources and alternative care options, for Category 2 related to those elderly clients with at least three physical handicaps.

$D_2 = 867$

Resources	Alternative Care Options					
Location	1	2	3	4	5	6
1 - Hospital	X					
2 - Houses for elderly-Long stay		X				
3 - Houses for elderly-Short stay			X			
4 - Sheltered HOusing				X		
5 - Own Home					X	X
Community Support						
1 - District health visitors		2	3	2	1	2
2 - Chiropody services	1		1		1	
3 - Home helps		3		3	4	3
4 - Meals-on-Wheels		2		3	2	4
5 - Attendance at Geriatric Hos.			2			
6 - Attendance at Day Place Hos.	5					
7 - Day centre		1	2	1		0.5

TABLE 7 : Scheme showing alternative requirements for resources and alternative care options, for Category 3 related to those elderly blind or partially sighted clients.

$D_3 = 1378$

Resources	Alternative Care Options					
Location	1	2	3	4	5	6
1 - Hospital	X					
2 - Houses for Elderly-Long stay		X	X			
3 - Houses for Elderly-Short stay				X		
4 - Sheltered Housing					X	
5 - Own Home						X
Community Support						
1 - District health visitors			1	1	1	1
2 - Chiropody services						
3 - Home helps		5	3	3	1	2
4 - Meals-on-Wheels		4	5	5	3	3
5 - Attendance at Geriatric Hos.						
6 - Attendance at Day Place Hos.	7		1		2	2
7 - Day centre		1		1	1	

TABLE 8 : Scheme showing alternative requirements for resources and alternative care options, for Category 4 related to elderly clients with impaired hearing.

$D_4 = 292$

Resources	Alternative Care Options					
Location	1	2	3	4	5	6
1 - Hospital	X					
2 - Houses for elderly-Long stay		X	X			
3 - Houses for elderly-Short stay						
4 - Sheltered Housing				X		
5 - Own Home					X	X
Community Support						
1 - District health visitors		1	1	1		
2 - Chiropody services						
3 - Home helps		1		2	3	
4 - Meals-on-Wheels			2			3
5 - Attendance at Geriatric Hos.						
6 - Attendance at Day Place Hos.	7					
7 - Day centre		0.5		0.5		0.5

TABLE 9 : Scheme showing alternative requirements for resources and alternative care options, for Category 5 related to elderly clients unable to bathe and/or use the toilet unaided.

$D_5 = 179$

Resources	Alternative Care Options					
Location	1	2	3	4	5	6
1 - Hospital	X					
2 - Houses for elderly-Long stay		X				
3 - Houses for elderly-Short stay			X			
4 - Sheltered Housing				X	X	
5 - Own Home						X
Community Support						
1 - District health visitors		1		1	2	1
2 - Chiropody services		0.5		0.5		0.5
3 - Home helps		6	3	6	5	7
4 - Meals-on-Wheels		2	5		2	3
5 - Attendance at Geriatric Hos.						
6 - Attendance at Day Place Hos.	6					
7 - Day centre	1	0.5	1	1	1	0.5

TABLE 10 : Scheme showing alternative requirements for resources and alternative care options, for Category 6 related to those elderly clients unable to clean their house and/or go out of their houses unaided.

$D_6 = 575$

Resources	Alternative Care Options					
Location	1	2	3	4	5	6
1 - Hospital						
2 - Houses for elderly-Long stay	X	X				
3 - Houses for elderly-Short stay			X			
4 - Sheltered Housing				X		
5 - Own home					X	X
Community Support						
1 - District health visitors	1	1	1		1	1
2 - Chiropody services	0.5			0.5	0.5	
3 - Home helps	3	4		5	4	5
4 - Meals-on-Wheels	1	2			1	
5 - Attendance at Geriatric Hos.						
6 - Attendance at Day Place Hos.			2			
7 - Day centre		0.5	1	1		1

TABLE 11 : Scheme showing alternative requirements for resources and alternative care options, for Category 7 related to those elderly clients unable to cook adequately unaided.

$D_7 = 92$

Resources	Alternative Care Options					
Location	1	2	3	4	5	6
1 - Hospital						
2 - Houses for elderly-Long stay	X	X				
3 - Houses for elderly-Short stay			X			
4 - Sheltered housing				X		
5 - Own Home					X	X
Community Support						
1 - District health visitors		1	1	1		
2 - Chiropody services	0.5					
3 - Home helsp	2	1	2	1	3	3
4 - Meals-on-Wheels	4	5	5	5	4	4
5 - Attendance at Geriatric Hos.						
6 - Attendance at Day Place Hos.						
7 - Day Centre	1	0.5		1	1	1

TABLE 12 : Scheme showing alternative requirements for resources and alternative care options, for Category 8 related to those frail elderly clients.

$D_8 = 1725$

Resources	Alternative Care Options					
Location	1	2	3	4	5	6
1 - Hospital	X					
2 - Houses for elderly-Long stay		X	X			
3 - Houses for elderly-Short stay				X		
4 - Sheltered Housing					X	
5 - Own Home						X
Community Support						
1 - District health visitors		2	2	1	1	1
2 - Chiropody services	1			1	0.5	
3 - Home helps		5	5	5	6	6
4 - Meals-on-Wheels		3	4	3	4	5
5 - Attendance at Geriatric Hos.	7					
6 - Attendance at Day Place Hos.						
7 - Day Centre		1		1		1

TABLE 13 : Scheme showing alternative requirements for resources and alternative care options, for Category 9 related to elderly clients who are not included in Categories 1 - 8 assuming to be in a better health state.

$$D_9 = 1219$$

Resources	Alternative Care Options					
Location	1	2	3	4	5	6
1 - Hospital						
2 - Houses for elderly-Long stay	X					
3 - Houses for elderly-Short stay		X				
4 - Sheltered Housing			X	X		
5 - Own home					X	X
Community Support						
1 - District health visitors	1	1		1		1
2 - Chiropody services			0.5		0.5	
3 - Home helps	1	2	2	3	3	2
4 - Meals-on-Wheels	1	2	2		1	1
5 - Attendance at Geriatric Hos.						
6 - Attendance at Day Place Hos.						
7 - Day centre	1			0.5	0.5	1

3.3 STATEMENT OF CONSTRAINTS OF MODEL

Because available resources cannot provide acceptable cover to satisfy potential demand, it has to be assumed that the overall usage of each resource must not exceed the availability of that particular resource. Hence, if u_{ilk} are the cover or use of the resource k in category i under alternative l and if x_{il} are the elderly clients in category i under alternative l

$$\sum_{i} \sum_{l} u_{ilk} x_{il} \leq B_k \qquad \text{for all } k$$

where B_k is the availability of resource k. Since the above inequalities restrict us from using more resources than are available we call them Resource Constraints hereafter.

