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AN EVALUATION OF THE USE OF HELICOPTERS AS AIR AMBULANCES

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AN EVALUATION OF THE USE OF HELICOPTERS AS AIR AMBULANCES

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AN EVALUATION OF

THE USE OF HELICOPTERS

AS AIR AMBULANCES

by

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Abstract

An Evaluation Of The Use Of Helicopters As Air Ambulances, by Philip Brigham.

This study reviews the evaluative literature of air ambulances in other countries and concludes it has little relevance to Britain. Other reviews are undertaken of the British ambulance service, evaluative economics, and market structures. The relationship between effectiveness, efficiency and equity is explored. It is concluded that there is a role for air ambulances in servicing rural areas within the revised structure of the NHS.

This is tested by three studies of the Cornwall Air Ambulance. Initially, the resources and standards of the ambulance service in Cornwall are investigated by analysis of routine data spanning two years. It is concluded that standards of response and times to hospital are poor in North Cornwall. This was deduced from the modelling of response times and time to hospital for incidents from every electoral ward in the county. Two options of 'land ambulance only' and 'land ambulance with the air ambulance' are tested for effectiveness, equity and efficiency.

The first study considers the effectiveness of service provision, while the second study considers geographic equity with the use of simple regression analysis to indicate the cost of service provision at differing levels of rurality. The third uses a cost benefit analysis framework to indicate the costs and benefits associated with air ambulance use in a rural area.

The contribution to knowledge is highly significant in the modelling of routine data to assess the effectiveness, efficiency and equity relationship, in appraising accessibility. This is the first study to apply economic principles to the ambulance service within the recently revised NHS.

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ABBREVIATIONS

AA	Air Ambulance.
ORCON Standards	Standards of response time for the ambulance service.
DOH	Department of Health.
A&E	Accident and Emergency.
DHA	District Health Authority.
CBA	Cost Benefit Analysis.
EMS	Emergency Medical Systems.
HEMS	Helicopter Emergency Medical Service.
ASHBEAMS	American Society of Hospital Based Emergency Air Medical Services.
TISS	Theraputic Intervention Scoring System.
SAMU	Service D'assistance Medicale D'urgence.
RAC	Royal Automobile Club.
DGH	District General Hospitals.
PTS	Patient Transport Services.
RHA	Regional Health Authority.
SMR	Standard Mortality Ratio.
CEA	Cost Effectiveness Analysis.
ED	Enumeration District.
FAAST	First Air Ambulance Services Trust.
MAS	Management Advisory Services.

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Declarations

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award. none of the material herin has been used in any other submission for an academic award.

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Conferences

Health Economics Services Group Conference Oxford January 1990

Ambex Conference on International Ambulance Services, Harrogate Yorkshire August 1992.

Health Economics Statistical Support Users Conference. London School of Hygiene and Tropical Medicine. November 1992.

Transport Health Conference. Manchester. September 1992.

External Visits

Ambulance Headquarters Cornwall. Numerous visits and discussions with Chief Ambulance Officer on the practicalities of running both land and air ambulances.

Ambulance Headquarters Dorset. Discussions with Vernon Jollife Chairman of Chief Ambulance Officers Association regarding the publication of Ambulance 2000. August 1991.

Ambulance Headquarters Northumberland. Discussions with Chief Ambulance Officer regarding the trust status of the service December 1991.

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Section One

Chapter One

Introduction

The use of helicopters as air ambulances (AA) in Britain has increased from one service in 1987 to nine current services. They are very expensive to operate, and are supported by a variety of funds including public money, industrial sponsorship and charities. The ambulance services that operate AAs claim them to be an efficient use of resources, but virtually no independent evaluative work has been undertaken to establish the true costs and benefits within the British system. The main aim of this thesis is to identify useful parameters within which to evaluate air ambulance use in Britain.

At a superficial level the lives saved by the use of AAs in other countries looks compelling. This in fact hides a complexity of intertwining issues which questions the assumption that the use of AAs *per se* reduces morbidity and /or mortality. Moylan (1988) in a review of US literature regarding AAs, demonstrates significant reduction in trauma mortality for those patients transported by air from the scene of an accident. However he concludes that the primary factor is not the speed of the transport, but the high quality of life saving skills administered by the helicopter medical crew at the scene of the accident. There are acknowledged difficulties in isolating the impact of the helicopter transport element from other parts of the emergency medical services system. This, and considerable differences between health systems abroad and in Britain, limits the extent to which they can contribute usefully, in respect of theory or systems.

In Britain the majority of emergency calls are answered within the revised ORCON standards (Vicary 1990). These are standards accepted by the industry which state that 50 per cent of all calls will have an ambulance on the scene within eight minutes, 95 per cent within fourteen minutes in designated urban areas and 95 per cent within nineteen minutes in rural areas. (See appendix A1 for a further explanation). In the majority of circumstances this would seem to give little scope in most areas of Britain for helicopters to arrive at the scene quicker than a conventional land ambulance.

Over the last ten years in Britain, considerable advances have been made in improving standards of training of ambulance personnel by extending the range of skills and investing in equipment to enhance the quality of pre-hospital care. Paramedics are trained to a high standard to administer the life saving skills of defibrillation, endoctracheal intubation, drug administration and infusion. The combination of land ambulances offering a reasonable response time to most situations and the high level of skills that the increasing number of paramedics have would seem to offer fewer situations where a helicopter can be justified on the grounds of a response to trauma cases alone. Irving (1988), in his arguments for the establishment of regional trauma centres in Britain, notes that 'The working party remains to be convinced of their (helicopters') value in primary evacuation', noting that they are cramped, noisy, expensive to run, may not be useable in bad weather and are more prone to mishap than other forms of ambulance transport. Despite this, dedicated AA systems have been established in Devon, Cornwall, London, Northumbria, the West Midlands, Kent and Scotland. Shared helicopter facilities with the police operate in Wiltshire and Sussex. Other areas such as mid Wales have expressed an interest in initiating similar systems.

Operational Advantages of AAs

The identified, but not quantified, benefits of using a helicopter are an increase in the response range within an acceptable time limit and the speed and quality of subsequent patient transport. This provides the opportunity to choose from a wider range of receiving hospitals and therefore to determine the most appropriate hospital for the patient. This is particularly of value at the scene of major disasters because of the speed with which AAs can take in doctors and emergency supplies and then distribute patients to more distant receiving hospitals, while land ambulances concentrate on the closer hospitals.

The main advantage of speed, and hence the physical area that can be covered, is shown by Stensrud (1980). A land ambulance travelling at 45 mph and allowing one hour travelling time to hospital from the scene offers a catchment area for that hospital of 6,382 square miles. One hour's travelling for an AA at 130 mph gives a working area of 53,093 square miles. This means that for a given area employing one or more AAs, the cost could be offset against the need for fewer land ambulances, which should achieve an improved utilisation of vehicles. Brismar (1984) noted that AAs are no quicker than land ambulances in urban areas. As over two thirds of emergency calls emanate from such areas any model would have to take account of this. Macione and Wilcox (1987), from a survey of 30 AA systems in the United States, note that the best predictor of a high utilisation for AAs is rural square miles covered. Beyond a certain level of increasing population density, utilisation fell off, which they hypothesise was due to the relationship between population density and proximity to hospitals. As population density increased, the distance to hospitals decreased, and therefore land ambulances became more efficient at patient transport.

AAs could also be effective with inter hospital transfers. It is very costly for land ambulances to be used for this type of work, particularly if the transfer involves large distances. Vehicle and crew utilisation tends to be low for long distance work and a replacement crew and vehicle are needed to be on call in the area from which the land ambulance started. There are also certain types of injury that transport better in AAs than land ambulances. 'Transport trauma', i.e. further deterioration occurring to a patient during transport purely as a result of acceleration forces and vibration, is reduced, and the higher vibration frequencies during helicopter transit are outside the 'danger zone' of 1-20 Hz in which land ambulances operate. This is particularly beneficial to back injuries and burns.

From the discussion so far identifiable markets for AAs in Britain could be listed as:

a. Rural or sparse populations.

b. Inter-hospital transfers.

c. Certain types of injury or trauma such as burns or back injuries, where speedy transit to a specialist unit will have a direct affect on morbidity or mortality.

Identifying and testing the sensitivity of the above parameters would answer only one half of the questions, i.e. the potential usefulness for such a service. Whether or not many ambulance services will adopt AAs is dependent on very different factors more concerned with the results of organisational and structural changes taking place in the ambulance service. These are outlined below.

Competition and the Ambulance Service

At present there are forty five ambulance services in England and Wales funded mainly by national taxation. The service has been opened to competition in the form of contracts between purchasers and providers of services. This forms the basis of the internal market for health as facilitated by the white paper 'Working For Patients' (DHSS 1989). This effectively puts each ambulance service at arm's length from the purchaser of its services, the District Health Authority (DHA). Ambulance services can tender for contracts in any area, and DHAs can accept tenders for ambulance work from services other than the incumbent. Three ambulance services were awarded Trust status in the first round of contracts, seven in the second, and eighteen in the third wave of contracts. Trust status for an ambulance service means that it is entirely independent, with a board of directors controlling the assets leased from the local health authorities. The government's intention is to push all ambulance services into trust status at the fourth round. Income generation schemes, market segmentation and diversification are pursued by most services in order to be efficient in pricing contracts and to ward off competition from other ambulance services.

The creation of the internal market for health care has political and ideological ramifications for the operation of the ambulance service. The NHS was set up on an equity principle, which in this case means the principle of equal opportunity of access for its consumers (Williams 1987). This is a distributional issue which is often at odds with the concept of allocative efficiency, which is the *raison d'etre* of the free market. The likely trade offs between efficiency, effectiveness and equity will highlight the role that AAs may be able to play in maintaining equity of access to those in rural areas, while offering savings in manpower and vehicles.

The decade of the 1980s saw the ambulance service criticised for inefficiency (Payne

1983), (Whalley 1983), (Kohner 1984), (National Audit Office 1990) against a background of cash limiting in the service. In 1984 the ambulance service budget was cut by £8 million against a background of increasing demand (Sutton 1990). Much of the criticism of the ambulance service for poor efficiency was also applicable to the NHS in general, particularly in the lack of good management and management information to assess the quality of the service. These valid criticisms were addressed in the health service in general in the controversial Griffiths Report (1983).

A recurring criticism regarding inefficiency in the ambulance service is the widely varying costs in the different parts of the country. However, the cost per patient carried is a function of the demand rate, population density and distance to an A&E department. As there are national guide-lines of response times there is little that can be done to change the anomalies in the cost of the service related to geographic and demographic conditions, as shown in Table 1.1 below. Looking at the use of AAs in high cost areas is one possible option.

Table 1.1. Varying Cost of Ambulance Services

Ambulance Service	Average cost per head of population served per annun.	Cost per patient carried per annun.
Cornwall	£8.03	£52.4
Buckinghamshire	£4.4	£18.8
Mean of 39 services	£6.1	£20.03

Source: National Ambulance Services Survey (1988/89).

While the NHS in general is constrained by the need to contain expenditure within cash limits, this need not inhibit efficiency. It may, however, mean that the most useful returns from economies of scale may not be realised. Consequently, much of the emphasis on efficiency in the NHS has been to do with cost improvement, so that the same level of services are provided at least cost. Jones and Prowle (1987) argue that such a policy can only lead to cuts in services, and this would make it difficult to ascertain whether efficiency savings have been made or services reduced. Efficiency savings would need to be audited in such a way that any harmful impact on patient services can be calculated. Traditional welfare economics has seen health care as a market failure, a commodity that cannot be freely traded, and therefore cannot achieve the allocative and technical efficiency that is predicted by the Neo Classical market theory (Roberts 1990). However, the prevailing 'New Right' school of economic thought believes that health care is a tradeable commodity, and the creation of the internal market for this exchange will ensure greater efficiency.

On April 1st 1991 the internal market for health care started to function by allowing purchasers and providers of health care to contract for services. The ambulance service in a competitive market should reach the Neo Classical state of allocative efficiency, as firms competing for business will use contracts to bid down the cost of the service. Technical efficiency will be achieved as competition forces the inefficient out of business and an industrial structure of optimum size firms emerge. If the ambulance service operates in a contestable market, this argument will hold. However it could be claimed that the ambulance service should operate as a public good, which in the Neo Classical tradition is not a tradeable commodity.

A pure public good has two distinct characteristics of non-rivalness and non-exclusivity. A good has the property of non rivalness if the marginal cost of providing it to another customer is zero. A good is non exclusive if people cannot be excluded from using it. There are various degrees of public goods, such as being non-rival but not non-exclusive, and vice versa, called mixed goods. It could be argued that the front line ambulance service was designed to have a large degree of non-rivalness in that the demand for the service is unpredictable. Thus, because of its necessity, it may well be that the marginal cost of the next customer is nearly zero. Thus the service has to be resourced to cope with such unpredictable events. The law at the moment states that the Secretary of State for Health is obliged to provide an ambulance service, and that for emergencies any member of the public can request its use. This request cannot be ignored and, in fact, takes precedence over urgent requests from doctors. So the emergency service was set up to be a public good, with non-exclusivity and non-rivalness, and can therefore claim that in the Neo Classical tradition it cannot be traded

in the market place.

Baumol, et al (1982) argue that public goods are simply a class of goods whose production has a large fixed cost component and for which there is a comparatively low marginal cost (in the sense of the cost of serving another customer rather than the cost of providing another unit of physical product) and relatively low sunk costs. However, the bulk of total cost is fixed, so that if the good is supplied at a price equal to its marginal cost, then the sale will involve a loss. This is a good representation of the ambulance service, where the fixed costs for supplying cover are huge in relation to the marginal cost of transporting the next customer or patient.

It is already apparent that contracting procedures are encouraging changes in the industry. Competitive tendering from a larger ambulance service that has, or can show that it could have economies of scale by taking over the incumbent, could win a contract. In fact, take overs and amalgamation have already occurred. The National Audit Office (NAO) report (1990) quoted that many ambulance services were too small, whilst the head of the Chief Ambulance Officers' Association has estimated that in the not too distant future there will be only twenty five ambulance services.

The internal market was set up to improve efficiency, but little has been said about the cost of transactions within the contracting process. Williamson (1985) defines a transaction as 'When a good or service is transferred across a technologically separate interface'. This can be described more simply as when one stage of an activity stops and another begins. Efficiency in transaction costs can be seen in two forms, governance to facilitate efficient adoption and measurement to assure close correspondence between deeds and awards. Problems of governance and measurement disappear if either bounds (limits) on rationality or opportunism are presumed absent. In other words, the more trust that exists between contracting parties, the less the assumed need for costly protection in law to be written into the contract. This is liable to be dependent on the degree of asset specificity. The more specific the assets, the less redeployable they are if a contract fails. The opportunity cost of highly specific assets is liable to be very low, making the cost of contracting high and thus reducing the efficiency of the process. This leads to vertical integration to economise on transaction costs. For the ambulance service this can be seen as backward integration with the A&E service, and/or with trust status hospitals. Backward vertical integration of ambulance services is reinforced by information asymmetry, or in other words the hospital or A&E service would have a good idea of the costs involved in the ambulance service and vice versa. This diminishes fear and mistrust of the unknown and aids integration.

In order to cope with the new order of the internal market and its implications for competition, the ambulance service has turned its attentions to market structure. Apart from the already discussed issues of size of firm, market segmentation and income generation schemes are being pursued in order to increase revenue by identifying new markets or existing markets which will support differential pricing. The main and often under utilised assets owned by the ambulance service are their communications systems, vehicle repair and maintenance facilities and personnel. Identifying markets that increase the use of such facilities helps to increase income and justify the expense of more state of the art technology. This in turn increases the firm's portfolio and hence security, and helps to minimise the risk of take overs from 'predatory' firms.

Competition will change the dynamics of cost structures and the size of firm, allowing experimentation with novel modes such as AAs. This provides a large part of the rationale for the introduction of competition into the ambulance service. In a perfectly competitive market there is an assumption that transaction costs are zero. Williamson (1985) notes that where asset specificity exists, as with the ambulance service, substantial transaction costs can exist. These need to be considered with reference to the ambulance service that may involve monopolistic market structures in the long run. Buchanan (1985) argues that transaction costs are reduced by the market. This may be so, but only by integration and hence a return towards monopoly control. He does note that monopoly is not deemed as necessarily detrimental as long as it exists without government support and the market is contestable.