The restriction on the number of people being treated is that the potential demand of elderly clients, or the case loads in each category, must not be more than the number of elderly clients who are currently receiving care. If x_{il} are the number of elderly clients in category i under alternative of care l, and if D_i is the case load in category i, then

$$\sum_{l} x_{il} \geq D_i \quad \text{for all } i$$

The name of Demand constraints will be used for these constraints hereafter.

3.4 FORMULATION OF THE DECISION PROBLEM

For productional use the adopted model needs to be straightforward, easy to understand and as uncontroversial as possible.

It has been decided to avoid any attempt either to formulate a utility function or to maximize health directly. Instead it was decided to minimize operating costs. Although less emotionally attractive than

maximizing health or some other interpretation of benefit, cost minimization has the advantage that the results are easier to interpret. While the ultimate objective is maximizing health, the area of decision is limited by resources. This model deals with the minimum cost allocation of resources to categories of patient to satisfy a given case-load.

The specification of the model is shown below.

$$\text{minimize} \quad \sum_{k} C_k \sum_{i} \sum_{l} u_{ilk}\, x_{il}$$

Subject to

$$\sum_{l} x_{il} \geq D_i \quad \text{for all } i$$

$$\sum_{i} \sum_{l} u_{ilk}\, x_{il} \leq B_k \quad \text{for all } k$$

$$x_{il} \geq 0 \quad \text{for all } i \text{ \& } l$$

where

i is a category of patient ($i = 1,\ldots,9$)

l is an alternative set of services uses per patient ($l = 1,\ldots,6$)

k is a resource ($k = 1, \ldots,7$)

x_{il} is the number of elderly patients from category i to be allocated alternative l.

C_k is the given unit cost of resource k (Table 3).

u_{ilk} is the given use of resource k per patient from the category i under alternative l (Technological coefficients u_{ilk} are shown in Tables 5 to 13)

D_i is the given potential demand in category i ($\sum_i D_i = 7363$, Table 2)

B_k is the given availability of resource K (Table 4).

When this model was run through a computer package (subroutine H01 AEF NAG FLIB : 1134/671 : MK5 : JUL 75) for the given data (Di's, B_k's, u_{ilk}'s) it was found to be infeasible because the demand and resource constraints were incompatible (16,17).

3.5 FEASIBILITY AND OPTIMALITY

A number of modified models for which feasible solutions are obtainable can be specified ; each involves some loss of desirable features. For the result of each model several related tables have been produced. These tables give the allocation of elderly clients from each category to a particular alternative of care (values of x_{il}'s) the percentage of satisfied demand in each category ($100 \sum_{l} x_{il}/D_i$), and the percentage of each resource used ($100 \sum_{i} \sum_{l} x_{il}\, u_{ilk}/B_k$) together with the average usage of each resource per person (i.e. an average cover).

Description of these models now will be given with their results.

1. Removal of Resource constraints

A major simplification is to solve the problem :

$$\text{Minimize} \quad \sum_{k} C_k \sum_{i} \sum_{l} u_{ilk}\, x_{il}$$

$$\text{subject to} \quad \sum_{l} x_{il} \geq D_i \quad \text{for all } i$$

$$x_{il} \geq 0 \quad \text{for all } i \text{ and } l$$

which corresponds to satisfying all demands at minimum cost ; that is the demand ratio $\alpha_i = 100\%$ for all i. The corresponding required resources B_k', can then be calculated from

$$B_k' = \sum_{i} \sum_{l} u_{ilk}\, x_{il}$$

by substituting the values of x_{il}'s obtained from the above model. This result is also the solution to the problem of minimizing cost subject to the given demand constraints if resources B_k' were available. The values of x_{il} produced by this model are given in Table 16.1, the ratio $B_k B_k'/B_k$ by which the kth resource needs to be increased in Table 16.2, and the full analysis in Table 16.3.

2. Modified Demand Constraints

Another alternative model is produced by finding the minimum cost solution subject to modified demand variables (D_i's). This can be done by assigning $0 \leq \alpha_i \leq 1$ to corresponding potential demands ($\bar{D}_i$'s), while trying to maximize the number of clients to be given care ; the model then becomes

$$\text{Maximize} \quad \sum_i \alpha_i D_i$$

STAGE 1.

$$\text{Subject to} \quad \sum_i \sum_l u_{ilk} x_{il} \leq B_k \quad \text{for all } k.$$

$$\sum_l x_{il} \geq \alpha_i D_i \quad \text{for all } i$$

$$\alpha_i \leq 1 \quad \text{for all } i$$

$$x_{il}, \alpha_i \geq 0 \quad \text{for all } i \text{ \& } l$$

Given this result we then solve the problem

$$\text{Minimize} \quad \sum_k C_k \sum_i \sum_l u_{ilk} x_{il}$$

STAGE 2.

$$\text{Subject to} \sum_i \sum_l u_{ilk} x_{il} \leq B_k \quad \text{for all } k$$

$$\sum_{l} x_{il} \geq D'_i \quad \text{for all } k$$

$$x_{il} \geq 0 \quad \text{for all } i \text{ \& } l$$

where $D'_i = \alpha_i D_i$ obtained from Stage 1.

This model corresponds to satisfying a part of the demand with a full standard of care at minimum cost. Results for this problem are given in Tables 17.1 and 17.2.

3. Modified Resource Constraints

A more realistic model than (1) is produced by finding the minimum cost solution subject to increased resource variables (B_k's). We assign $\beta_k \geq 1$ to the available resource B_k but try to minimize the additional resource cost.

This leads to the following formulation

Minimize $\sum_{k} C_k \beta_k B_k$

STAGE 1.

Subject to $\sum_{i} \sum_{l} u_{ilk} x_{il} \leq \beta_k B_k$ for all k

$$\sum_{l} x_{il} \geq D_i \quad \text{for all } i$$

$$\beta_k \geq 1 \quad \text{for all } k$$

$$x_{il} \geq 0 \quad \text{for all } i \text{ \& } l$$

Note that the additional cost is $C_k (\beta_k - 1) B_k$ but that $\Sigma C_k B_k$ is of course fixed).

Having obtained the values of β_k we then calculate the new values for required resources $B'_k = \beta_k B_k$. Then substituting these newly obtained resource limits in the main model, minimum operating cost requires the solution of the problem :

$$\text{Minimize} \quad \sum_k C_k \sum_i \sum_l u_{ilk} \; x_{il}$$

STAGE 2.

$$\text{Subject to} \quad \sum_i \sum_l u_{ilk} \; x_{il} \leq B'_k \quad \text{for all } k$$

$$\sum_l x_{il} \geq D_i \quad \text{for all } i$$

$$x_{il} \geq 0 \quad \text{for all } i \text{ \& } l$$

where $B'_k = \beta_k B_k$.

This model corresponds to satisfying full demands in all categories at minimum operating cost, having supplied extra resources at minimum additional expense. Results for this problem are given in Tables 18.2 and 18.3.

4. Modified Standards of Care (Cover)

One alternative model to the previous ones that we described, is allocation of less care for everybody in such a way that the resource constraints are not violated. This is possible by using a fraction of provision of standards of care ; we assign θ, $0 \leq \theta \leq 1$ to each technological coefficient in the resource constraints and objective function and solve the following model :

Minimize $$\theta \sum_k C_k \sum_i \sum_l u_{ilk}\, x_{il}$$

Subject to $$\theta \sum_i \sum_l u_{ilk}\, x_{il} \leq B_k \quad \text{for all } k$$

$$\sum_l x_{il} \geq D_i \quad \text{for all } i$$

$$x_{il} \geq 0 \quad \text{for all } i \text{ \& } l$$

We try to solve the above system with $\theta = .9, .8, \ldots$ until a feasible solution is found. This will indicate what overall level of service is possible.

After we reach a feasible solution we extend to $\theta = .1$, and plot the final minimum cost against θ (Graph 1).

Results for this problem are given in Tables 19.1 and 19.2 to 25.1 and 25.2. As can be seen from the graph the solution starts to be linear with θ, i.e. to be fixed at the same corner of the feasible space, after reducing the standard of care to 30%. For this reason we have omitted the tables related to the results of 25%, 20%, 15% standard of care.

5. Varying θ According to Resources

A more realistic model than model 4 is produced by finding the minimum cost solution subject to modifying the standard of care (cover) according to resources. In other words, since a unified proportion or fraction of standards of care for all the resources cannot be always justified, it is therefore recommended to assign different values of θ_k, $0 \leq \theta_k \leq 1$ to the corresponding standards in each of the resource constraints.

Realistically upper and lower bounds should be set on the θ_k, and an overall average level should be kept.

The following model can be used to obtain suitable values for θ_k's.

$$\text{Minimize} \quad \sum_k \theta_k \sum_i \sum_l u_{ilk} C_k$$

$$\text{Subject to} \quad \sum_l x_{il} \geq D_i \quad \text{for all } i$$

STAGE 1

$$A_L \leq \theta_k \leq A_u \quad \text{for all } k$$

$$\frac{1}{n} \sum_k \theta_k = A_m \quad k = 1 \ldots\ldots n$$

$$\theta_k > 0 \quad \text{for all } k$$

where A_u is the given upper bound of percentage of acceptable standards of care.

A_L is the given lower bound of percentage of acceptable standard of care

A_m is the value of θ obtained in (4) i.e. the productive overall level of service.

n is the number of services provided (always equal to the number of resource constraints).

Here $A_u = 0.70$ (assumed)

$A_L = 0.30$ (assumed)

$A_m = 0.55$ (estimated)

$n = 7$ (exist)

The results for θ_k is given in Table 26.1

In order to calculate the minimum operating cost these values of θ_k are put in the following model

$$\text{Minimize} \sum_k \theta_k C_k \sum_i \sum_l u_{ilk} x_{il}$$

STAGE 2.

Subject to

$$\theta_k \sum_i \sum_l u_{ilk} x_{il} \leq B_k \quad \text{for all } k$$

$$\sum_l x_{il} \geq D_i \quad \text{for all } i$$

$$x_{il} \geq 0 \quad \text{for all } i \text{ \& } l$$

The results for this problem is given in Table 26.1 and 26.2.

3.6 CONCLUSIONS

As we said at the beginning of the first chapter, the target of Health and Personal Social Services is the health care and social support of the community as fully as possible. Expansion of resources required for this purpose could be a solution, but as we again mentioned, community's expectations grows and standards of care have to cope with this growth. This would make the task difficult and the aims hard to achieve. The model developed in this chapter demonstrates the difficulty since the initial specification proves to be infeasible.

The solution of models 1-5 provide figurs showing the allocation of elderly clients under each alternative mode of care, i.e. the number of

elderly people in category i dealt with under alternative 1, together with the amount of resources being used, the average standard of care delivered and finally the minimum cost for each approach.

Any decision would have to be made on the basis of these results. Now we are left with five alternative solutions generated from these five models, each having its own particularities.

From the first model, results show that with an operating cost of £97580.00 the full demand in all categories can be satisfied. However, this implies a substantial shift of resource provision. By comparing the required calculated resources with the current available resources it is obvious that all the resources have to be shuffled either to be increased, like chiropody services, meals and day centre capacities or decreases, like health visits and home helps ; some have fallen to zero level like geriatric beds and day place hospital beds.

Under model two part of categories 1, 3 and 8 and the whole of categories 2 and 5 would not be treated at all. Only 69% of overall demand can be met, but with full services. The minimum cost for this sort of arrangement would be £113684.00. Out of this £51170.00 are due to the expensive services of geriatrix beds and day place hospitals. By reducing the cost of provision of these two services a great effect on overall cost could be achieved. However, a solution which drops altogether category 2, i.e. those elderly clients with three physical handicaps and category 5, i.e. the elderly clients unable to bathe and/or use the toilet unaided, is hardly a realistic one.

Model 3 could be a solution to this problem, that is providing to everybody in all categories, all the services with almost full standards. This leads us to provision of more resources in chiropody, meals and day centres services, and capacity. An overall cost of £192658.00 which is the minimum cost would be required to fulfil this ideal arrangement. It is

hard to accept that the department can be financed with this significant high extra weekly cost which generates approximately £10 m yearly budget. So the next alternative could be the reduction of standards of care although we agreed upon the increasing expectation of clients from the government as the technology develops.