This brings us full circle, and begs the question as to whether the original NHS structure might eventually prove the most efficient, but that it does not happen to fit the present political ideology. The implications of this for the ambulance service are quite profound. The existing standards of service have been brought about because of the lobbying power of the ambulance service. It is a highly visible and easily understood service. Consequently, funds had been won at the expense of less visible services, which may however contribute more in terms of overall health care. Contracting has reduced funding in real terms by ten per cent and over half of the ambulance services in Britain now fail to achieve the ORCON standards. (Butler 1993).

Within the contracting ethos it is important to monitor how equity will be defined and maintained, particularly in rural areas. This is important as much of the emphasis within the internal market is on efficiency, which is often defined by the lowest tendered cost. In very rural areas efficiency is low due to the high level of resources deployed to answer very few emergency calls. Emergency cover for rural areas will gradually be reduced if market efficiency pressures predominate. A possible response to this challenge is the use of AAs in rural areas. As yet however, very little evaluation work has been done on the contribution that can be made by an AA in this role. There are many issues involved in such an evaluation which have not as yet been addressed. This study attempts to identify the issues and demonstrate an approach for the necessary evaluation.

<u>Aims and Objectives</u>

The aim of this thesis is:-

> To evaluate the potential contribution of AAs to health care in Britain in terms of effectiveness, equity and efficiency within the new internal market for healthcare.

This will be achieved by pursuing the following objectives:-

1. To review the literature of AA systems in other countries that could be relevant to Britain.
2. To review a brief recent history of the British ambulance system to discover why there is a perceived need for AA services in Britain.
3. To identify definitions of effectiveness, efficiency and equity within the discipline of evaluative economics that are useful in assessing the contribution of an AA within the structure of the internal market for health.
4. To review the conflicts for the ambulance service within the internal market for health care.
5. To describe and assess the operation of the AA operated by the Cornwall Ambulance Service in terms of its processes, contribution to equity and social efficiency, using the definitions explored in objective three.
6. To discuss issues of policy arising from the case study.

Approach

Objectives one to four will be achieved by reviews of the relevant literatures, and interviews with economists and healthcare professionals.

Objective five will be achieved by a study of the Cornwall Ambulance Service which has operated an AA since 1987. This will be divided into three-sub studies. The first looks at the demands, resources and standards of the service. This is achieved by analysis of a two year survey of data collected from the ambulance service and data from other sources. From analysis of the data the optimum role for an AA is defined. Within this optimum role two options of 'with' and 'without the AA' are set up to explore the contribution made by the AA to effectiveness, equity and efficiency.

Study One explores the relationships between demand standards and resources for the Cornwall Ambulance Service. This is used to assess the effectiveness of the service.

Study two explores ways of identifying the cost of ambulance service provision at differing levels of rurality in order to comment on equity. This is achieved by using linear regression techniques with measures of population density and the cost of service provision.

Study three uses the framework of cost benefit analysis to identify the additional costs and potential benefits of AA use over the use of land ambulances alone, as they accrue to different sectors of society.

The results of the three sub studies provide discussion on policy issues regarding the use of AAs.

<u>Structure of Thesis</u>

The thesis will be divided into two sections, the first will address the literature to establish a background to the subject area and definitions for use in Section Two.

The second chapter will review the literature on the use of AAs in other countries. The review will try to identify whether any improved outcome claimed from AA services is as a result of the use of helicopters, or whether such improvement can be attributed to other components of the A&E system.

The third chapter will document the recent history of the ambulance system and identify the existing AA services in Britain. Chapter four is a review of the literature on evaluative economics in order to define the terms of effectiveness and efficiency. Definitions of equity will similarly be sought in chapter five. These definitions will be used for the case study. The final chapter of Section One reviews the ambulance service within the internal market for health.

Section Two will use the definitions sought in Section One to assess the use of the AAs in Cornwall. Chapter Seven gives a detailed explanation of the data sources and the methods for the subsequent studies. The methodology for the case study is essentially an economic evaluative study consisting of three sub studies. The field work undertaken is discussed before going on to explain the methods of analysis for each of the three studies.

Chapter Eight is the first study and investigates the structures of the case study area to explore the effectiveness of ambulance provision with and without the AA. The second study (Chapter Nine) looks at the equity implications with the use of an AA, while the third study (Chapter Ten) looks at efficiency.

Chapter Eleven discusses policy implications arising from the case study. This addresses the extent to which the aims and objectives of the thesis have been met. The results and analysis of the case study are discussed in terms of the implications for policy. Finally, further areas of research are suggested.

Chapter Two

Air Ambulance Literature Review

Introduction

The aim of this chapter is to review the literature on AA use in other countries in order to gain an insight into the issues surrounding the adoption and use of AAs. In reviewing this literature certain characteristics of Britain and its health care system need to be borne in mind. The first point is that Britain is a very densely populated country with very small numbers of its population living further than 35 miles from a DGH and often much less from a community hospital. The Health Service in Britain is free at the point of contact and our ambulance system has a national network which aims to have an ambulance at the scene of any emergency within fourteen minutes in urban areas and nineteen minutes in rural areas. Britain does not have a history of doctors going out to the scene of accidents except in disaster situations. This has led to an increasingly highly trained ambulance service staff.

In countries such as Australia and South Africa there has been a long history of aircraft taking doctors to the scene of an accident. The vast distances involved in these countries means that the patient could be a very long distance from major medical facilities, therefore the system has been developed to alleviate the problems caused by such distances. The British Isles are so much smaller and the scale of distances is minute in comparison. The literature of these areas therefore was of little relevance to this country and therefore not reviewed.

Our European neighbours of Sweden, Germany and France operate helicopters as AAs. However, there is little available literature from Europe relating to the role, uses and evaluation of their AAs, particularly in English. The country in which the largest number of AA systems operate is America. There is also a considerable literature emanating from the States, and it is from this that the most useful papers were found and reviewed.

Helicopter Emergency Medical Services and Trauma Centres

Sixty percent of the American medical system is private in as much as insurance companies meet medical bills with a state baseline for the indigent and elderly. There are several grades of hospital, but the area of concern to AAs are trauma centres. These are often teaching hospitals and could in England be the equivalent to regional specialist centres. As the name implies trauma centres deal with the most severe of accident cases, which are either referred on to them from the less specialist hospitals or are brought in by their own private ambulance services. The centres have specialists in all medical and surgical disciplines working together and on call 24 hours a day.

Moylan (1988) points out that helicopters fit well with the emergency medical system (EMS) that has evolved across the states. An EMS can be described as having four component parts:-

1. Rapid transport of the victims to appropriate trauma care facilities.
2. Early resuscitation and stabilisation of the patient by trained personnel, beginning at the scene of the accident and continuing in the trauma centre.
3. Rapid surgical intervention, as necessary, for the type of incident.
4. Multi-disciplinary team approach to definitive care.

The helicopter is ideally suited to factors one and two; the rapid transport of victims, and to transport trained personnel to the scene of the accident to begin initial and early resuscitation and stabilisation. The first EMS on the above lines was set up in 1972 in Colorado. Many others followed during the next ten years with a focus on 'first response'. This means getting a specially trained crew and helicopter dispatched directly to the scene of an accident. This is especially useful where such factors as traffic congestion or the remoteness of the site delay normal ground access of the land ambulance. Redick (1979) proposed that the primary benefit of a helicopter service is speed of delivery of a patient from the accident scene to definitive care at the trauma centre. Retrospective studies suggest that helicopter programmes have significantly reduced the mortality rate for patients who were rapidly deteriorating or unstable and who would have died during ground transportation or required specialised care during transport which would not have been possible under statutes governing ground ambulances and emergency medical technicians.

However, the role for the helicopter has in general become modified to a 'second responder', after triage at the scene of the accident indicates serious injuries. While this may seem to conflict with much of the evidence on the initial usefulness of AAs, it can also be seen as a measure of how the training of ambulance service personnel has improved over recent years in stabilising patients at the scene of an incident. Other roles for the AA emerged, such as the transport of medical experts, equipment, organs, blood and plasma from trauma centres to outlying hospitals. Critically ill patients are transferred from secondary hospitals to trauma centres. This work has expanded to include high risk pregnancies and patients with acute myocardial damage. Today it is estimated that 50 per cent of air ambulance work is non-trauma inter-hospital transports. These expanded roles of helicopters have extended the care offered by major medical centres for the critically ill or injured patients. A land catchment area for a trauma centre with land ambulances would extend to a distance of 45 miles (or 1 hour land transport). An AA would extend this to 150 miles (1 hour air transport). Stensrud (1980), working at St Louis University Hospital, demonstrated that the service radius area for a trauma centre may expand by 44 per cent by introducing an AA into an EMS system. The total land area served with a helicopter based solely at the hospital is increased by 109 per cent giving a service radius area of 65 miles.

This benefitted the high cost private trauma hospitals, as the use of AAs increased the catchment area of the hospital into the area of other hospitals which would not normally be competing for patients. This produced the scenario that trauma hospitals which did not have AA services had to invest in them in order to redress the advantage given to neighbouring trauma centres which did. This led to a proliferation of AA services. Scwab et al (1985) state 'With recent economic changes in health care causing increased hospital competition for patients, administrators have turned to the implementation of AA systems to secure an adequate patient load'. Scwab looks at the first year of operation of the 'Nightingale' AA service system of Norfolk Hospital Virginia. The AA flew 325 missions, of which 192 patients were classified trauma patients. Sixty six of these patients (34.2 per cent) were considered within the normal referral pattern of the trauma centre. However 126 patients (65.8 per cent) were considered to have been 'captured' by the AA system.

As the number of Helicopter Emergency Medical Services (HEMS) expanded, many concerns were raised concerning the effectiveness, safety and cost of AA programmes. With regard to AA safety of operation, Howell and Brown (1987) report that in the early 1970s the Department of Transportation expressed concern over the ability of AAs to provide good patient care and safety. The department recommended that AAs be regulated by the Federal Aviation Committee (FAC). The FAC ruled in 1978 that the economic costs of regulating AAs would outweigh the public benefits. Enforcing standards was thereby left to the individual states. Few states have attempted to control the industry, hence many AAs today operate free from government regulations. It has been argued that it is this lack of regulation and the competitiveness that has led to many accidents with the AA service that forced American Society of Hospital Based Emergency Air Medical Services (ASHBEAMS) to produce a code of conduct for their members in 1987 and the American Medical Association urged the adoption of these guide-lines for all AA services at its AGM in 1988. These concerns have brought about a series of guide-lines for helicopter use, as outlined by Burney and Fischer (1986). The guide-lines are:

a. Trauma scene response by helicopter should be dispatched only for seriously injured patients who are potentially salvageable. This guide-line depends on an effective and accurate triage system.

b. Trauma scene flights are not justified if the flight does not significantly reduce the interval between injury and patient arrival at an appropriate hospital, unless the flight delivers needed medical expertise and equipment to the scene. Therefore time/distance as well as the therapeutic capabilities of the helicopter medical team have to be carefully analysed in each EMS region.

c. Critically injured patients should be returned to the nearest hospital with appropriate capabilities and demonstrated expertise to manage serious injuries. The guide-line is dependent on accurate categorisation and evaluation of emergency departments.

d. Flight services should be fully integrated into the existing EMS system, thereby avoiding competition between ground and AAs for patients.

e. Flights should be dispatched within medical guidelines established by the regional EMS system, demanding co-operative efforts from all involved in providing trauma care in designated regions.

f. EMS air evacuation of trauma victims should assist the regionalisation of trauma care to centres with specialised capabilities for the management of seriously ill patients.

g. Helicopters should be dedicated vehicles, i.e. should be used as an AA only, and not as a multi-purpose vehicle. The helicopter should be equipped and staffed by personnel with advance life support training.

Burney (1987) notes that competition from rival HEMS systems has led to numerous accidents. In 1985 there were fourteen accidents with AAs leading to thirteen fatalities. In 1986 twenty one accidents again led to thirteen fatalities. Of eighty four AA programmes surveyed, one third had suffered an accident and thirteen per cent had more than one.

While it was almost certainly the competitive nature of trauma centres already discussed that spawned so many HEMS systems, their operators have tried to justify their use on the improved morbidity and mortality they offer to patients. However, it is difficult to pinpoint the exact nature of what in the AA system is responsible for any life saving over the previously existing services. A study by Baxt and Moody (1983) compared the mortality rates of patients treated at the scene of the injury and transported by standard ambulance service, with the rate of similar trauma patients treated and transported from the scene by the helicopter service to the same trauma centre. Both groups of patients were matched for type of injury, age and trauma scores. Only patients attended by helicopter had an improved mortality rate compared with the predicted rate. The AA time from injury to arrival at the trauma centre was 23 minutes longer than the land ambulance. However, there were significant differences in the type of intervention between the two groups. The air medical group provided the same basic service as the land ambulances, but in addition provided endotracheal intubation, placement of central venous catheters, chest tubes and even open cardiac resuscitation.

This would indicate that the more advanced training received by the AA team significantly contributed to the improved morbidity and/or mortality, which opens the query as to what difference there would be if the training levels were the same for land and AAs, and what should the composition of the AA team be?

Team Composition

The appropriate mix of crew is a constant dilemma for those who run AA services. Rhee et al (1984) argue that as a physician accounts for only seven per cent of the operational costs of an AA system, the improved mortality and morbidity he can achieve through his skill and judgement makes his presence on the helicopter crew desirable. In a trial at Herman hospital of 174 flights, Rhee states that the physician's skill was essential in one per cent of cases, skill and judgement in four per cent of cases and judgement in 38 per cent of cases. The paramedic, however, constantly practices his skills in difficult circumstances, not in the clinical conditions of an operating theatre. This has to be taken into account. Rhee describes judgement as diagnosis, initiating critical medical treatment, determining the destination of the patient; the latter can be critical. An accurate diagnosis coupled with referral to a centre with the appropriate specialist service secures the greatest reward in reduced mortality.

A similar study involving the question 'was the physician necessary on the flight for judgement, skill, or both?' was conducted by Snow et al (1986). Their report concluded that of 395 flights from the Metro Cleveland Life Flight programme in Ohio, a physician was necessary 25.6 per cent of the time, not necessary 39.7 per cent of the time, and may be necessary 34.7 per cent of the time. While the conclusions are in general harmony with the Rhee study, the protocol differs somewhat. It would seem possible to conclude that a physician's presence was beneficial in the Snow et al (1986) study, given the degree of training of the paramedics.

Triage, or the Assessment of the Nature and Degree of Injury

At the Grady Memorial Hospital in Atlanta, Georgia, decision trees were created for each of thirty six primary medical complaints and categories, for use of the controller receiving calls for assistance. The decision trees were so designed that the more critical the call, the less the number of questions asked. The decision tree formed three despatch codes. The lowest priority emergency is two. A non-life threatening emergency is three. A life threatening emergency is one.

Slovis et al (1985) monitored the new despatch system and looked retrospectively at the old system. They concluded that with the new system the average response time for code one calls reduced from a mean of fourteen point two minutes to ten point four minutes. One point one minutes of the decrease was attributed to the dispatchers use of key pieces of information to establish a code or priority for each call. Response time for code two calls was thirteen point eight minutes. This is still quicker than the fourteen point six minutes prior to the implementation of triage. Group three response times increased to 21.7 minutes. While a certain amount of mis-triage occurred up the scale, very little occurred down the scale. This and similar systems in other countries have a lot to recommend them, and are discussed in the British context in Chapter Three.

Speed of Response or Delivery

The essence in the use of helicopters is speed to the scene, and the speed of transport from the scene of an accident to hospital. Again, according to Moylan (1988) increasing experience with helicopter services tends to support the assumption that improved survival was not due primarily to a shortened length of time between injury and arrival at the trauma centre, but more importantly, to the decreased interval between the time of injury and the start of appropriate life saving resuscitative measures as implemented by the air transport team from the referring hospital.

Some victims have a very small chance of survival or recovery. A speedy response by an AA to pick up these patients before they die will only have the effect of increasing the mortality rates for the system and distorting the benefits the system can have on less marginal patients, so any trial must be careful not to misinterpret performance and to be sure that like is being compared with like.

Ambulance Utilisation

Brismar et al (1984) conducted a study of ambulance utilisation in rural and urban districts in Sweden. The study looked at ninety districts with varying population densities, but with a population size between 10,000 and 40,000. The study found that urgent missions due to trauma were more frequent in the urban area (20 per cent), than in the rural area (10 per cent), while the incidence of false alarms or cases not requiring transport was higher in the rural area.