Model 4 which gives us a feasible solution at 55% of standard of care generates an overall cost of £70007.12 per week. It is interesting to notice that if the standard level of care fell to 50% the cost will fall by 20% (approx) from £70007.12 to £56579.30.

The differing nature of the services makes the idea of a unified proportional change unrealistic. So model 5 may help to put a proper percentage to the standard of services using each separate resource. This arrangement has given an improved cost of £59611.63, which is the lowest cost so far ; Chiropody services and meals are provided at minimum level (30%) and geriatric beds services fall to zero level.

There are other facts to be considered like the average usage of resources per person. In model 5 standard of chiropody ..... meals services go down to 30% but it allows more people to be provided with these two vital services ; locally there are complaints for lack of chiropody services for everybody (mentioned in chapter one section two).

Once the model is explained the decision depends on the attitude and financial capacity of decision makers. The model can be applied at a national level for prediction of overall costs and required resources. If any of the 5 approaches is adopted it is possible to calculate an average resource increase in any of the categories if the demand rises. We said before, standards and alternatives are subject to alteration and a careful provision of these two factors could give more reliable results and guidance to the management. It is clear that given data of the form used here, this approach is capable of generating feasible alternative solutions for future planning.

TABLE 16.1

Categories	Values of x_{il}'s	$\Sigma x_{il} = D_i$
1	$x_{14} = 1036$	1036
2	$x_{26} = 867$	867
3	$x_{32} = 1378$	1378
4	$x_{46} = 292$	292
5	$x_{53} = 179$	179
6	$x_{61} = 575$	575
7	$x_{75} = 92$	92
8	$x_{85} = 1725$	1725
9	$x_{93} = 1219$	1219
TOTAL	7363	7363

TABLE 16.2 Amount of resources obtained after putting the value of x_{il}'s from the above table in resource constraints.

Resources	New values $B'_k = \beta_k$	Old values B_k	$\beta_k \geq 0$
1	5070	5700	0.8895
2	1759.5	592	2.9721
3	28961	34200	0.8468
4	23104	9998	2.3109
5	0	9923	0
6	0	1400	0
7	2364.5	1050	2.2519

TABLE 16.3

Services / Categories	HEALTH VISITS			CHIROPODY			HOME HELPS			MEALS			GERIATRIC HOSP.			DAY PLACE HOSP.			DAY CENTRES		
	No.of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No.of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average
1	1036	1036	1	-	-	-	1036	4144	4	1036	2072	2	-	-	-	-	-	-	1036	1036	1
2	867	1734	2	-	-	-	867	2601	3	867	3468	4	-	-	-	-	-	-	867	433.5	.5
3	-	-	-	-	-	-	1378	6890	5	1378	5512	4	-	-	-	-	-	-	1378	1378	1
4	-	-	-	-	-	-	-	-	-	292	876	3	-	-	-	-	-	-	292	146	.5
5	-	-	-	-	-	-	179	537	3	179	895	5	-	-	-	-	-	-	179	179	1
6	575	575	1	575	287.5	.5	575	1725	3	575	575	1	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	92	276	3	92	368	4	-	-	-	-	-	-	92	92	1
8	1725	1725	1	1725	862.5	.5	1725	10350	6	1725	6900	4	-	-	-	-	-	-	-	-	-
9	-	-	-	1219	609.5	.5	1219	2438	2	1219	2438	2	-	-	-	-	-	-	-	-	-
TOTAL	4203	5070	1.21	3519	1759.5	.5	7071	28961	4.1	7363	23104	4.14	0	0	-	0	0	-	3844	3264.5	.85
%	57.1	100		47.8	100		96	100		100	100		0	0		0	0		52.2	100	

OPTIMUM VALUE = £97580.60

TABLE 17.1

Categories	Values of x_{il}'s	$\sum_e x_{il}=D_i$	$\alpha_i = D_i/D_i$	D_i'
1	x_{11}=590, x_{14}= 2	1036	0.5714	592
2	x_{22}= 0	867	0.0	0
3	x_{32}= 102, x_{36}=554	1378	0.4762	656
4	x_{45}= 292	292	1.0	292
5	x_{53}= 0	179	0.0	0
6	x_{61}=2, x_{62}=473, x_{66}=100	575	1.0	575
7	x_{73} = 92	92	1.0	92
8	x_{81}= 1, x_{83} = 1629	1725	0.9449	1630
9	x_{94}= 1219	1219	1.0	1219
TOTAL	5056	7363		5056

TABLE 17.2

Services / Categories	HEALTH VISITS			CHIROPODY			HOME HELPS			MEALS			GERIATRIC HOSP.			DAY PLACE HOSP.			DAY CENTRES		
	No.of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No.of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average
1	2	2	1	590	590	1	2	8	4	2	4	2	590	4130	7	-	-	-	2	2	1
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	554	554	1	-	-	-	656	1618	2.5	656	2070	3.15	-	-	-	554	1108	2	102	102	1
4	-	-	-	-	-	-	292	876	3	-	-	-	-	-	-	292	292	1	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	574	575	1	2	1	.5	575	2398	4.17	475	948	2	-	-	-	-	-	-	573	336.5	.6
7	92	92	1	-	-	-	92	184	2	92	460	5	-	-	-	-	-	-	-	-	-
8	1629	3258	2	1	1	1	1629	8145	5	1629	6516	4	1	7	7	-	-	-	-	-	-
9	1219	1219	1	-	-	-	1219	3657	3	-	-	-	-	-	-	-	-	-	1219	609.5	.5
TOTAL	4071	5700	1.4	593	592	1	4465	16886	3.8	2854	9998	3.5	591	4137	7	846	1400	1.7	1896	1050	.55
%	55.29	100		8.1	100		60.5	49.4		38.76	100		8	41.7		11.5	100		25.75	100	

OPTIMUM VALUE = £113684.

TABLE 18.1 Value of β_k obtained through the model described in Section 3 of this chapter.