Uncertainty in judging the nature of an alarm was more prevalent in the rural areas (46 per cent) than in the urban area (sixteen per cent). The average response time was eight point one minutes in the urban area, and ten point two minutes in the rural area. Ambulance utilisation can be illustrated by the number of missions per manned ambulance hour. In the urban area, the degree of utilisation was higher (0.37 missions/ambulance hour) than in the rural area (0.22 missions/ambulance hour). Time in use (i.e. while on a mission) for ambulances expressed as a percentage of time available was also higher in the urban area (31 per cent) than in the rural area (eighteen per cent). Alarm incidence per inhabitant was higher in the urban area than in the rural area.

The social structure of the two areas also influenced ambulance use. Alcohol abuse was a more common reason for urgent missions in the urban area, while in the rural area unconsciousness and breathing difficulties were the dominating symptoms, the latter reflecting the greater number of elderly in the rural area. The report concludes that response time was closely related to alarm incidence. The authors doubt that increasing the number of ambulances in districts with low alarm incidence could significantly reduce response time. At the same time, increasing the number of ambulances would make ambulance utilisation unacceptably low and the cost high.

In many countries land ambulances have been complemented by AAs. This development within the ambulance service has led to explosive cost increases, with an accompanying demand for cost/benefit analysis. Such analyses have been carried out, but the results have often been difficult to evaluate and have sometimes been contradictory (Brismar et al 1984).

The interpretation of these results also need caution in relation to applying in the British context. The French AAs operated by Service d'Assistance Medicale d'Urgence (SAMU); the Norwegian, Swedish and German systems all operate on a graded response system as previously described, which makes comparison more difficult. However, studies from Germany are difficult to ignore as it is the most intense AA system in Europe. Virtually the whole country is covered by thirty five air rescue centres. Each centre covers an approximate 50km radius and four different organisations are involved in providing the aircraft. They are the Civil Defence Service, the equivalent to the British RAC, the Federal Airforce, the Red Cross and a private company. In the absence of a national health service all ambulance transport is paid for by insurance. In 1985 more than 30,000 missions were carried out by AAs, and 26,100 patients were treated. Studies have shown that the use of AAs in Germany have saved up to three days hospitalisation for serious trauma patients (Biege 1987).

System Evaluation

Rhee et al (1986) have concerned themselves greatly in producing a methodology to predict the usefulness of AAs. Their paper makes the point that HEMS are expensive and resource intensive, but lack measures for system evaluation. To combat this they undertook a six month trial using a therapeutic intervention scoring system (TISS). The TISS assigns values ranging from one to four for fifty seven medical and surgical interventions to measure the intensity of care during a 24 hour period. Classification was on the basis of whether the following criteria ensured patient survival or improvement of outcome: speed of transit, presence of medically skilled flight team and the helicopter's ability to overcome hostile environmental conditions. Of 203 patients tested it was found that the AA was medically appropriate for 132 (65 per cent) of them. For thirty four patients it was thought to be appropriate at the time of request, but not later. Thirty six patients (eighteen per cent) did not appear to need the helicopter at any time.

Accurately predicting the rate of use of helicopter emergency services is critical to both resource allocation and fiscal integrity. Most predictions are based solely on the experience of other services, despite wide variation in need and type of use. Rhee et al (1984) produced a systematic identification of conditions that would benefit significantly from helicopter transport. In their study of a HEMS system in South Michegan, they first define the medical needs for which patients would benefit significantly from helicopter transport to a referral centre. After defining the population to be served, the incidence of each condition is determined. Need for service is calculated by multiplying the population to be served by the incidence of conditions likely to benefit from helicopter transfer. This will give the potential number of patients for a service. Simple queuing theory can then be used to ascertain the likelihood of a helicopter service being able to cope with the predicted demand and to give an idea of the utilisation of the service.

This was a good attempt to produce a systems methodology for the use of AAs, and although simple, it still has a lot to commend it. Macione and Wilcox (1987) argued that Rhee et al's method of predicting use was frequently inaccurate due to unique local demographics and environmental factors. Estimation of need based on incidence rates of various diseases or injuries obtained from national or state statistics proved to be a crude estimator of demand. In seeking a better method Macione and Wilcox undertook a national survey of hospital based HEMS to determine factors that best predict transport volume and case mix. They then produced a correlation matrix of system variables and best predictors. HEMS programmes which had not been established at least twelve months were excluded from the survey results to minimize skewing the data as the organisation went through the learning curve. The aim of the study was to determine the demographics and characteristics which could best predict number of patients and case mix for a helicopter in the service. Variables selected for predictive potential included the following:-

a. Total population served.
b. Standard metropolitan statistical area.
c. Urban population.
d. Rural population.
e. Square miles.
f. Population density.
g. Age of service.
h. Total number of trauma beds at base hospital.
i. Programme marketing budget.
j. Number of helicopters per programme.

The factors the survey wished to predict included:-

a. Average number of flights per helicopter per month.
b. Total number of trauma patients transported directly from the scene of the accident per month.
c. Total number of cardiac patients transported per month.
d. Total number of paediatric patients transported per month.

Little information is given on how the analysis was performed; sixty nine HEMS services were included in the data. Their results suggested that the best overall predictor for service size or number of patients transported was the 'rural square miles served by the helicopter programme'. Predominately rural services covering large or inaccessible areas are far more likely to have higher numbers of patients than those serving predominately urban areas, regardless of the total population served.

In all cases, where more than one helicopter was used, they not only had a greater total number of patients, but also had increased numbers per craft. Single craft operations averaged 40 flights per month, while those with multiple helicopters levelled off at 57 flights per month.

Rural population is a good predictor for overall numbers of patients, but does not alter the case mix. When the urban element of a population is included to make the total population, it does not reach statistical significance, therefore cannot be used accurately to predict the use of a service. Rural population density is a good predictor up to a certain level of population density. Macione & Wilcox theorise that as rural population density increases above this threshold, the density of hospitals will also increase. The percentage of trauma transports originating from the scene of an accident decreased as rural population density increased. Again Macione & Wilcox theorise that as rural population density increases, a parallel increase in hospital density reduces the likelihood that the helicopter can reach the scene of an accident more rapidly than the patient can be transported to a local hospital.

Rural square miles and rural population are the best indicators for predicting the use of helicopters and the patient numbers, including average flights per month and average flights per craft. The total service area population and urban population are not good indicators for overall use or case mix, with the exception of paediatric patients.

During the last two decades the development in emergency care has moved in the direction towards a high degree of centralisation and specialisation. Centralisation of emergency care, however, implies extension of catchment areas and thus an increase in transport distances. This leads to a demand for an advanced transport system whereby patients can quickly come under adequate care. This system may have some benefit retrospectively but seems hard to apply at the time of call out. It does highlight the need for a sound system of triage in order to get the best out of existing resources, and to maximise survival chances for serious trauma cases.

Slovis et al (1985) highlighted the high number of emergency requests that turned out to be non-emergencies. A paper by Scalice (1978) found that fewer than half the EMS calls justified the use of an ambulance. Care by a paramedic was justified in a maximum of 30 per cent of the calls which ranged down to as low as three per cent. This suggests the need for triage to ascertain the degree of emergency.

Summary

In looking at AA systems suitable for adoption in Britain, it was noted that AA systems in the USA grew out of competition between specialist hospitals rather than from a medical imperative. European systems are based on a graded response system not practised in Britain. As such, while the lives saved by the use of AAs in other countries looks compelling it hides a complexity of intertwining issues which questions the assumption that the use of AAs *per se* reduces morbidity and /or mortality. The variables of team composition, speed of response and delivery and triage compound the difficulties in isolating the impact of the helicopter transport element from other parts of the emergency medical services system. This, and the considerable differences between health systems abroad and in Britain, limit the extent to which they can contribute to this study either in terms of theory or systems.

Britain is the only country, of those investigated, that does not have a graded response system to emergency calls which could target AAs to the type of call in which their inherent advantages could be put to best use. The strand that appears most useful from evaluation papers from the USA, Sweden, Germany and France is the use of AAs in rural areas and aids land ambulance utilisation (Brismar 1984). AAs perform a valuable role in rural areas, where the speed of response to serious trauma can be critical (Moylan 1988), and the use of AAs for speedy response to serious trauma has been shown to reduce hospitalisation by three days (Biege 1987). It is these factors which will be borne in mind while looking at AA use in Britain.

Chapter Three

British Ambulance System

Introduction

This chapter discusses the British Ambulance Service and the changes in that service in relation to other Health Service changes. In order to understand why the concept of using AAs is gaining ground in Britain, there is a need to understand the responses within the ambulance service in relation to recent health reforms. The development of ambulance service policy has been inextricably linked to hospital policy. Little thought has ever been given to the ambulance service when hospital policy has been set; the ambulance service has always had to adjust its strategies in a rather reactive way to accommodate changing demands from the hospital sector.

A policy that particularly affected the ambulance service was the report chaired by Platt on Accident and Emergency (A&E) services (1962) which noted that there were too many small casualty departments and that consultant involvement in casualty cases was low. There were inadequate facilities and staff shortages and the existing staff had to deal with too many minor accidents. Only twelve per cent of patients seen had injuries needing admission. It was decided that these twelve per cent of patients should be given a better service and it was recommended that they should be sent to a unit capable of dealing with them at any time of the day or the night, hence the beginning of A&E departments. A&E departments offered twenty four hour cover for dealing with seriously ill patients and it was envisaged that each unit must have at least three consultant surgeons, adequate junior medical staff and nurses, and auxiliary staff such as radiographers. To finance such a system there was a need to reduce greatly the number of hospitals offering casualty services, which fitted in well with the District General Hospital (DGH) concept. The Platt committee thought it better for a seriously ill or injured patient to have a longer ambulance journey to a fully staffed A&E dept, than to go to the nearest hospital. No evidence was offered in support of this view. There was also no discussion of the detrimental effects on patients of increasing the travelling distance and time to the accident unit. The committee acknowledged that in remote rural areas cottage hospitals should continue to give first aid treatment to major injuries before sending them on. It seems that staffing considerations were given more attention than the geographical implications of the policy. Non medical costs and benefits to the community which centralism implied received scant mention. Arguments used in the Platt report continue to be the foundation of A&E planning. In 1970 there were 245 major A&E departments. In 1982 there were less than 200 (The Hospitals and Health Services Year Book 1982). The Bonham Carter Report (1969) stated that there should be 250 hospitals of approx 600 to 900 beds. This supported larger hospitals to justify employing two consultants in every major speciality, with a catchment area of 200,000 to 300,000 people. It was envisaged that most small hospitals would close; however, by the late 1970s this policy was seen as too ambitious and the closures proved unpopular. Those hospitals not already completed would be constructed to have a nucleus of 300 beds, and would be extended when more money became available. Against a background of fewer hospitals and increasing accident rates, particularly road traffic accidents, the ambulance service had to develop strategies to meet the twin demands of greater numbers of patients more seriously injured having to travel greater distances before receiving definitive care. The ambulance service's traditional response of first aid then 'scoop and run' to the nearest hospital was becoming inadequate. The need arose to stabilise the condition of badly injured patients in order to prevent further deterioration on longer journeys to hospital, hence the tentative start of paramedic training.

Paramedic Training

Lucas (1979) listed four reasons for promoting extended training of ambulance men beyond the basic skill level. These were:

a. The increase in the number and severity of road accidents, especially high impact speed accidents and the emergence of a new phenomena, the multi-vehicle crash on motorways.

b. The skill and experience ambulance personnel acquire in working at the scene of an accident and their abilities to advise and assist in situations not always familiar to medical staff.

c. The possible shortage of skilled medical staff in the first 30 minutes after an accident.

d. The practice of closing smaller hospitals and concentrating specialist services at larger district general hospitals often requiring longer ambulance journeys.

In order to cope with the immediate care necessary in the above situations, the commission suggested that the following essential needs of patients should be met:-

a. To ensure a perfect airway, by intubation if necessary.

b. Circulatory support by intravenous infusion.

c. Possible monitoring of the heart beat by electrocardiogram and injection of suitable drugs if needed.

d. Pain relief by the inhalation of Entonox, along with the ordinary first aid measures such as splinting, bandaging and arrest of bleeding.

Section eight of the report, notes that there has been growing evidence that suitably trained ambulance staff are able to make important interventions in the provision of cardiopulmonary resuscitation, which led to a variety of schemes containing all the major elements of advanced ambulance aid: cardiac monitoring, ventricular defibrillation, the administration of a set of restricted drugs and intravenous infusion. Modular training in all, or selected parts of the above, developed in response to local demands.

Paramedic training had its infancy in the South of England, by courtesy of a few forward looking consultants who, against a backdrop of a reduction in the number of A&E departments, recognised the need for immediate treatment of trauma to reduce morbidity and mortality. The first two modules taught were intubation and infusion, which were adopted by many services. By the 1980s the government had become alarmed at the spread of these practices for a number of reasons, namely:-

a. Did ambulance staff have authority in law to perform such 'medical' tasks? (This was overcome by the paramedics in effect performing under licence from the A&E consultant, who took the ultimate responsibility).

b. Who was monitoring standards in training, teaching and application of these processes?

c. Did such procedures save lives? and how could pay and conditions be standardised with such a hotch potch growth?

The government's response was to commission York University to find out whether or not these skills saved lives and whether they were cost effective. The report from York by Wright (1985) was positive and recommended that the skills be expanded. The government's response to this was to give a green light to expand the skill base.

During this time span the bulk of A&E work had shifted from major accident trauma to urgent work. This was as a result of safer roads, seat belt legislation and increased safety at work legislation. On the other hand the incidence of heart disease was increasing, as were medical interventions to improve morbidity and mortality from such conditions. With this in mind the paramedic skill base was increased to include modules in defibrillation and drug use, the drugs being 'prescription only' medicines. Until the early 1980s training and certification in these modules was done at local level. In the early 1980s however the National Health Services Training Association in Bristol took on this training on a national basis, although local schemes still existed. In the 1985 pay negotiations, ambulance staff agreed to a national salaried pay scale. This was enhanced by the pay deal following the 1989 strike, which recognised and promoted paramedic status in the ambulance service.

The present situation is that the National Health Services Training Association only sets standards and protocols in order to make the standard national. However, the acceptance of professional status of paramedics has not pleased all ambulance persons. Eighty five per cent of all ambulance work is non emergency, and the possibility of hiving off this work to another agency and the corresponding job losses is not viewed favourably.

The trade unions involved with the ambulance service are many and diffuse. Such diffusion has given very little bargaining power, not helped by the caring nature of the men and women who provide the service and their reluctance to strike. Currently the number of paramedics in each service varies. The aim is to have at least one paramedic on every A&E ambulance as soon as possible and extend the skill base with modules on obstetrics and chest drains.

Organisation Problems

Upgrading the skill base of the front line ambulance service from basic first aid to complex paramedic procedures has taken place against a changing organisational structure. The service has frequently been criticised for poor organisational structure and efficiency by such commentators as Payne (1983), Whalley (1983), Kohner (1984) and the National Audit Office (1990). The reason for much of the criticism was due to the service trying to respond to increasing demand against a background of cash limiting. In 1984 the ambulance service budget was cut by £8 million (Sutton, 1990). Much of the criticism laid at the door of the ambulance service for poor efficiency applies to the NHS in general, in terms of a lack of good management information to assess the quality of the service.

The ambulance service currently carries around 25 million patients per year and employs approx 24,000 staff. The costs to the NHS are about £400 million per annum (National Audit Office 1990). This contrasts with a 1981/2 expenditure of £213 million per annum when 20 million patients per annum were carried (Kohner 1984).

The ambulance service moved to NHS control from the local authorities in 1974, and underwent a rationalisation resulting in 45 services. As local authorities were not coterminous with DHA areas, an individual ambulance service could end up serving anything from one to nine DHA areas. During the period from the inception of the NHS in 1946 to the 1973 NHS reorganisation act Health Services and hence the ambulance services were under the control and political direction of the local authority. Access and quality of health care varied from one local authority to another, contradicting the ethos of the 1946 act of free and equal access for all (Roger 1972). The 1973 act claimed to take health care out of the local political arena and created a new hierarchical structure for the NHS based on regional and district health authorities. DHAs worked within the strategy formulated by the regions, who in turn implemented policies laid down by central government. The DOH funds the ambulance service through the Secretary of State, which over the years has delegated to DHAs the management of the ambulance service within a broad policy framework. Rarely has the impact of health service requirements on ambulance services been identified, or targets for volume or quality of service set out. DHAs which did have responsibility for managing the ambulance service could make demands on that service without any direct financial consequences to themselves. There has, therefore, been little or no incentive for such authorities to exercise control over requests for patient transport.

It is the duty of the Secretary of State to provide sufficient ambulance services to meet all reasonable requirements. Current rules state that, 'Anyone may request an ambulance by dialling 999. An ambulance must be dispatched immediately, and no medical authority is necessary'. However, ambulances should be used for medical conditions only, and not for social reasons such as lack of accessibility or money. Clinicians over the years have frequently been accused of interpreting social need as medical need, partly because extensive journeys on public transport can be viewed as detrimental to the health of the patient. Ambulance controllers are now much more aware of costs and ensure that ambulance services meet only essential demands. Common practice is now to charge patients who require transport for social rather than medical reasons. While the ambulance services 40 years ago carried only emergency patients, emergency and urgent patients now represent only fifteen per cent of those carried but account for 60-70 per cent of costs in most ambulance services.

In order to achieve improved and cost effective A&E training and at the same time respond to demands for improved efficiency and financial accountability, the majority of ambulance services have 'tiered' the services they offer.

Tiering

Tiering means the adoption of a second level of service. This does not imply a first and second rate level of quality, but does mean the separation of the A&E function, known as the front line service, from the business of delivering patients to clinics and day care hospitals; the second tier is known as Patient Transport Services. (PTS)

The main benefits of tiering are fewer highly qualified crews and fully equipped vehicles, thus reducing costs. The main disadvantage of tiering is low utilisation of some crews and vehicles, particularly in very rural situations in the front line service. However, this has been offset by the greater use of part time staff in the second tier, and since the Great Britain Transport Act of 1985 which deregulated public transport, the tendering out of PTS to private concerns has become possible. The case for tiering in recent years has been strengthened by increased differentials in ambulance persons' pay scales, a centralisation of facilities at DGHs, the introduction of computer scheduling and a reduction in the scale of directly provided non-emergency services. The National Audit Office report (1990) showed that tiered services incur lower costs per patient journey and faster activation time.

Efficiency in the ambulance service is often questioned because of the wide ranging costs of provision. The report by the National Audit Office (1990) produced three working categories for the degree of difficulty in delivering a service based on population density, proximity of patients to major and acute hospitals, cross boundary flows and the number of hospitals served by the ambulance service. A range of costs per person and the ambulance services which typically fall into these categories are outlined below.

Easy - £10-£17. (Oxfordshire, Gloucestershire)
Medium - £11-£35. (E. Sussex, Isle of Wight)
Hard - £15-£46. (Cornwall, Pembrokeshire)

The need to provide a competitively priced quality service has induced certain ambulance services to look at novel modes for rapid response such as motor bikes, fast cars and helicopters. The introduction of Ambulance Service Trusts has also encouraged such innovation.

Trusts

The enactment of 'Working For Patients' has allowed health authorities to develop their own proposals regarding the purchase of health care. This may involve the retention of core emergency services, but DHAs are free to choose the source of supply for non emergency services. While to date this has involved the retention of core emergency services, the purchasers can demand quality in emergency care.

The introduction of competition in special needs transport, such as social services and the ambulance service, once thought immune from such afflictions, has in the last few years been plunged into the competitive transport revolution. Just as private bus operators have to justify their subsidy demands by competitive tendering, so the ambulance service may soon have to compete to provide services which since 1946 it has virtually monopolised.

To achieve trust status, ambulance services must show that they can competently manage their own organisational and financial affairs. The acquisition of trust status gives, within limitations, the power to acquire and dispose of assets, the ability to borrow, subject to annual financing, the retention of operating surpluses and the determination of their own management structure and staffing together with the ability to advertise their own services. As a trust the ambulance service is answerable to the Secretary of State for Health.

Currently the front line ambulance service is seen as a core service to which patients need guaranteed local access and where there is often no real choice available to the consumer on timing, location or delivery of that service. In the future the service may be absorbed by vertical integration into the A&E department of the DGH, and serve that hospital's catchment area. The more likely trend appearing at the moment is horizontal integration with other services to form larger units.

Whether a trust or a directly managed unit, all ambulance services have block contracts for a designated A&E area. The contract is based on a certain number of calls per annum. Calls in excess of this are paid for on a marginal cost formula. PTS are on a cost and volume basis with an activity level agreed with the DHAs. Eventually this will be with individual hospitals, or even at unit level, but at the moment the technology is not in place and those who would order the transport have no real perception of its cost. Purchasers will learn what the real cost of transport is and therefore assess transport versus support care.

While in the early years of 'Working For Patients', block A&E contracts will not greatly change, the emphasis of the purchasing authorities will focus more and more on value for money and quality of service. Ambulance services can improve their costs by amalgamating with other services. This reduces cross boundary flows, communications equipment costs and costs associated with a smaller command structure.

The Department of Health in negotiating trust status for ambulance services has encouraged the adoption of British standard BS5750. This was first awarded to the Northumbrian Ambulance service, but has since been awarded to other services. The idea was to give the public a benchmark regarding the quality of the service provided. However, concerns have been raised about the adequacy of this kite mark for indicating quality in an ambulance service when the standard was originally devised for quality control of repetitive production line processes and not the care of patients.

The reforms have introduced competition. An example is again the Northumbrian

Ambulance Service, one of the first to gain trust status. It answers 1.4 million A&E calls per annum, while its neighbour with the same command structure answers 300,000. The Northumbrian communications equipment, which is state of the art, can manage a catchment population of two million. The economies of scale that could be achieved are obvious and while A&E contracts offer a geographically based monopoly during the term of the contract, the contract is time limited. This offers the threat of takeover from a competing authority when contracts come up for renewal. In the cited case, Northumbria will be able to offer a much lower unit cost than its threatened neighbour for services in its neighbour's patch. The threatened neighbour is seeking to amalgamate with another local service to stave off the threat of takeover from Northumbria. The subject of contestable markets is discussed at greater length in the next chapter.

The ability of trusts to indulge in income generation is another departure from core services allowed in trusts. In the Northumbrian service during 1989/90, income generation provided a £0.24 million gross, and in 1990/91 £0.5 million. Turnover is expected to double in each of the first three years, and then level off. Trading managers have to generate their own salary, so it is not unusual now for ambulance services to be running such ventures as courier motor bike services, car repairs and radio paging services. While innovative trusts such as Northumbria have employed the use of an AA, such ideas have also coincided with a move by the Royal College of Surgeons to attempt to change hospital policy to emulate the American system of trauma centres at regional level.

The Management of Patients with Serious Injuries

A report by Professor Miles Irving of the Royal College of Surgeons in 1988 (Irving, 1988) stated that 'Evidence clearly reveals that there are serious deficiencies in the management of severely injured patients and that these deficiencies must be remedied'.

Irving suggests that more injured patients die from preventable causes whilst in hospital than before they reach it and suggests that regional trauma centres serving a population of around two million people each should be established in the UK. Their primary purpose would be to treat the nought point five per cent or less of those patients attending an A&E department that have multiple injuries and would benefit from a transfer to a trauma centre and a multi-disciplinary approach to major injuries.

Irving further suggests that death from trauma has a trimodal distribution; the first peak is within seconds or minutes of injury; the second peak occurs within the first two hours of injury, often described as the 'golden hour' for the critically injured. It is in these cases that a team with full facilities can prevent death from such conditions as intercerabral, subduard and epidural haematomas, haemopeumathorax, ruptured spleen, lacerations of the liver, fractured pelvis or multiple injuries associated with major blood loss. According to Irving, the number of patients that fall into these categories is significant. The third peak occurs days or weeks after injury and is most often due to sepsis and multiple organ failure. The number that die during the third peak is influenced by the quality of initial resuscitation and treatment. The two imperatives that stem from the above are to get the seriously injured patient to hospital alive and at the hospital provide the patient with expert surgical and anaesthetic care within the 'golden hour'.

In order to achieve this, Irving believes that the ambulance service needs greater involvement with A&E staff. Facilities at receiving hospitals need to be improved, as rapid transport to hospital is pointless if a patient lies on a trolley in casualty for hours. There is then the question of patient transfer from an A&E department to a regional trauma centre. Unlike previous hospital policy, transport has been addressed and Irving points to the system in Germany where thirty five helicopters perform this role, and an estimated eleven lives are saved per helicopter each year.

In light of this Irving is convinced of the need for helicopter use in inter hospital transfer to trauma centres. He is not so convinced of use in primary missions (direct from the scene) stating that they are cramped, noisy, and difficult to work in. He therefore suggests that the patient needs stabilisation before takeoff. They are also expensive and not useable in bad weather or at night. He does not make a complete condemnation of AA transport, as any Regional Health Authority (RHA) with an AA working in their area would have the facility to transfer patients from any of the DGHs to a specialist unit if Irving's ideas are eventually accepted and acted upon.

British AAs

The late 1980s saw the coincidence of several factors which led to tentative adoption of AAs in this country. The first was the need for the ambulance service to adopt a more efficient, cost effective and competitive outlook to the provision of the front line emergency and urgent service. The second was the interest from a number of doctors in how severely injured patients are managed in this country and the role helicopters may be able to play in this. These points coincided with reduced helicopter activity in the North Sea and helicopter companies looking for other markets for their aircraft. All of this coincided further with the ambulance service being able to set up charitable trusts to inspire the public to pay for an enhanced service over and above that which their tax revenue already provided.

This led to the first UK AA service which started in April 1987, and by 1989 four services were in operation. A short article by Delamothe (1989) reflects the situation up to that date. Delamothe noted that all four UK operations in Cornwall, London, Northumberland, and Scotland were run by charitable trusts, helped to a varying extent by the helicopter company concerned. Delamothe also noted that three of the AA systems are manned by paramedics and run by the relevant ambulance authorities, the exception being the London HEMS which carries a specially trained surgical registrar and is independent of the London Ambulance Service. The most relevant comment that Delamothe makes is "So far no clear criteria have been agreed for evaluating emergency helicopter services other than comparing transit times and therapy free intervals with those of other means of transport. With a single helicopter costing some hundreds of thousands of pounds a year to run, there are good reasons for getting the answer right first time". The number of services operating in the UK has now grown to nine. There is still very little useful published evaluation of the services to date, and the experience of other countries has been inappropriately used to justify these services. It is suggested that the use of helicopters to respond directly to the scene of emergency incidents would produce significant benefits in terms of a reduction in mortality/morbidity and could in many cases prove cost effective. While the point has already been made regarding direct translation of experiences from overseas to the situation in Britain, evidence of the value of AAs in Britain is still scant.

The police service has for many years operated helicopters in this country; these are owned and piloted by the police force themselves. They have been somewhat under utilised and the police in a number of scenarios have welcomed the ambulance service contributing to the cost of provision of the service. This is in return for a specific time period allocated to the ambulance service, or a joint use period where the relative use depends on the scope of the emergencies arising at the time. This is the system that has worked in Sussex, although a lack of funds has seen the service interrupted. Possibly the best example of joint use is the Wiltshire police and ambulance service. The Wiltshire Ambulance Service covers a population of 536,000 people and spans the Salisbury, Swindon and part of Bath health authorities. The joint 'Air Support Unit' was set up with the Wiltshire Constabulary in April 1990. The current cost to the Wiltshire ambulance service is around £115,000 per year excluding the costs of paramedic staffing. Whilst a dedicated helicopter provides fewer operational restrictions, some advocate that the cost of such a system cannot be justified and that joint use with another agency, usually the police, represents a more realistic and cost effective approach. Whilst the economic advantages may be offset by the degree of compromise necessary and the potential for a clash of priorities, there would seem to be particular scope for an identified role. This has been achieved in the Wiltshire case by targeting the helicopter mainly to road traffic accidents along the M4 corridor. Patients retrieved from such situations are always taken to the same hospital. These protocols have evolved over a few years of use and have involved a learning curve for everyone to achieve present performance. There has been a small but significant reduction in response time and time to hospital, and a better spread of paramedic response in rural areas.

Until recently the Devon and Cornwall Constabulary had made their helicopter available for the emergency transport with ambulance staff attending the patient as necessary. This has now stopped and Devon has initiated its own dedicated AA.
Of the dedicated AA systems the Scottish service has an obvious role of paramedic response to the Highlands and Islands. The Northumbrian AA service is used to support a large rural area outside the metropolitan area of Tyneside. The West Midlands AA operates mainly in rural Shropshire where poor roads and isolated communities make it difficult for land ambulances to meet standards. The Cornwall AA provides a similar role responding to emergencies where land ambulances have difficulty in reaching the scene. The Cornwall service forms the basis for evaluation in Section Two.

Limitations

There are some limitations associated with the use of helicopters for patient transport imposed by the aircraft itself, its availability and its capabilities, weather conditions, the nature of the terrain and regulations governing its operation.

The actual choice of aircraft will inevitably call for some compromise between economy and versatility offered by a helicopter in the light to medium category and the restrictions in the space available in the patient compartment. Cramped conditions, high noise levels, inadequate lighting and vibrations are the most common criticisms of the helicopter as an environment for the care of patients, hence a need to stabilise a patient prior to loading is generally accepted.

The contractual costs of dawn to dusk seven days a week operations are considerable, thus limitations in flying hours are often necessary. The capacity of the aircraft to fly in adverse weather conditions is generally governed by visual flight rules. Other restrictions, requirements and regulations govern the operation of the aircraft, particularly in urban areas and with respect to take off and landings where environmental considerations should also be taken into account. Perhaps one of the main current limitations is the absence of suitable landing sites within stretcher carrying distance of the A&E departments of most DGHs.

Whilst it is theoretically possible for a Health Authority to purchase and operate its own aircraft, the costs and practical implications make it much more likely that the machine, its air crew and supporting staff would be provided by a commercial operator.

Funding

There are a number of ways of underwriting the cost of an AA, such as charitable donations and/or interest shown by commercial sponsors. To sustain such enthusiasm, which could be short term, will require a long term financial commitment from the NHS. This would depend on proof of a significant improvement in mortality or morbidity. There is little definitive evidence currently available of this.

Claims are made that the use of helicopters provide a means of replacing a number of land ambulances, but whilst there is little doubt that their use, particularly in rural areas, presents a number of operational advantages, given current limitations and costs it is unlikely that they represent a cost effective substitute for such vehicles.
Even if sustainable, the current experimental approaches will tend to produce a patchwork arrangement and many believe that a comprehensive national system should be an ultimate goal. The British Emergency Air Medical Service is a charitable organisation whose aims are to raise funds to operate and finance such a national system perhaps along similar lines to the Royal National Lifeboat Institution.

If current developments prove effective, the additional benefits of some national and co-ordinated approach are worthy of detailed considerations. While the cost effectiveness of using a helicopter in a primary role remains to be demonstrated, there can equally be little doubt of the operational advantages presented by such systems, particularly in rural areas.

The British Insurance Association and the motoring organisations have shown an interest in contributing towards the establishment of a national system. The pay off for insurance companies relates to the fact that on the death of a client they not only pay out a death benefit, but also have to pay up on the many other policies that people now hold such as mortgage, pensions and endowments. It seems very unlikely that a national private system will become a reality. Similarly, the DOH remains to be convinced of the need for public funding of such a system.

<u>Summary</u>

Over the years the ambulance service has had to react to the increasing centralism of health policy. This has led to the need for ambulance persons to acquire enhanced skills to keep patients alive during long journeys.

The efficiency of the ambulance service was seriously questioned during the 1980s and, to address this, the service was divided into the two separate functions: Accident and Emergency work and Patient Transport Services. This move was also politically expedient in allowing the private sector to compete for PTS work.

The National Audit Office Report 1990 highlighted that certain ambulance services had more problems than others in containing costs. Services were grouped into three bands of difficulty in delivering their service based on factors such as population density and the proximity of their patients to a DGH. In difficult areas such as Cornwall and Pembrokeshire tiering had the effect of increasing the costs still further as ambulances used only for A&E work in remote areas were under-utilised.