Resources	β_k	Available Resources B_k	Required Resources $B'_k = \beta_k . B_k$
1	1	5700	5700
2	2.3945	592	1418
3	1	34200	34200
4	1.7454	9998	17450
5	1	9923	9923
6	1	1400	1400
7	2.5967	1050	2727

TABLE 18.2

Categories	Values of x_{i1}'s	$\Sigma x_{i1} = D_i$
1	x_{11}=426, x_{14}=610	1036
2	x_{26}= 867	867
3	x_{31}= 157, x_{33}=1216, x_{36}=45	1378
4	x_{45}= 292	292
5	x_{53}= 179	179
6	x_{62}=575	575
7	x_{73}=92	92
8	x_{81}=990, x_{83}=735	1725
9	x_{92}=1215, x_{93}=40	1219
TOTAL	7363	7363

TABLE 18.3

Services / Categories	HEALTH VISITS			CHIROPODY			HOME HELPS			MEALS			GERIATRIC HOSP.			DAY PLACE HOSP.			DAY CENTRES		
	No.of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No.of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average
1	610.5	610.5	1	425.5	425.5	1	610.5	2442	4	610.5	1221	2	425.5	2978.5	7	-	-	-	610.5	610.5	1
2	867	1734	2	-	-	-	867	2601	3	867	3468	4	-	-	-	-	-	-	867	433.5	.5
3	4.5	4.5	1	-	-	-	1221	6091.5	499	1221	4879.5	4	-	-	-	161.5	1108	686	1216.5	1216.5	1
4	-	-	-	-	-	-	292	876	3	-	-	-	-	-	-	292	292	1	-	-	-
5	-	-	-	-	-	-	179	537	3	179	895	5	-	-	-	-	-	-	179	179	1
6	575	575	1	-	-	-	575	2300	4	575	1150	2	-	-	-	-	-	-	575	287.5	.5
7	92	92	1	-	-	-	92	184	2	92	460	5	-	-	-	-	-	-	-	-	-
8	734.6	1469.2	2	990.4	990.4	1	734.6	3673	5	734.6	2938.4	4	990.4	6933	7	-	-	-	-	-	-
9	1214.75	1214.75	1	4.25	2.13	.5	1219	2438	2	1219	2438	2	-	-	-	-	-	-	-	-	-
TOTAL	4098.4	5700	14	1420	1418	99	5790	21131	365	5498	17450	317	1416	9911.5	7	463.5	1400	3	3448	2727	79
%	55.66	100		19.29	100		78.64	61.79		74.67	100		19.23	99.9		6.3	100		46.83	100	

OPTIMUM VALUE = £ 192658.20

TABLE 19.1 (55%)

Categories	Values of x_{il}'s	$\Sigma x_{il} = D_i$
1	x_{11}=108, x_{14}=928	1036
2	x_{22}=276, x_{25}=591	867
3	x_{33}=109, x_{36}=284	1378
4	x_{45}= 292	292
5	x_{54}= 179	179
6	x_{61}= 575	575
7	x_{73}=92	92
8	x_{83}= 1725	1725
9	x_{92}=166, x_{94}=1053	1219
TOTAL	7363	7363

TABLE 20.1 (50%)

Categories	Values of x_{il}'s	$\Sigma x_{il} = D_i$
1	x_{14} = 1036	1036
2	x_{22}=83, x_{25}=179, x_{26}=587	867
3	x_{32}=509, x_{36}= 869	1378
4	x_{45}= 292	292
5	x_{54}= 179	179
6	x_{61}= 575	575
7	x_{73}= 92	92
8	x_{83} = 1725	1725
9	x_{93} = 1219	1219
TOTAL	7363	7363

TABLE 19.2

Services / Categories	HEALTH VISITS			CHIROPODY			HOME HELPS			MEALS			GERIATRIC HOSP.			DAY PLACE HOSP.			DAY CENTRES		
	No.of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No.of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average
1	928	510.4	.55	108	59.4	.55	928	2041.6	2·2	928	1020.8	1·1	108	416.6	385	-	-	-	928	510.3	.55
2	867	629	1·32	591	325.2	.55	867	1755.7	2·02	867	953.7	1·1	-	-	-	591	325.2	·55	276	151.7	.55
3	1378	758	.55	-	-	-	1378	2117.3	1.5	1378	3476.8	25	-	-	-	1378	914.3	·66	-	-	-
4	-	-	-	-	-	-	292	481.8	1·65	-	-	-	-	-	-	292	160.6	·55	-	-	-
5	179	98	.55	179	49.2	.28	179	590.7	3·3	-	-	-	-	-	-	-	-	-	179	98.5	.55
6	575	316	.55	575	158.1	.28	575	948.8	1·65	575	316	.55	-	-	-	-	-	-	-	-	-
7	92	51	.55	-	-	-	92	101.2	1·1	92	253	2·8	-	-	-	-	-	-	-	-	-
8	1725	1897	1·1	-	-	-	1725	4743.8	2·8	1725	3795	2·2	-	-	-	-	-	-	-	-	-
9	1219	670	.55	-	-	-	1219	1920	1·6	166	182.7	1·1	-	-	-	-	-	-	1053	289.5	2·8
TOTAL	6972	4930	.71	1453	592	.41	7255	14701	2·03	5731	9998	1·74	108	416.6	3·86	2261	1400	·62	2436	1050	.43
%	94.7	86.5		19.7	100		98.5	43		77.84	100		1.47	4.20		30.7	100		33.1	100	

OPTIMUM VALUE = £ 70007.12

TABLE 20.2

Services / Categories	HEALTH VISITS			CHIROPODY			HOME HELPS			MEALS			GERIATRIC HOSP.			DAY PLACE HOSP.			DAY CENTRES		
	No.of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No.of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average
1	1036	518	.5	-	-	-	1036	2072	2	1036	1036	1	-	-	-	-	-	-	1036	518	.5
2	867	768.3	.89	197.5	98.8	.5	867	1399.3	1.6	867	1454	1.68	-	-	-	197.5	98.8	.5	669.5	188	.28
3	869	434.5	.5	-	-	-	1378	2141.5	1.55	1378	2321.5	1.68	-	-	-	869	869	1	509	254.5	.5
4	-	-	-	-	-	-	292	438	1.5	-	-	-	-	-	-	292	146	.5	-	-	-
5	179	89.5	.5	179	44.7	.25	179	537	3	-	-	-	-	-	-	-	-	-	179	89.5	.5
6	575	287.5	.5	575	143.8	.25	575	862.5	1.5	575	287.5	.5	-	-	-	-	-	-	-	-	-
7	92	46	.5	-	-	-	92	92	1	92	230	2.5	-	-	-	-	-	-	-	-	-
8	1725	1725	1	-	-	-	1725	4312.5	2.5	1725	3450	2	-	-	-	-	-	-	-	-	-
9	-	-	-	1219	304.7	.25	1219	1219	1	1219	1219	1	-	-	-	-	-	-	-	-	-
TOTAL	5343	3868.8	.72	2171	592	.27	7363	13074	1.78	6892	9998	1.50	0	0	-	1359	1113.8	.82	2394	1050	.44
%	72.6	67.9		29.5	100		100	38.2		93.6	100		0	0		18.46	79.6		32.5	100	