The introduction of the internal market for healthcare, which encouraged ambulance services to become self-governing trusts was thought to be the panacea for all the services' ills. Competition would lead to take-overs and produce economies of scale driving down unit costs. Diversification and income generation would also lower costs to the government for contracting A&E ambulance services, and the cutting edge of competition would encourage the adoption of new technologies which would increase efficiency.

With the above in mind for areas noted as 'difficult to serve' by the National Audit

Office Report 1990, the use of AAs was becoming more attractive. Such thoughts were also given a boost by the report on the Management of Patients with Major Injuries (Irving 1988) which went some way to encouraging the use of AAs to transport patients to trauma centres, should they be set up.

The next chapter looks at the study of evaluative economics to identify definitions of effectiveness and efficiency that would be useful in the evaluation of an AA within the British Ambulance system.

Chapter Four

Literature Review of Evaluative Economics

Introduction

The aim of this chapter is to explore the economic concepts of effectiveness and efficiency. This will provide definitions for evaluating the contribution of the AA in the case study explored in Section Two.

Effectiveness

The main measure of effectiveness for the front line ambulance service is the ORCON standard. The ORCON report was issued in 1974 and the recommended measures and standards of service for emergency and urgent calls were endorsed. The standards were revised in 1990. The standards are fully outlined Appendix A1. They specify that:-

a. 95 per cent of activation time should lie within 3 minutes.

b. In urban services 50 per cent of calls should receive a response within 8 minutes and 95 per cent within 14 minutes.

c. In rural services 50 per cent of calls should receive a response within 8 minutes and 95 per cent within 19 minutes.

These standards have been influential in shaping ambulance service operations, organisation and resource deployment. They have successfully facilitated comparisons of service levels in different areas and encouraged some consistency in services nationally. However, the fifty percentile target for response time has been increasingly difficult to achieve in urban services as traffic density has increased. The 95 per cent target has been consistently difficult to achieve in some very sparsely populated rural areas.

The setting of response time targets has an effect on resource utilisation. A relatively low target will tend to correspond to a high level of resource utilisation, as fewer crews are required to serve a given demand. A high target will usually entail lower utilisation, as it requires more crews and ambulances for the same demand. The curve relating resources to service standards exhibits a declining marginal utility of deploying additional resources, i.e. each additional crew deployed on a particular shift will improve the service level less and less, reflecting the reducing utilisation. In practice these utility curves would vary widely, depending on individual circumstances that apply in particular ambulance services at given times. However, it would seem that targets of above 95 per cent in the time spans would require additional crews whose contribution would be very small and thus entail much lower levels of utilisation.

The grounds for differentiating between targets applicable to urban and rural services were based on the fact that it is operationally easier to meet a given target in an area of high population density. In general the lower the population density in a service area, the higher the resource level must be to achieve a given 95 percentile for response time, although this is not a simple relationship being complicated by a number of factors such as geographical distribution of the population. This point is pursued at greater length in the equity study in Chapter Nine. If all services operated a common standard, there would be much greater differences than at present in the utilisation of crews between different types of area. Under these circumstances the marginal contribution of an additional crew, i.e. the effect on response time of making a further crew available, would be much higher in urban areas than in sparsely populated areas. Several points can be deduced from this. The first is that the ORCON standard is an effective standard, in that the majority of services are able to achieve it and in achieving it most services are operating at their most effective position in terms of staffing and vehicle utilisation. This says nothing about the medical implications regarding ORCON standards which were discussed in Chapter Three.

The more rural the situation, the less likely it is that a good effective position can be found between utilisation of staff and vehicles, and maintaining sufficient cover to give as equitable a response as an urban situation. It is this dilemma on the effectiveness of access that much of the work of this thesis explores.

Effectiveness of Access

The ambulance service can be seen as a first bridge between people needing emergency medical services and the people providing those services. (We will ignore for the moment the essential and increasing medical contribution of the ambulance service personnel themselves). Babson (1972) notes that 'The requisites of accessibility are quantitative adequacy and an appropriate geographical distribution'. The degree of accessibility emergency and urgent patients have to the ambulance service is the key issue in the effectiveness and efficiency of the service. If the ambulance service is to be regarded as a public good, as discussed in Chapter Six, then equity and distributional issues are also paramount. The usefulness of an AA can be measured in how its use affects the inter-relationship between the three factors of equity, effectiveness and efficiency. In the case of the ambulance service an appropriate geographical distribution can initially be interpreted as enough vehicles and sufficiently trained crews in the right locations in order to carry out this role effectively.

The desirability of evaluating quantitative adequacy becomes increasingly apparent as expanding medical knowledge accelerates the rate of specialisation. As paramedics make more use of practices such as defibrillation, then potentially more lives can be saved. Here an unmet need becomes a demand due to the supply side changing. There are ramifications to this in that it becomes an imperative for the ambulance to reach a potential victim in a time span where the use of such procedures can affect a reasonable outcome. It can be argued that if the remit of primary care is to save lives threatened by injury or illness in line with the medical technology that exists, then there must be an ambulance and a fully trained paramedic crew within three to four minutes access time of every potential patient. This is the critical time for the treatment of such conditions as cardiac arrest. Similarly patients suffering major trauma with low trauma scores need definitive care within the first few minutes of injury if they are to be salvageable. This would mean the provision of ambulances up to saturation point where providing the next ambulance would have no effect on outcomes. This is unrealistic for rural populations. Therefore access is thought to be substantially met as long as the ambulance service can deliver emergency patients to definitive care in a stabilised condition. Thus the element of accessibility requires only that all potential users have the opportunity to utilise any service, and the point at which any specific service is rendered should not be of such distance as to endanger seriously the health of individuals who must be transferred to receive such services. This is at odds with the Naylor Report (1981), where it was suggested that in many situations patients suffer adversely because of the distance that they have to be transported to centralised hospital facilities. Thus while the emergency services do provide an entry to the system, the accessibility does not match the medical technology available, and the speed of access to the system varies depending on your geographic location. The third element of accessibility is the absence of economic barriers. The front line ambulance services in Britain do not charge patients for responding to an emergency or urgent call, so from this perspective access is the same regardless of income.

Effectiveness of Quality

The components of quality medical care for the front line ambulance service rely on the competence of the individual providers and the availability of the relevant equipment to perform the most effective procedures. Individual performance is dependent upon adequate initial training, both formal and informal and motivation. For effectiveness of quality the most extensive paramedic training should be given to all front line ambulance staff so that when they attend patients with life threatening conditions, they have the skills to effect a positive outcome. There will not be a paramedic on every front line ambulance until 1996. Similarly, the potential of telementary technology on ambulances falls well behind its capability. (Telementary technology uses radio waves to transmit such information as electro cardiogram read outs direct from the ambulance to a hospital department. Consultants can then interpret the printouts and give the paramedics advice on treatments for a number of conditions such as arrhythmias). The Health Service in general has put a good deal of emphasis on quality but has not got to grips with adequately measuring it.

Effectiveness of Integration

Integration here represents the degree of co-ordination of all the components of the primary care services. Accessibility and quality are aided by good administrative arrangements, by which the appropriate services can effectively be brought to bear according to the medical needs of the population served. Barriers to co-ordination suggest a lack of integration, and therefore work against the attainment of an effective primary health care delivery service. This is discussed further in Chapter Six.

Cost Effectiveness

In order to get a comparative measure out of any effectiveness, programme valuations have to be in the same units. While not exclusively so, it is usual for the units of comparison to be reduced to monetary value, or cost effectiveness. Mishan (1988), describes cost effective analysis (CEA) as 'A truncated form of cost benefit analysis (CBA), which draws inspiration only from the cost side, or alternatively only from the benefit side of a cost benefit format'. Mishan goes on to stress that the most important difference in the two formats is the explicit difference in political constraints involved in CEA, and therefore its prescriptive significance. In a cost effective approach the funds available are under political control and the aim is to maximise the benefits or minimise the cost within the political constraints. Issues of technical effectiveness previously discussed take on a different outlook when viewed in terms of cost effectiveness. While the ORCON standards have been set at a level that is achievable by most services, it is almost by definition the most cost effective point providing national cover. Any increase in these standards reducing the time span of response, or increasing the percentile to be achieved, will produce accelerating diminishing returns. Therefore the most cost effective aim is to minimise the cost of producing the most effective cover to respond to emergencies.

With regard to the cost effectiveness of the medical intervention by ambulance persons, Drummond (1989) reviews the stages of effectiveness evaluation in the following way:-

a. The specification of the main dimensions in which health state is to be measured.

b. The scaling, and hence the measurement, of positions (or states) along the specified dimensions.

c. The relative valuation of combinations of characteristics in the specified dimensions.

d. The absolute valuation of the combinations.

It can be noted that the last two factors need a valuation in order to rank them, hence cost effective analysis. (CEA)

Williams (1987) shows that CEA operates at the micro economic level and is concerned with alternative ways of delivering care in terms of choice of mode, place, timing or amount. It is affected by our perceived attributes of health as indicated by health state indices, valuation of life, and our utility scaling of health. Williams agrees with Babson (1972) in that the supply of health care also affects CEA and also inter relates with demand. Demand can be affected by barriers to access in terms of price, time and place. The supply of health care at the micro economic level is affected by available manpower, drugs, equipment and technology.

Joy Townsend in Williams (1987) defines CEA as 'Essentially a comparative analysis either explicitly or implicitly in that it offers a comparison with alternative means of achieving an equivalent outcome'. Townsend notes that the essence of a CEA is to decide on a homogenous outcome which can be precisely defined. The different outcomes should be able to be scaled and give an example of outcomes. It is common to rate states of health on interval scales with two extreme reference points. Such a scale could have nought as death, and one as good health against which all intermediate states are rated. Such scales exist also for the measurement of trauma of accident victims, as well as overall quality of life. For example The Injury Severity Score, Major Trauma Outcome Study, Revised Trauma Score. Suffice it here to note that measurement not only has a physically measurable facet, such as morbidity and mortality, but also in terms of pain relief. The ambulance service uses trauma scoring to indicate what medical interventions will be pursued. All interventions have strict protocols and rules of how and when to apply them The cost effectiveness of these interventions have been considered and thought worthwhile, particularly in terms of the paramedic skills (Wright 1984).

Drummond (1989) notes that CEA measures the benefits of different treatments in the most convenient natural units 'years of life gained' or cases successfully treated'. Drummond also notes that CEA is appropriate when comparing two ways of meeting the same objective. The worth of the objective is not questioned, neither is the extent to which that objective should be met compared with others currently being considered. Nevertheless the CEA approach does offer a number of methodological simplifications the value of which should not be under estimated. The ambulance service has proved cost effective in terms of producing a service that operates in both urban and rural areas to the point of diminishing marginal utility. Its medical interventions have been proved largely cost effective. But does this mean that the service is efficient?

Managerial Efficiency

Small (1989) notes that the language of 'efficiency saving', 'cuts' and 'rationalisation', have been interpreted as linguistic constructions that offer a dominant form of discourse from the 'New right' social dynamic. They represent a shift from ethical constructs of paternalism and professionalism to ones generated by entrepreneurship and managerialism, as something located in expediency rather than justice. The power of language use to redefine cannot be ignored. On a less controversial basis Jones and Prowle (1987) argue that it is implicit in efficiency criteria that a given treatment or procedure cannot be preferred over another solely on the basis of being more beneficial, or solely on the basis of being less costly. It must assume relative benefits and relative costs, unlike cost effectiveness.

Greater efficiency can be said to have been achieved when:-

a. An increase in expenditure produces a proportionately greater increase in output.

b. The same amount and standard of service are produced for less cost.

c. Improved amounts and/or standards of service are produced for the same or lower cost.

d. A more useful activity is substituted for a less useful one at the same cost.

e. Needless activities are eliminated.

The above situations in health care terms are analogous to those in industry, for instance an increase in the hours an outpatient clinic is open, the more is the additional expenditure on nursing time and drugs. This would be balanced by increased output in the form of patient throughput and patient care. However such action within the NHS is constrained by the need to contain expenditure. While budget constraints should not affect efficiency, the finite budget may not yield the greatest economies of scale. Consequently much of the emphasis on efficiency in the NHS has been to do with cost improvement so that the same level of services are provided at least cost. Jones and Prowle (1987) argue that such a policy can only lead to cuts in services. Small (1989) argues along similar lines, in that the debate on the efficiency saving programme is a complex one. In September 1986 the Secretary of State for Health claimed that HAs in England and Wales had saved £150 million, equivalent to one point five per cent of their resources (Jones and Prowle 1987). It is difficult to ascertain whether these efficiency savings had been made, or were merely reductions in service called something else? Had 'efficiency savings' been audited in such a way that any deleterious impact on patient services was calculated? If this has been achieved had the scope for more savings now disappeared?

Sutton (1990) notes that in the years leading up to the introduction of trusts, the second tier of the ambulance service known as Patient Transport Services (PTS) had its budgets severely cut. The services could claim with some justification to have

become more efficient in terms that more attention was paid to routing vehicles to reduce wasting time and saving on miles. There was also a stricter adherence to the terms of eligibility of patients for the use of ambulance transport. There had been complaints over the years that GPs, particularly, had ordered ambulance transport for social rather than medical reasons. While this is allowed it was to be actively discouraged. Similarly a charge was introduced for the use of PTSs, which again discouraged patients whose need was social. This corresponds well with Jones and Prowle's concerns as to whether this constitutes efficiency or purely a reduction in service. While PTSs may appear more efficient as a result, how were the displaced people now getting to and from hospital and to their day centre appointments? Why does the PTS exist if it is not to fulfil a societal rather than an economic role and is the alternative cost of transporting those displaced patients higher, only borne by a different section of society? The Griffiths Report of 1984 agrees with Jones and Prowle's point that sufficient managerial input is needed for an efficiency search. This led to a shift from consensus to hierarchical management, but confirmed two basic trends, a centralisation of power and a preoccupation with costs, rather than the type or quality of service.

The new structure with tighter controls over money was designed to underline the reality that it was the DHSS who allocated resources and set priorities, not the doctors. This signalled an increasing shift in efficiency being measured even more explicitly in terms of resources used. This was reflected in the ambulance service by most services moving from a single tier to a two tier service, which in a number of services enabled the expensive front line service to maintain standards while the second tier suffered.

Jones and Prowle (1987) also note that efficiency has a spatial aspect, and the emphasis with increasing technology has been to transfer the treatment into larger hospitals to achieve economies of scale from advanced medical technologies with little consideration for efficiency in terms of accessibility.

Technical, Industrial and Allocative Efficiency

The commentators to date have identified issues of efficiency in the health service. A more formal definition of efficiency comes from Babson, (1972). He reflects that efficiency can be defined at three levels:-

1. Technical efficiency where the individual institution is producing at the lowest possible average cost for that amount of output.
2. The second is industrial efficiency and is achieved when a firm is producing at that level of output which will enable it to achieve its lowest average cost for the product.
3. The third is allocative efficiency, which is achieved when a nation or region has just the number of industrially efficient firms to produce the amount of the item desired by the population at the products lowest average cost.

Green and Mayes (1991) gave an excellent definition of allocative and technical inefficiencies which helps to clarify the concepts. They note that allocative inefficiency is defined as a failure to choose the optimal combination of inputs, with a result that at a given price ratio it would be possible to use a smaller total input. Technical inefficiency is thus the failure to achieve maximum possible output from whatever combination of inputs have been chosen. Technical inefficiency appears to be an important source of under performance brought about not by a lack of capital, but an inability to exploit that capital due to poor skills of both operatives and management. This contrasts with industrial efficiency, which is ultimately limited by the technology employed by the system and by the demographic and geographic characteristics of the region. Historically, within the ambulance service, this type of efficiency has sometimes had to be sacrificed, for example by the need to maintain a level of accessibility. This requires the provision of costly services for an isolated population which cannot utilise them fully. Such exceptions involve an efficiency, equity trade off, which is addressed more fully in the distribution section of this chapter.

Allocative efficiency, unlike technical or industrial efficiency, is not a measure of efficiency within the health care system but refers to society at large, thus providing a crucial measure of the appropriateness of the level of investment in the health care sector. If a health care system is to be allocatively efficient then the marginal social benefit must equal marginal social cost. Allocative efficiency dictates optimal utilisation of resources for any purpose as long as its contribution to the overall well being of society exceeds that of investment elsewhere. Within a given sector, efficiency dictates striving for the lowest unit cost consistent with desired quantitative and qualitative characteristics.

Social and Distributional Efficiency

Traditionally the approach taken to ensure efficiency in the public sector has been CBA. The cost benefit approach adopts a societal perspective to ensure maximum utility for society as a whole. Allocative efficiency exists where it is not possible to make any person better off without making some other person worse off. This is known as the Pareto affect. The existence of the perfect market can be shown to lead to both technical and allocative efficiency. However, historically, health care in this country has not been a traded market and as a market failure the state has been the allocator of funds on such principles as CBA. Drummond (1989), while accepting the notion of maximising the total benefit to the community, notes that the discussion of efficiency raises such questions as who or what constitutes the community, and what are the benefits arising from health care programmes. Drummond goes on to point out that benefit to the community of a particular activity is merely the sum of the benefits accruing to individuals in the community, in that the community does not constitute a person in its own right. Also within this context it is not just the benefit of those directly affected by a course of action, but also the ripple effects on the community of that action. To give an example, if an ambulance person by receiving paramedic training reduced the hospital stay of an accident victim by using his enhanced skills, the benefits would not just extend to the patient concerned, but also to society at large. The patient's reduced time in hospital means the hospital could treat more patients; relatives visiting the patient would have to travel to the hospital less often reducing their transport costs. They would reduce their use of the road in respect of that incident offering a saving to any congestion costs etc. Such ripple effects make Drummond's point of defining the community very important.

McGuire et al (1988) note that the allocatively efficient state is held to be desirable because if it is possible to undertake some change so that at least one person is better off without making anyone worse off then this must be a 'good thing' and 'ought to be done'. In reality public projects that provide a Pareto improvement by the strict definition are rare, so the criterion of approach becomes the potential Pareto improvement. This is defined by McGuire et al (1988) as 'A project that would satisfy the Pareto improvement criteria if it could make at least one person better off and no one worse off, if the losses were to be compensated from the beneficiaries' gains'. Thus the criteria are satisfied if the amount by which the beneficiaries gain exceeds the amount by which the losers lose. This is termed social efficiency. The Paretian principle requires only that we are able to determine whether each individual is better or worse off in relation to his/her own former condition, and so ignores utilitarianism.

The concept of efficiency for evaluating social states is not morally neutral as it must pre-suppose a view of what society is. The Pareto Optimality principle can be challenged as an appropriate tool for the practical assessment of social arrangements. If most have nothing, but a few have everything it may be Pareto Optimal, since improving the condition of the unfortunate majority may require worsening the condition of the privileged minority, therefore Pareto Optimality need not be mutually advantageous in any sense.

Social efficiency differs from allocative efficiency in that allocative efficiency implies there are no losers, whereas social efficiency implies that there can be losers. If in a Pareto improvement the beneficiaries actually compensate the losses then social and allocative efficiency coincide. The question of whether losers should be compensated is an equity issue requiring value judgements over how society should distribute its resources. McGuire et al (1988) therefore conclude that value judgements concerning the distribution of welfare are implicit, if not explicit, and are not additional. This begs the question of what should happen in the NHS. Should equity be an issue when projects are evaluated? This area is explored further in Chapter Five.

The final question on efficiency is what sort of ambulance service do we need in the future? It is worth emphasising certain points in relation to effectiveness. There can be little dispute that the main reason the ambulance service exists is to transport to hospital members of the public needing immediate treatment for illness or the result of an accident that may affect the duration or quality of their lives. In this respect the ambulance service can be viewed as an efficient taxi service. If it did not exist in public or private form, then the victims of accidents or illness, or their relatives would be willing to pay substantial sums, relative to their own economic well being, to be transported to definitive care. On this basis the ambulance service is effective, in that it already has in place a national taxi system tailored to such needs. It is also cost effective to the individual who pays little or nothing in contribution to the upkeep of the service in relation to what they would be willing to pay if their life depended on such transport.

Whether society as a whole benefits from the cost of maintaining an ambulance service depends to a large extent on the value given to a life or limb saved by using the ambulance service as opposed to alternatives. Perhaps the only *prima facie* evidence that a CBA ratio would be positive is that no first world country is without an ambulance service. However, the more sophisticated the ambulance service becomes in trying to save people with low trauma scores, the closer to the margin the service must move in terms of no longer being a positive benefit to society. In fact, from an efficiency point of view the service would benefit from greater differentials of urban and rural services (Vicary, 1990). If this is so why bother with equity?

Summary

In summary it can be noted that the ORCON standards offer a useful measure of the internal effectiveness of the ambulance service in providing emergency access to the A&E system. However, the ORCON standards are not medically effective as the skills of the paramedics need to be applied to patients with life threatening conditions within the first five minutes. Hence the need for a graded response system as discussed in Chapter Two. The ORCON standards can be viewed as cost effective as a blanket reduction in the response time, or an increase in the response percentile will escalate the costs as additional crews and vehicles will suffer an increasing diminishing marginal utility.

The managerial efficiency of the ambulance service has traditionally been constrained by poor information systems. This has not aided technical efficiency of providing the service at the lowest cost. Industrial and allocative efficiency in the service is a function of the optimum size of the firm that can take advantage of scale economies. Scale economies are often the result of new technologies, which hopefully are not only allocatively efficient but also socially efficient.

CBA is an analytical tool for measuring social efficiency. The relationship of monetary inputs to the monetary value ascribed to the benefits (outputs) provide a measure of efficiency, which is useful in comparing systems and in calculating the opportunity costs. The structure of cost benefit analysis will be used in Section Two to investigate the social efficiency of AA use in Cornwall.

Chapter Five

Equity

Introduction

This chapter explores equity and its relationship with effectiveness and efficiency in relation to ambulance service provision. The area explored in this chapter will aid the evaluation of AA provision in Cornwall explored in Section Two.

Equity is an ideological construct so its definition, and hence any optimal combination with effectiveness and efficiency will change with the pertaining political ideology. It is the ideological shift in the health service from a collectivist doctrine to a more libertarian attitude that poses many questions for the ambulance service. Fairness has been accepted as a fundamental principle of decisions about health care allocation within the NHS. However the purchaser/provider contracts that are forming the internal market for health care are placing a greater emphasis on the maximisation of improved health status at least cost above its distribution within society. The self interested operation of the market must deny the validity of decision making based on such principles as equity.

In the last chapter it was suggested that the main criterion for effectiveness of the ambulance service was that it should be accessible to all those who need it at a point of entry into the A&E system. For the ambulance service the requisites of accessibility are quantitative adequacy and an appropriate geographical distribution. In order to be equitable, in geographic terms, the quantitative adequacy and geographic distribution of resources must be such that in the most rural of areas the same level of response and quality of staff is received as those in the most urban areas. The last chapter indicated that in order to achieve this level of service, effectiveness and efficiency would suffer as the utilisation of services in rural areas dropped, and the cost of provision rose. The introduction of an AA to help service rural areas has totally changed the dynamics of this situation. The existing paradigm of the trade offs between service time, cost and equity for land ambulances breaks down with the introduction of the AA. The case study in Section Two explores the establishment of a new paradigm. The next part of this chapter looks at how the AA may help to shift the frontier of what can be regarded as efficient, effective and equitable outcomes. This is then followed by a review of the literature on equity.

Illustrated Examples of Land and AA Integration

In order to understand the AA's contribution to the dynamics of the situation, it is first necessary to understand the logistics for controlling a fleet of ambulances. Figures 5.1 to 5.5 and accompanying text are aimed at providing such an understanding and for outlining scenarios which will be referred to in the studies.

Figure 5.1. is a representation of a typical ambulance service area. Each square represents a similar population, but very different population densities. The larger squares are more rural in nature and therefore have a lower population density, while the smaller squares are more urban, with a higher population density. A hospital (H), is situated in area 1, an urban area. The urban areas have more ambulances closer to the district general hospital, which will almost always be in an urban area, and will therefore have shorter journeys to hospital than the ambulances serving the rural communities. Also there are more ambulances concentrated in the urban area giving more scope to juggle responses to emergencies, as will be displayed later.

Each area has a front line ambulance on call, but in this situation there are no calls that need a response. Each ambulance is responsible for responding to 999 calls in its own 'patch' and therefore will be stationed where it can respond quickest to all areas of its own patch. This is shown as roughly the centre of each, but this will in reality depend on the road system in the area and the locality from which most calls emanate. For instance if in square 6 there was a large town close to one corner, which represented a large proportion of the population of that area, the ambulance would site nearer to that town, as it is highly probable that a large proportion of calls would arise in this area.

The cover provided in each area is maintained 24 hours a day, 365 days a year. In most of Britain an ambulance area as represented in the figures would be surrounded by other ambulances areas. In this way neighbouring ambulance services can help each

Simulation of A.A. Operations

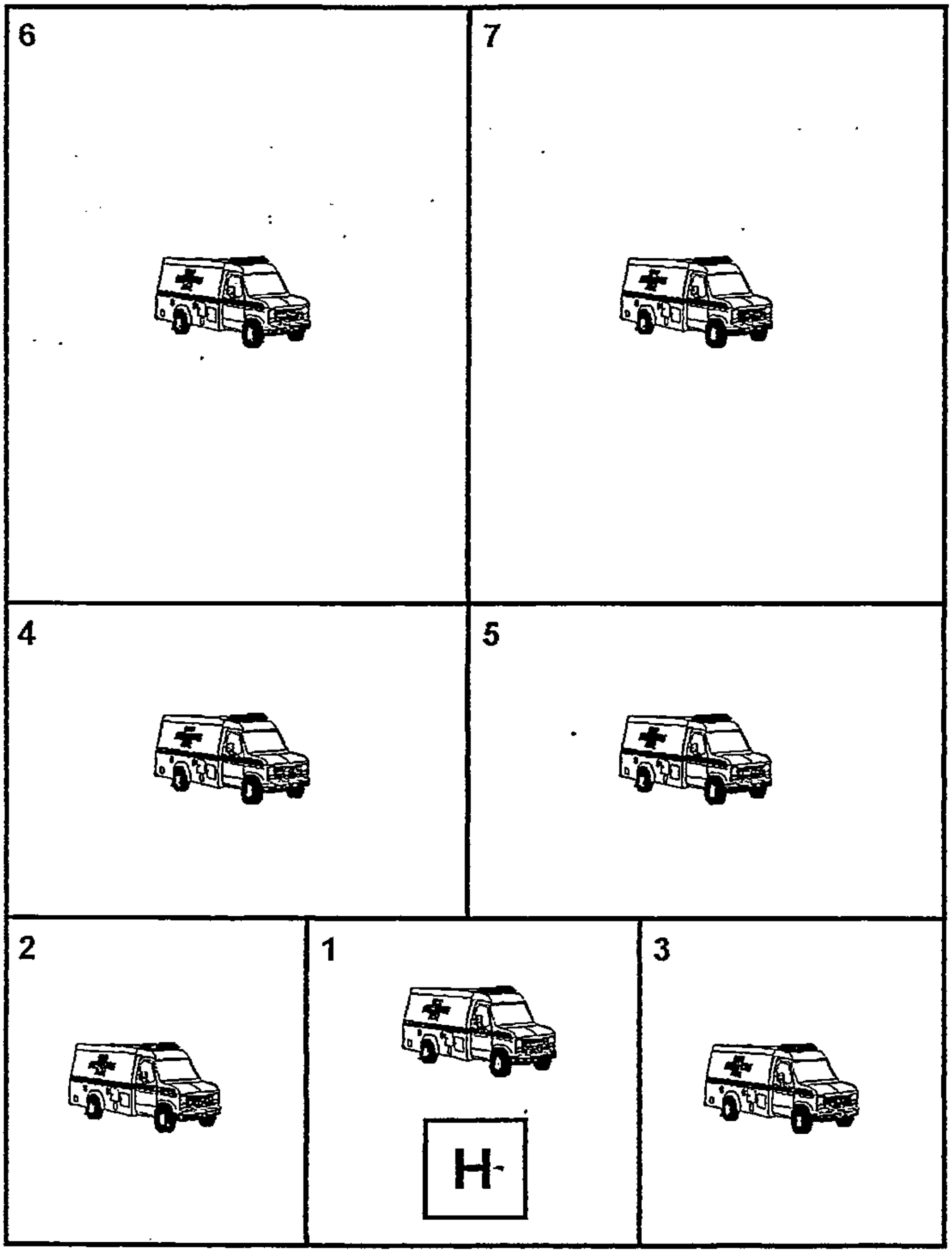


Figure 5.1

other out in times of need. This is not the case in Cornwall, where areas four, five, six and seven are surrounded by sea, and no such support can be relied upon.

Situation two as shown in Figure 5.2 demonstrates that a 999 call has been received in areas seven and two, and the ambulances in those areas have responded to those calls. The ambulances in areas six and one have repositioned to enable them to cover squares six and seven and squares one and two respectively. As area one and two are more urban in nature there is a greater probability that they will receive another emergency call before the ambulance from area two returns from its emergency call. As area two is much closer to the hospital than area seven, the ambulance in area two will return quicker to its patch than the ambulance in area seven.

Situation three, Figure 5.3, shows that the ambulances from area one and seven have delivered their patients to the hospital and are in the process of returning to their patch. All ambulances returning to their patch are on call and can be diverted to another incident. As the hospital acts as a honey pot for ambulances from many areas, it can be seen that there is almost always a good supply of ambulances on call near to major hospitals. In this time period three 999 calls are received from areas six, seven and three respectively. The emergency in area three is no problem as there is an ambulance in that area, and there are three ambulances in area one, one of which can supply cover to area three while the ambulance in area three deals with the emergency.

The situation in area six and seven is not so good. There is the not unusual situation of one ambulance temporarily covering two areas when a call arises in each area.

This means that the ambulance in area six will answer the call in area six. The ambulance in area five will answer the call in area seven, but it will take a long, and perhaps critical time to reach the scene of the accident. The ambulance in area four will move to a position where it can offer some form of cover to areas five, six and seven. The ambulance travelling back to area two will be diverted into area four to maintain cover in areas two and four, until enough ambulances become available to