OPTIMUM VALUE = £ 56579.30

TABLE 21.1 $\theta = 45\%$

Categories	Values of x_{il}'s	$\Sigma x_{il} = D_i$
1	$x_{14} = 1036$	1036
2	$x_{25} = 301.2, x_{26} = 565.8$	867
3	$x_{32} = 924.9, x_{33} = 453.1$	1378
4	$x_{43} = 292$	292
5	$x_{52} = 179$	179
6	$x_{61} = 575$	575
7	$x_{73} = 92$	92
8	$x_{83} = 1669.2, x_{85} = 55.8$	1725
9	$x_{93} = 1219$	1219
TOTAL	7363	7363

TABLE 22.1 $\theta = 40\%$

Categories	Values of x_{il}'s	$\Sigma x_{il} = D_i$
1	$x_{14} = 1036$	1036
2	$x_{26} = 867$	867
3	$x_{32} = 976.5, x_{33} = 401.5$	1378
4	$x_{43} = 292$	292
5	$x_{53} = 179$	179
6	$x_{61} = 575$	575
7	$x_{73} = 92$	92
8	$x_{83} = 559, x_{85} = 1166$	1725
9	$x_{93} = 1219$	1219
TOTAL	7363	7363

TABLE 21.2

Services / Categories	HEALTH VISITS			CHIROPODY			HOME HELPS			MEALS			GERIATRIC HOSP.			DAY PLACE HOSP.			DAY CENTRES		
	No.of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No.of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average
1	1036	466.2	.45	-	-	-	1036	1864.8	1.8	1036	932.4	09	-	-	-	-	-	-	1036	466.2	.45
2	867	644.8	.74	301	135.5	.45	867	1306	1.51	867	1289.5	1.49	-	-	-	301	135.5	.45	566	127.3	.23
3	453	203.9	.45	-	-	-	1378	2692.7	1.9	1378	2684.3	1.95	-	-	-	453	203.9	.45	925	416.2	.45
4	292	131.4	.45	-	-	-	-	-	-	292	262.8	0.9	-	-	-	-	-	-	-	-	-
5	179	80.6	.45	179	40.3	.23	179	483.3	2.7	179	161.1	0.9	-	-	-	-	-	-	179	40.28	.23
6	575	258.7	.45	575	129.4	.23	575	776.3	1.35	575	258.8	.45	-	-	-	-	-	-	-	-	-
7	92	41.4	.45	-	-	-	92	82.8	0.9	92	207	2.25	-	-	-	-	-	-	-	-	-
8	1725	1527.4	.88	56	12.6	.22	1725	3906.4	2.26	1725	3105	1.8	-	-	-	-	-	-	-	-	-
9	-	-	-	1219	274.3	.23	1219	1097	.9	1219	1097.1	0.9	-	-	-	-	-	-	-	-	-
TOTAL	6255	3354.4	.54	2330	592	.25	7071	112209	1.73	7363	9998	1.36	0	0	-	754	349.4	.45	2706	1050	.39
%	84.95	58.85		31.64	100		96	35.7		100	100		0	0		10.24	24.24		36.75	100	

OPTIMUM VALUE = £ 47549.63

TABLE 22.2

Services / Categories	HEALTH VISITS			CHIROPODY			HOME HELPS			MEALS			GERIATRIC HOSP.			DAY PLACE HOSP.			DAY CENTRES		
	No.of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No.of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average
1	1036	414.4	.4	-	-	-	1036	1657.6	1.6	1036	828.8	.8	-	-	-	-	-	-	1036	414.4	.4
2	867	693.6	.8	-	-	-	867	1040.4	1.2	867	1387.2	1.6	-	-	-	-	-	-	867	173.4	.2
3	402	160.6	.4	-	-	-	1378	2434.8	1.91	1378	2365.4	1.72	-	-	-	402	160.6	.4	977	390.6	.4
4	292	116.8	.4	-	-	-	-	-	-	292	233.6	.8	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	179	214.8	1.2	179	358	2	-	-	-	-	-	-	179	71.6	.4
6	575	230	.4	575	115	.2	575	690	1.2	575	230	.4	-	-	-	-	-	-	-	-	-
7	92	36.8	.4	-	-	-	92	73.6	.8	92	184	2	-	-	-	-	-	-	-	-	-
8	1725	913.6	.53	1166	233.2	.2	1725	3916.4	2.27	1725	2760	1.6	-	-	-	-	-	-	-	-	-
9	-	-	-	1219	243.8	.2	1219	975.2	.8	1219	975.2	.8	-	-	-	-	-	-	-	-	-
TOTAL	4989	2565.8	.51	2960	592	.49	7071	11003	1.56	7363	9322.2	1.27	0	0	-	402	160.6	.4	3059	1050	.34
%	67.76	45		40.2	100		96	32.17		100	93.2		0	0		5.46	11.47		41.55	100	

OPTIMUM VALUE = £ 40501.88

TABLE 23.1 $\theta = 35\%$

Categories	Values of x_{il}'s	$\Sigma x_{il} = D_i$
1	x_{14} =.1036	1036
2	x_{26} = 867	867
3	x_{32}=1351.5,x_{33}=26.5	1378
4	x_{43} = 292	292
5	x_{53} = 179	179
6	x_{61} = 575	575
7	x_{73} = 92	92
8	x_{83},136.1,x_{85}=1588.9	1725
9	x_{93} = 1219	1219
TOTAL	7363	7363

TABLE 24.1 $\theta = 30\%$

Categories	Values of x_{il}'s	$\Sigma x_{il} = D_i$
1	x_{14} = 1036	1036
2	x_{26} = 867	867
3	x_{32} = 1378	1378
4	x_{46} = 292	292
5	x_{53} = 179	179
6	x_{61} = 575	575
7	x_{75} = 92	92
8	x_{85} = 1725	1725
9	x_{93} = 1219	1219
TOTAL	7363	7363