Simulation of A.A. Operations

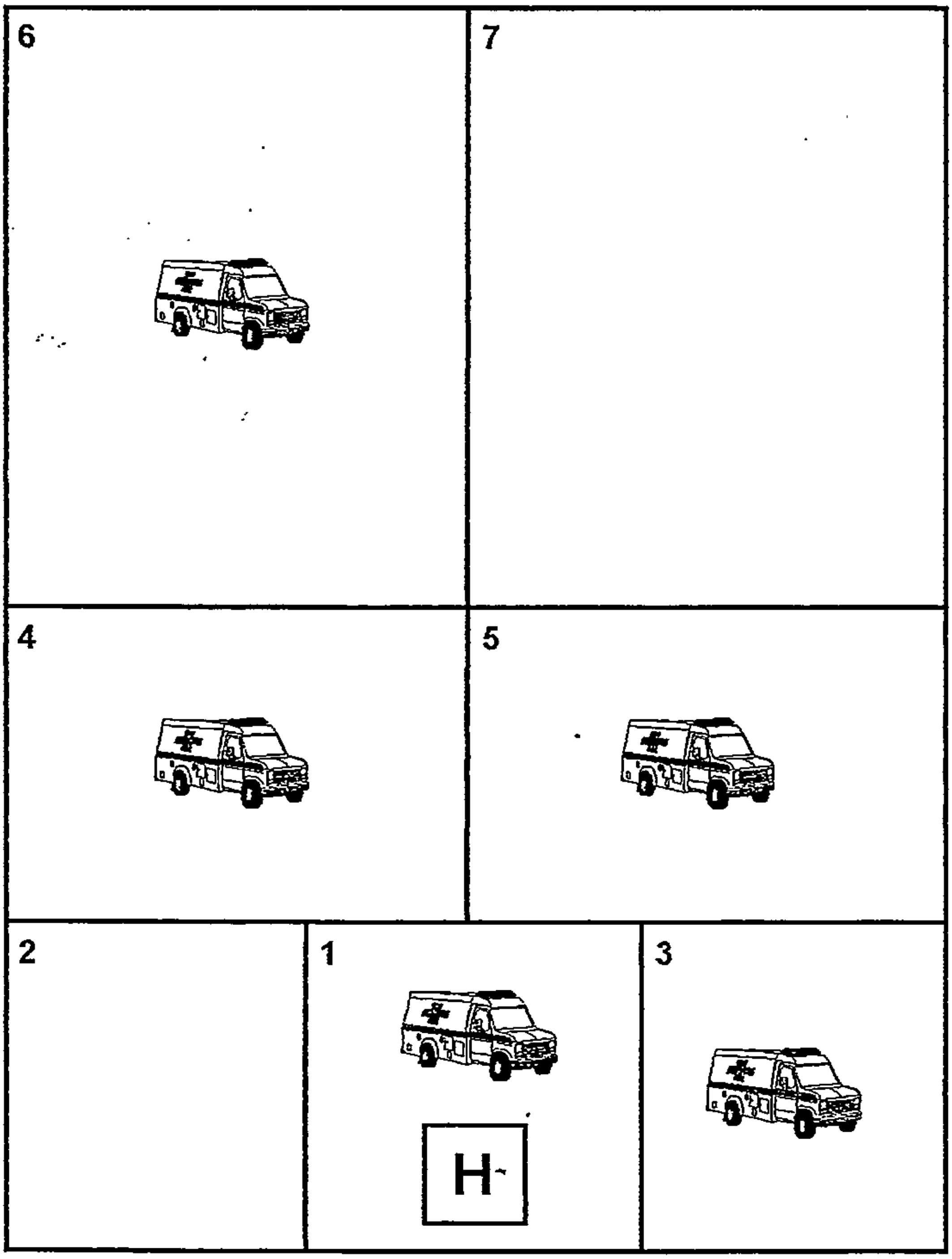


Figure 5.2

Simulation of A.A. Operations

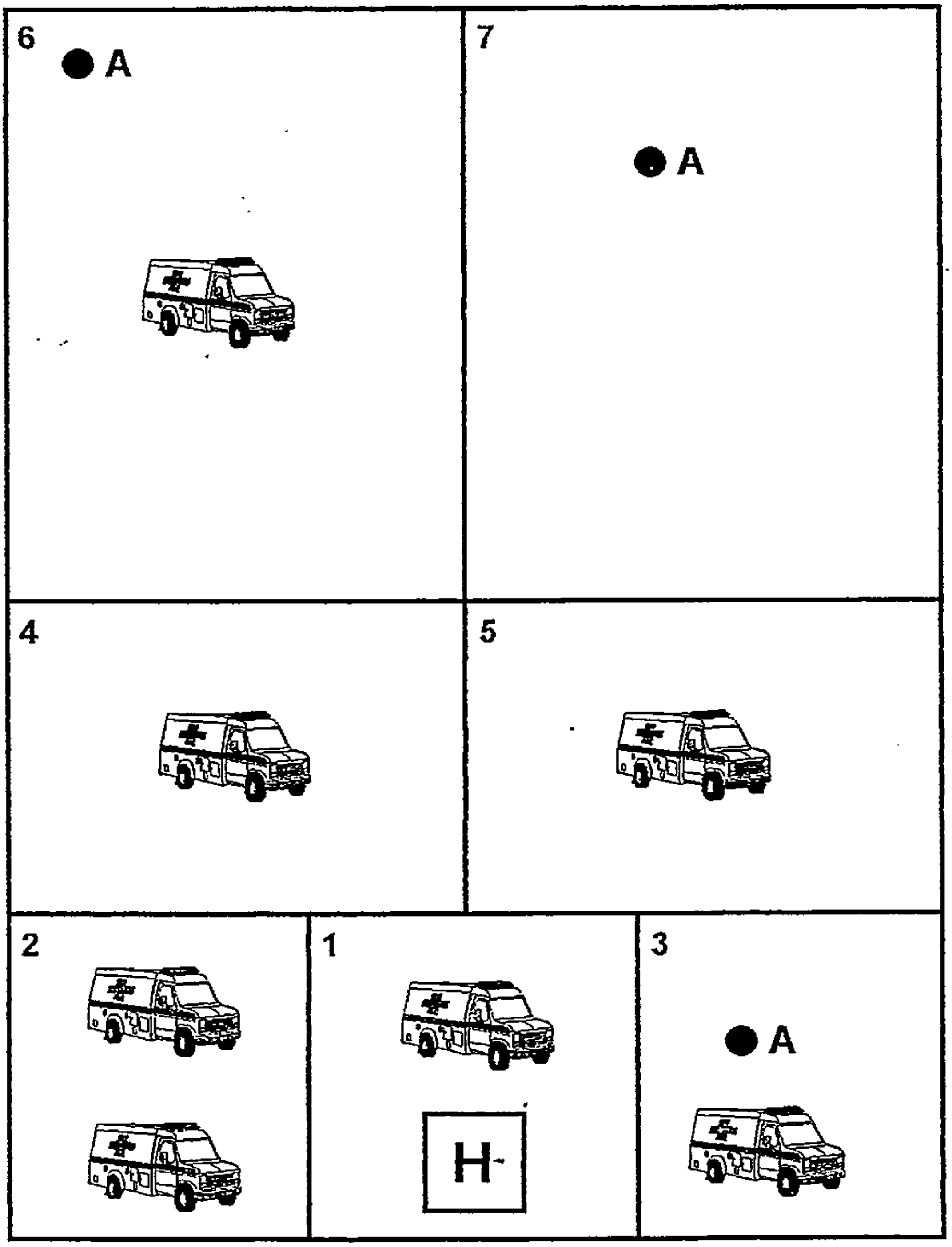


Figure 5.3

Simulation of A.A. Operations

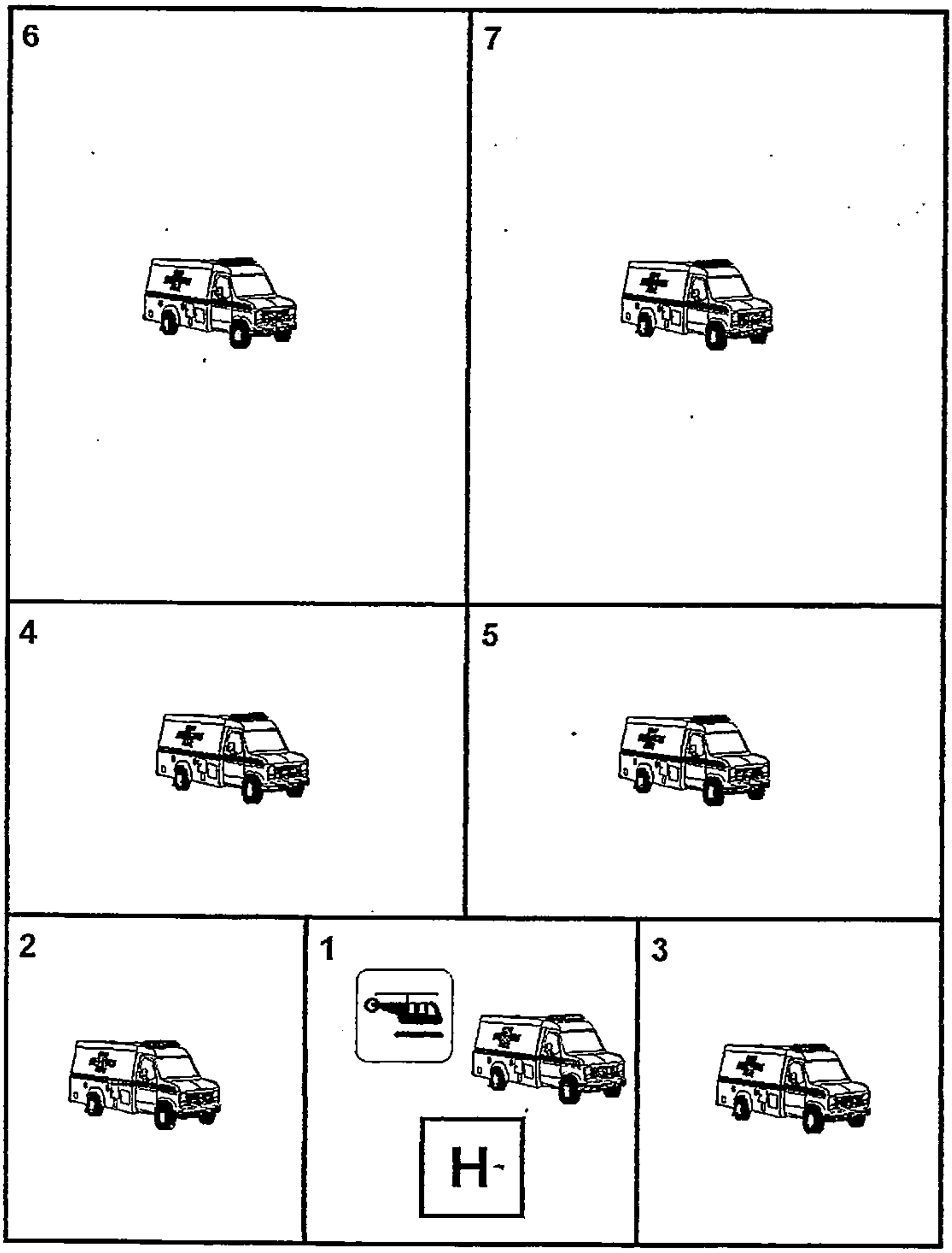


Figure 5.4

Simulation of A.A. Operations

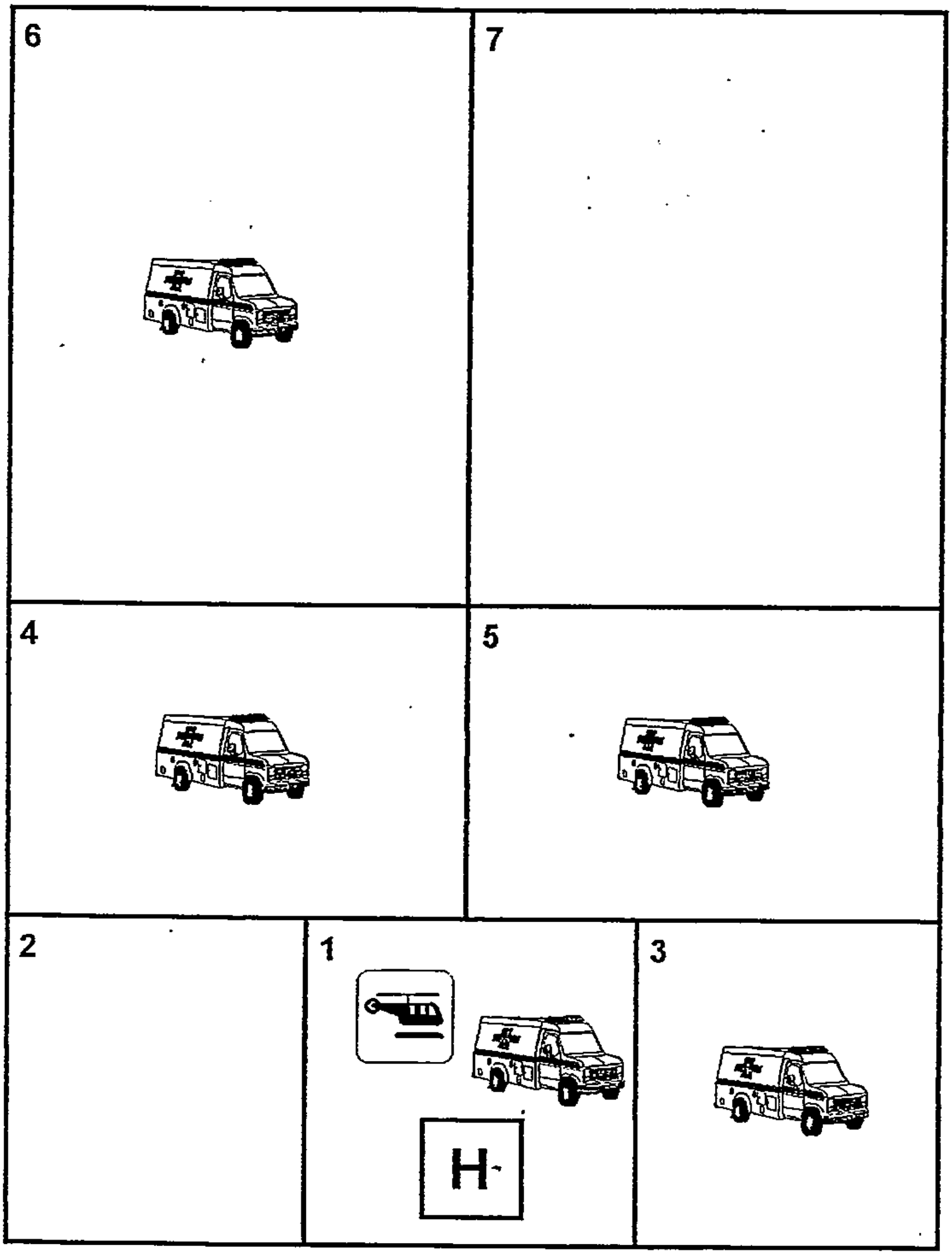


Figure 5.5

restore full cover. This juggling act goes on in every ambulance control centre around the clock. Most areas which have other ambulance services in neighbouring localities can overcome extreme demand situations more easily than areas such as Cornwall where there is very little contact with other services.

The main point of the scenarios is to demonstrate that rural areas often receive a poor response, in that their ambulances have a larger physical area to cover. The rural ambulances also have further to travel to hospital and on their return journey can be summoned to help in the more urban situations. This is not reciprocated, as the urban ambulances seldom make return journeys through rural areas.

Figure 5.4 situation four shows the same starting situation as scenario one, only this time there is an AA to supplement the land ambulances. The AA from its base near the hospital in area one can reach an incident in all the areas within the ORCON standards. In scenario five Figure 5.5, emergencies have arisen again in areas two and seven, and the land ambulances from those areas have responded to those calls. This time however the remaining ambulances have not moved to help cover the vacated areas as the AA can cover the whole area from its base in area one. If a repeat of situation three now occurs, the ambulance in area six can reach the call in its area within a reasonable time. The AA can respond to the call in area seven in a reasonable time and be back on call much quicker than a land ambulance from this area. The incident in area three would be responded to by the ambulance in that area, and the three ambulances in area one can provide cover for areas one, two and three. Ambulances in areas four and five would move to provide cover in areas four, five, six and seven for the relatively short period, until the AA became available again to cover the whole area.

AA use in the Real World

The above scenario shows the main advantage of the AA to the ambulance service. Its ability to cover large areas means that controllers spend less time repositioning ambulances around the county in anticipation of the next incident. This means that response times to incidents can be shortened and occasionally this may be critical.

Greater utilisation can be achieved of the land ambulances under an umbrella of cover from the AA and most important of all, the cover in the more rural areas is improved and becomes more equitable in terms of geographic access.

At this point it is necessary to look at the concept of equity. McGuire et al (1988) defines equity in health care as:-

> 'Involving some conscious departure(s) from the pursuit of maximising welfare (subject to some budget constraint) in the interest of a more equal distribution of some health related characteristic (e.g. health care utilisation)'.

Drummond 1989 sees equity as a ' slippery concept' that can be defined in many categories which are not necessarily compatible with each other. He offers the following examples:-

Equal access to care by geographical area.
Equal shares between client groups.
Equal access irrespective of income.
Equal access for people in need.

He further suggests that situations with more than one criterion resort to a political process such as whether to allocate resources by region or client group, with efficiency criteria between alternative patterns of care for each group being the deciding factor and equity acting as a constraint on how far to pursue efficiency. He suggests that an appraisal should be made on efficiency criteria and selected subject to equity considerations. Philips (1985) poses the question, 'What is planned for health care: efficiency, equality or equity?' Does equality mean that every person receives the same treatment or share of resources regardless of who or where he or she may be? If so is it arithmetical or proportional equality? Philips suggests that arithmetical equality implies that everyone receives exactly the same, whilst proportional equality can mean that people receive things in proportion to preset norms: equal treatment in the same circumstances where these can vary among groups and individuals.

Weale 1983 outlines the problem as being that the Pareto principle of economic efficiency is concerned with utility of one set of individuals under one set of circumstances as compared with those same individuals in another set of circumstances. In other words equity is about comparing different individuals across the same circumstances, or horizontal equity.

In essence concern with equity involves the wish to abandon a strict willingness to pay criterion, since such willingness must inevitably be based on an ability to pay, which in turn reflects the existing distribution of income and wealth. If ability to pay is for some individuals or groups judged to be impaired, then for various reasons this may mean that society generally may wish to ensure that the distribution of certain relevant commodities is not based on willingness to pay. In this case the general commodity is health care and the specific commodity is emergency transport to hospital. If the ambulance service is perceived as being efficient in the terms described in the previous chapter, is it also equitable? In terms of equal access irrespective of income, equal access for people in need, or equal shares between client groups, there is no dispute that the service is equitable. However, equal access to care by geographical area does not exist.