TABLE 23.2

Services / Categories	HEALTH VISITS			CHIROPODY			HOME HELPS			MEALS			GERIATRIC HOSP.			DAY PLACE HOSP.			DAY CENTRES		
	No.of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No.of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average
1	1036	362.6	.35	-	-	-	1036	1450.4	1·4	1036	725.2	.7	-	-	-	-	-	-	1036	362.6	.35
2	867	606.9	.7	-	-	-	867	910.4	1·05	867	1213.8	1·4	-	-	-	-	-	-	867	151.7	.18
3	26.5	9.3	.35	-	-	-	1378	2393	1·74	1378	1938.5	1·41	-	-	-	26.5	9.28	.35	1352	473	.35
4	292	102.2	.35	-	-	-	-	-	-	292	204.4	.7	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	179	188	1·05	179	313.2	1·75	-	-	-	-	-	-	179	62.65	.35
6	575	201.2	.35	575	100.6	.18	575	603.7	1·05	575	201.3	.35	-	-	-	-	-	-	-	-	-
7	92	32.2	.35	-	-	-	92	64.4	.7	92	161	1·75	-	-	-	-	-	-	-	-	-
8	1725	651.4	.38	1589	278.1	.18	1725	3574.9	2·07	1725	2415	1.4	-	-	-	-	-	-	-	-	-
9	-	-	-	1219	213.3	.18	1219	853.9	.7	1219	853.3	.7	-	-	-	-	-	-	-	-	-
TOTAL	4613.5	1965.8	.43	3383	592	.18	7071	10038	1·42	7363	8025.7	1·1	0	0	-	26.5	9.28	.35	3434	1050	.31
%	62.66	34.49		45.95	100		96.03	29.35		100	80.27		0	0		0.36	0.66		46.64	100	-

OPTIMUM VALUE = £

TABLE 24.2

Services / Categories	HEALTH VISITS			CHIROPODY			HOME HELPS			MEALS			GERIATRIC HOSP.			DAY PLACE HOSP.			DAY CENTRES		
	No.of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No.of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average
1	1036	310.8	.3	-	-	-	1036	1243.2	1.2	1036	621.6	.6	-	-	-	-	-	-	1036	310.8	.3
2	867	520.2	.6	-	-	-	867	780.3	.9	867	1040.4	1.2	-	-	-	-	-	-	867	130.1	.15
3	-	-	-	-	-	-	1378	2067	1.5	1378	1653.6	1.2	-	-	-	-	-	-	1378	413.4	.3
4	-	-	-	-	-	-	-	-	-	292	262.8	.9	-	-	-	-	-	-	292	43.8	.15
5	-	-	-	-	-	-	179	161.1	.9	179	268.5	1.5	-	-	-	-	-	-	179	53.7	.3
6	575	172.5	.3	575	86.25	.15	575	517.5	.9	575	172.5	.3	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	92	82.8	.9	92	110.4	1.2	-	-	-	-	-	-	92	27.6	.3
8	1725	517.5	.3	1725	258.75	.15	1725	3105	1.8	1725	2070	1.2	-	-	-	-	-	-	-	-	-
9	-	-	-	1219	182.9	.15	1219	731.4	.6	1219	731.4	.6	-	-	-	-	-	-	-	-	-
TOTAL	4203	1521	.36	3519	527.9	.15	7071	8688.3	1.23	7363	6931.2	.94	0	0	-	0	0	-	3844	979.4	.25
%	57.1	26.68		47.8	89.17		96.03	25.4		100	69.32		0	0		0	0		52.21	93.28	

OPTIMUM VALUE = £ 29274.18

TABLE 25.1 θ = 10%

Categories	Values of x_{il}'s	$\Sigma x_{il} = D_i$
1	x_{14} = 1036	1036
2	x_{26} = 867	867
3	x_{32} = 1378	1378
4	x_{46} = 292	292
5	x_{53} = 179	179
6	x_{61} = 575	575
7	x_{75} = 92	92
8	x_{85} = 1725	1725
9	x_{93} = 1219	1219
TOTAL	7363	7363

TABLE 25.2

Services / Categories	HEALTH VISITS			CHIROPODY			HOME HELPS			MEALS			GERIATRIC HOSP.			DAY PLACE HOSP.			DAY CENTRES		
	No.of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No.of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average	No. of Elderly Clients	Units of Service Used	Average
1	1036	103.6	.1	-	-	-	1036	414.4	.4	1036	207.2	.2	-	-	-	-	-	-	1036	103.6	.1
2	867	173.4	.2	-	-	-	867	260.1	.3	867	346.8	.4	-	-	-	-	-	-	867	43.35	.05
3	-	-	-	-	-	-	1378	689	.5	1378	551.2	.4	-	-	-	-	-	-	1378	137.8	.1
4	-	-	-	-	-	-	-	-	-	292	87.6	.3	-	-	-	-	-	-	292	14.6	.05
5	-	-	-	-	-	-	179	53.7	.3	179	89.5	.5	-	-	-	-	-	-	179	17.9	.1
6	575	57.5	.1	575	28.75	.05	575	172.5	.3	575	57.5	.1	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	92	27.6	.3	92	36.8	.4	-	-	-	-	-	-	92	9.2	.1
8	1725	172.5	.1	1725	86.25	.05	1725	1035	.6	1725	690	.4	-	-	-	-	-	-	-	-	-
9	-	-	-	1219	60.95	.05	1219	243.75	.2	1219	243.8	.2	-	-	-	-	-	-	-	-	-
TOTAL	4203	507	.12	3519	175.95	.05	7071	2896.1	.41	7363	2310.4	.31	0	0	-	0	0	-	3844	326.45	.08
%	57.1	8.9		47.79	29.72		96.03	8.47		100	23.11		0	0		0	0		52.21	31.09	

OPTIMUM VALUE = £ 9758.06

TABLE 26.1

$\theta_1 = .70$

$\theta_2 = .30$

$\theta_3 = .70$

$\theta_4 = .30$

$\theta_5 = .70$

$\theta_6 = .70$

$\theta_7 = .45$

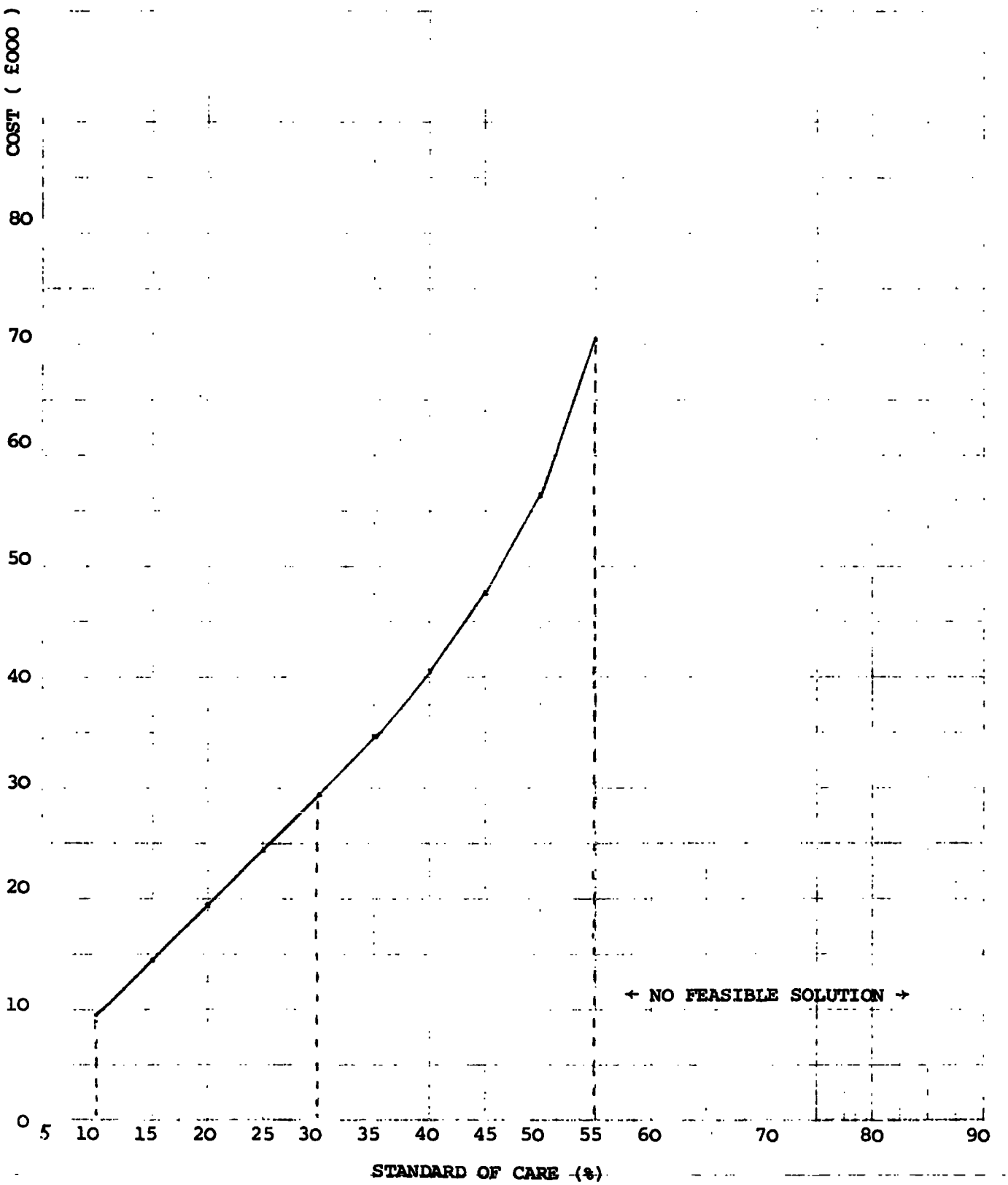
Categories	Values of x_{il}'s	$\Sigma x_{il} = D_i$
1	$x_{14} = 1036$	1036
2	$x_{26} = 867$	867
3	$x_{32}=684.8, x_{33} = 693.2$	1378
4	$x_{43} = 292$	292
5	$x_{53} = 179$	179
6	$x_{61} = 575$	575
7	$x_{73} = 92$	92
8	$x_{85} = 1725$	1725
9	$x_{93} = 1219$	1219
TOTAL	7363	7363

TABLE 26.2

Services / Categories	HEALTH VISITS			CHIROPODY			HOME HELPS			MEALS			GERIATRIC HOSP.			DAY PLACE HOSP.			DAY CENTRES		
	No.of Elderly Clients	Units of Service Used $\theta_1 = .70$	Average	No. of Elderly Clients	Units of Service Used $\theta_1 = .30$	Average	No. of Elderly Clients	Units of Service Used $\theta_3 = .70$	Average	No.of Elderly Clients	Units of Service Used $\theta_4 = .30$	Average	No. of Elderly Clients	Units of Service Used $\theta_5 = .70$	Average	No. of Elderly Clients	Units of Service Used $\theta_6 = .70$	Average	No. of Elderly Clients	Units of Service Used $\theta_7 = .45$	Average
1	1036	725.2	.7	-	-	-	1036	2900.8	2.8	1036	621.6	.6	-	-	-	-	-	-	1036	466.2	.45
2	867	1213.8	1.4	-	-	-	867	1820.7	2.1	867	1040.4	1.2	-	-	-	-	-	-	867	195.1	.23
3	693	485.1	.7	-	-	-	1378	3852.5	2.3	1378	1861.5	1.35	-	-	-	693	485	.7	685	308.2	.45
4	292	204.4	.7	-	-	-	-	-	-	292	175.2	.6	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	179	375.9	2.1	179	268.5	1.5	-	-	-	-	-	-	179	80.55	.45
6	575	402.5	.7	575	86.25	.15	575	1207.5	2.1	575	172.5	.3	-	-	-	-	-	-	-	-	-
7	92	64.4	.7	-	-	-	92	128.8	1.4	92	138	1.5	-	-	-	-	-	-	-	-	-
8	1725	1207.5	.7	1725	258.75	.15	1725	7245	4.2	1725	2070	1.2	-	-	-	-	-	-	-	-	-
9	-	-	-	1219	182.85	.15	1219	1706.6	1.4	1219	731.4	.6	-	-	-	-	-	-	-	-	-
TOTAL	5965	4303	.72	3519	527.85	.15	7071	19237.8	2.72	7363	7079.1	.96	-	-	-	693	485	.7	2767	1050	.38
%	81.01	75.5		47.79	89.16		96.03	56.25		100	70.81		-	-		9.41	34.65		37.58	100	

OPTIMUM VALUE = £ 59611.63

GRAPH 1.


COST (£000)
80
70
60
50
40
30
20
10
0
5
10
15
20
25
30
35
40
45
50
55
60
70
80
90
← NO FEASIBLE SOLUTION →
STANDARD OF CARE (%)

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