Mooney (1986) notes the following definitions of equity which can apply to health care. The list is not exhaustive.
Equality of:-

1. Expenditure per capita.
2. Inputs per capita.
3. Inputs for equal need.
4. Access for equal need.
5. Utilisation for equal need.
6. Marginal need met.
7. Health.

Mooney explains the differences between one and two as simply that in two different areas of a country, the price of relevant manpower goods and services may differ. As a result a fixed level of expenditure may buy more inputs in one location than in another.

He further suggests that the difference between access and utilisation, as in four and five, is that the former is a supply side phenomenon and the latter is a function of both supply and demand (or need). Equal access means that two or more individuals face the same costs to themselves of using the health care facility, in that they might live the same distance from the health care facility. Whether they use it or not will depend on their demand for health or health care. If two individuals face equal cost of access and have equal demands for health care, utilisation of health care will also be the same. If they have different access but equal demands, they will have different utilisation. If they have both different access and different demand, it is likely, but not necessarily the case, that their utilisation will differ.

Mooney's explanation of number six, equality of marginal met need, is based on the cost benefit approach. All things being equal, a rational health authority, operating under a budget constraint, will allocate its scarce resources to those activities for which the ratios of benefit to costs are highest. It will continue to do this until it has used up all its allocation or expenditure. It will therefore want to establish a ranking of needs to be met, the ranking being based on the size of the benefit/cost ratio.

Having identified differing strands of equity considerations in health care, Mooney follows the same line as raised by Drummond (1989) but takes it further by identifying that health policy on equity is couched in terms of equality that can be defined in two ways as either horizontal or vertical equity. Horizontal equity, the equal treatment of equals, seeks to provide the same amount of health care for individuals who are identified in terms of all relevant characteristics such as health status, age, sex, geographical location etc. Vertical equity, the unequal treatment of unequals, is necessary to quantify the degree of inequality that exists and to establish a relationship between the level of health status and the level of service that should be received. It is not enough to say that those with worse health status should receive more health care, it is necessary to take account of how much additional health care those who are worse off should receive.

Mooney notes that the objective pursued in the NHS is based upon horizontal equality of opportunity. In other words the aim is to ensure that those in similar positions to one another in terms of their health care needs have equal access to health services. The goal is then equal service for equal need, which demands equal access for equal need. This is the objective most frequently found in policy documents. The implementation of policy in this pursuit is difficult to sustain, not least because of the individualistic nature of the goal. Mooney believes that the policy implementation corrupts the objective so that a standard of equal inputs for equal needs becomes sought over the whole area irrespective of differing localised demands. Any objective of equal health would raise problems in defining and comparing health levels, as well as being exceedingly expensive to obtain.

Equal access for equal need across the regions has not got much further than equal inputs for equal need, as it is easier to define and measure inputs than it is to measure access. A further problem is that of measuring differential health and consequently relative needs in the different regions. This is done using standardised mortality ratios (SMRs). These ratios compare the number of deaths occurring in a region with those that would be expected if the national mortality ratios adjusted by age and sex were applicable to the population of that region. SMRs are not wholly reliable as a guide to need, as certain chronic conditions such as arthritis can have a high prevalence rate that is not reflected in an increased mortality.

Historically the ambulance service has done well for funding in relation to many other services, as it is a highly visible service with easily defined boundaries of operation. As such the front line service could be seen to be equitable in offering a similar standard of service regardless of location. This was during a period in which the ambulance service was often criticised for being inefficient. While not being totally efficient it was fulfilling a mandate of equal access for equal need irrespective of geography. Although the efficiency of the service has improved, geographic equity has deteriorated in terms of response times. Response times improved close to the centres, but lengthened in the rural areas. The whole truth is not displayed by ORCON statistics. ORCON standards can be viewed as a summary statistic for an area and will as such compress information about a distribution into one number. The number gives an indication about the dispersion of that distribution which inevitably emphasises some information while suppressing other. The interpretation of this information involves a normative assessment, but the emphasis or suppression in the information within the statistic requires a value judgement. The development of the internal market for health gives rise to the question of whether there is a place for equity in the NHS. Equity, it has been argued, should not be among the objectives of economic organisation on grounds of impracticality, because agreement on the definition of equity is impossible and not value free.

While health care has moved towards a market system on the grounds of efficiency, or political ideology, the market is still very much controlled, giving the message that equity must still be an important consideration in the policy process. In the purchaser provider set up equity will still be a consideration in the allocation of resources. It will be equity of inputs for equal need. A purchaser will allocate a budget where the most health care can be bought for the least resources. This will certainly mean an even greater erosion of geographical equity while the fundamental desire should be that the two principles of equity and efficiency need not be reduced to a single one. To some extent it should be possible to substitute one for the other. An evaluation, therefore, in deciding which mixture of principles are better for a particular allocation of resources, is to say that one outcome is more equitable, or more efficient than another on an ordinal rather than a cardinal scale.

Summary

Equity can be defined in many categories that are not necessarily compatible with each other. The ambulance service can be viewed as provideing an equitable service by income group, but to provide a service that was geographically equitable would require a trade off with efficiency. This chapter has shown how the introduction of an AA can dramatically changed the trade off points between effectiveness, efficiency and equity that have existed with land ambulance only provision. The relationship between geographic equity and social efficiency is explored further in the studies presented of the Cornwall AA in Chapters Eight, Nine and Ten of this thesis. How various theories of justice are closely associated with the concept of equity are discussed briefly in Appendix B1.

Chapter Six

The Ambulance Service Within the Internal Market for Health

Introduction

The last two chapters have assessed effectiveness efficiency and equity and the trade offs that exist between them in the provision of rural ambulance services. The change in the trade offs and dynamics in this relationship by the introduction of the AA has also been discussed. The adoption of a market system for healthcare is the greatest change the Health Service has undergone since its inception. The changes in healthcare provision will be one of the most important aspects of whether AAs are adopted more generally in this country. The aim of this chapter is to outline the political and ideological debate that has underpinned the creation of the internal market for health. The discussion then moves on to outline some of the problems for the ambulance service competing in a healthcare market. The chapter concludes with thoughts on how this will affect the adoption and use of AAs in Britain.

The End of the Keynsian Post-War Consensus

During the 1970s most advanced western countries were suffering economic difficulties. The first oil shock from the Arab/Israeli war had sharply increased energy prices giving rise to high unemployment and high inflation at the same time. This was aggravated by competition, in the political arena, for power. Each political party promised more to the electorate than the other, producing what Dearlove and Saunders (1986), have called 'political overload' and 'ungovernability'. This led to a perceived failure of the Keynsian post war economy and a swing to the politics of the right. In 1979 Margaret Thatcher was elected as Prime Minister with a mandate to 'roll back the frontiers of the state' and to 'increase the freedom of the individual'. The Thatcher years have seen the embodiment, to varying degrees, of a political doctrine that has become known as the 'New Right'.

The Ideology of the 'New Right'

The ideology of the 'New Right' owes much to the writings of Friedman and Von Hayek and to the research efforts of the Adam Smith Institute. Hayek (1978) argued that the concept of equity is inapplicable to the outcomes of a spontaneous process such as allocation of resources determined by the free market. This is because the interactions of thousands of people through the market mechanism make it impossible to describe market outcomes as just or unjust, equitable or inequitable. While this takes no account of the initial allocation of property rights, it also ignores the substantial intervention by governments in the production and subsidisation of key products. Hayek further rejected the possibility of economic planning on technical and moral grounds. Technically, government planning must be inefficient because economic transactions are far too complex to plan any outcome in terms of productivity, growth and pattern of production and consumption. Morally, he argues, such planning needs to be rejected because it would inevitably lead to an authoritarian organisation which would pose a great threat to individual liberty. Such activities should be left to the market which is seen as a liberating force and a defence against authoritarianism. Government should therefore abandon its assumed but mistaken role in planning and hence any responsibility for economic outcomes such as unemployment, growth levels and welfare.

The 'New Right' saw the welfare state as a brake on the economy, and believed it to be a major actor in the fiscal crisis of the state in the 1970s. Drucker et al (1988) suggest that the 'New Right' thinkers believe that the fiscal crisis is due to the fact that in a constrained economy with a welfare state the government has two imperatives. The first is welfare expenditure, seemingly necessary to secure legitimacy and meet expectations raised in this field; the second is to secure the profitability of private industry. In reducing the public sector borrowing requirement the 'New Right' believe that there will be less competition for funds in the private sector. Another area of their strategy has been to encourage the development of market based forms of provision in the health field, such as private hospitals and insurance and latterly trusts and health care markets have been set up. There have been failures with this policy. Private insurance has not developed to the extent the government would have desired, and a leak of a confidential document before the 1983 election that proposed the wholesale privatisation of welfare services caused an uproar and prompted Mrs. Thatcher to claim that the NHS would not be privatised and would be safe in Conservative hands. This has not stopped the process of preparing sectors of the NHS for privatisation as fast as public opinion will allow.

The privatisation of welfare agencies as far as is judged possible, will reduce the power of the employees within the welfare agencies. The doctors, nurses, social workers, teachers and ancillary workers all subject politicians to enormous electoral pressure to increase welfare provision. This can only be reduced by a diminution of the State's role in welfare provision and distribution; hence the economic decentralisation. Economic decentralisation has not led to political decentralisation, in fact the reverse seems to have been the case. There have been severe constraints on local politics and the level of local funding required to sustain political demands and a greater centralisation of state power has occurred.

Efficiency Arguments for and Against the Free Market

According to Buchanan (1985) the claim for the market on grounds of efficiency rested on the assumption that a Pareto Optimal is reached in the perfectly competitive market and that actual (non-ideal) markets sufficiently approximate the efficiency of the ideal market to make them preferable to non-market arrangements, he also makes the point that the free market is cheap to administer. The diachronic effects of the market are efficiencies that result from competition in that those who fail to remain competitive and develop the least costly methods of production are replaced by those who do. In perfectly competitive markets perfect information is assumed and therefore there are no transaction costs. Actual markets tend towards Pareto Optimal outcomes only to the extent that transaction costs approximate to zero, as in the ideal market. In actual markets they are never zero as buyers and sellers struggle with logistical problems of transportation and communication costs. Strategic behaviour such as bluffing by either party and costs of the legal system for drafting, interpretation and enforcement of contracts all add to transaction costs. Health services are hindered in a competitive market environment by their high communication costs.

Factors that inhibit the market from reaching Pareto Optimal are:-

1. Changing consumer preferences.

2. Over or under production.

3. Information for consumers about the existence of alternative products or about the quality or performance of products due to restricted entry.

Monopolistic tendencies exist when some exchange can unilaterally influence prices brought about by economies of scale and/or government intervention, however, monopolistic tendencies are inherently unstable and eventually break down through competition. Positive or negative externalities exist when a third party benefits or suffers without being party to the transaction. While not being inefficient, markets will not work with them. Green et al (1990) point out that the Austrian School believe that externalities are over emphasised and can be internalised by reducing impediments to the market. They also note that Hayek and the Austrian School have criticised the orthodoxy of the Neo Classical interpretation of markets on three counts:-

1. Excessive pre-occupation with analysing the economy in terms of equilibrium.

2. The view of markets as static mechanisms.

3. Too little attention paid to the role of knowledge and how markets actually work as disseminators and processors of knowledge.

Green goes on to note that the neo-classical school relies on positivism, premised upon certainty relationships. The Austrian School argue that there are no certainty relationships and therefore reject positivism. It is the fact that things do not co-ordinate that sets off the market process, because it provides the environment in which individual agents will change their plans through time in order to improve their position. The market in this activity provides the incentives for the discovery of error, such as profit opportunities created by ignorance and uncertainty. The entrepreneur works in the same world of ignorance and uncertainty but somehow spots things just before others, such as gaps in the market, and/or price discrepancies. His knowledge is utilised, people discover things they previously did not know. As the market operates, the knowledge becomes collectively owned, and with the dynamics of a changing world becomes redundant. New ignorance emerges and the systematic process continues, but a complete equilibrium never occurs.

Efficiency the 'New Right' and the NHS.

The architects of the 'New Right' have produced a challenging response to the Neo Classical school and perfect competition. On welfare they believe that charity should be the prime mover as a mechanism to reduce taxation, which is itself viewed as theft. In the 1970s the mood in the country at large was being reflected in the NHS by a move from an era when the administrators facilitated the resources needed by the clinicians, to a mood for an audit of resources used. A planning cycle was introduced and programme budgeting adopted. The language of the economist, with such terms as 'opportunity cost' crept into the public consciousness and the management was starting to question the autonomy enjoyed by the clinicians in all forms of decision making within the NHS. New managers seemed to confirm two basic trends, a centralisation of power and a preoccupation with costs, rather than the type or quality of service.

The new structure with tighter controls over money was designed to underline the reality that it was the DOH who allocated resources and set priorities, not the doctors. This signalled an increasing shift in measurement of efficiency even more explicitly in terms of resources used. Small (1989) noted that by 1987 managers had a narrow concern with performance defined managerially not medically. Efficiency savings had been made. This was not surprising with the size of the NHS, but could such savings be made year after year?

The 'New Right' theory of the market providing the best allocation of resources while government provides the minimum legal framework to ensure that markets function in a newly created health care market was alluring but problematical. In order to ensure its own survival the government still has to consider that certain social objectives are met. This may mean that government regulation will modify the incentive structure upon which competition depends. An example is that from April 1991 health authorities have been charged for their existing capital assets and new investments, which were treated as 'free goods' with little incentive to use them efficiently. Rental payments upon site value will give wide variation in the cost of providing services at different locations. The market logic would be a relocation away from expensive inner city sites. The need to ensure that certain core services are always made available locally means that the market process cannot solely determine location decisions and government subsidy may be needed to ensure continued financial viability of high value sites such as ambulance stations in prime city sites. Such a subsidy is a market distortion. It could of course be argued that it was previous government policy regarding planning regulations that has created a distorted property market in the first place.

In similar vein self governing hospitals are able to set prices at marginal cost if they have unused capacity, but may not engage in cross subsidisation between services in order to makes its prices more competitive. How can you identify which users are additional and not expected to bear some of the fixed costs? Without the ability to demarcate patients, marginal cost pricing will necessarily involve cross subsidisation, which will probably happen anyway with so many joint costs involved in a particular speciality or case mix group. The high number of joint costs makes allocation impossible. Consequently, a large element of judgement will be involved even after an information technology revolution aimed at identifying such costs. Concern can be expressed that self governing hospitals may concentrate on profitable services in demand by purchasers of care outside their area to the detriment of services needed by local people. The end result of this could be a smaller number of hospitals able to provide these services which will offer a trade off between efficiency and accessibility.

In line with free market practice 'Working for Patients' proposes that trust status ambulance services will be given the freedom to determine their own staffing levels, rates of pay and conditions of service. In encouraging a free labour market, differentials will occur leading to winners and losers in terms of particular staff and/or institutions. A possible consequence of a free labour market could be the upward pressure on NHS spending, the monopoly that has existed being very successful in cost containment. It is difficult to know whether in the long run this will have a good effect in better morale and less wastage of experts to other industries and countries, or whether any increased productivity will be outweighed by higher costs.

One of the main objectives of the current NHS reform as set out in 'Working for Patients' (DHSS 1989) is to 'put people first', by providing improved services to patients and to give people working in the NHS greater job satisfaction. The mechanism chosen for achieving this, the creation of an internal market of purchasers and providers, has been quite well documented, but the arguments of economic theory as applied to a real world situation have not been as well aired. The written agenda is that those responsible for providing various forms of NHS care have no idea of the cost and the NHS budget is not a bottomless pit. The need to write a contract over issues of purchasing and providing NHS services focuses the mind of the providers of these costs and makes them more aware of the cost of alternative courses of action. This is based on the assumption that the cost of such contracting brings about improvements in effectiveness and efficiency which outweigh the cost of providing the contracts in the first place.

The Ambulance Service and the 'New Right'

The ambulance service makes a very interesting case study, in general, regarding the 'New Right' economic philosophy and in particular in the application of a created internal market facilitated by the enactment of the white paper 'Working for Patients' (DHSS 1989). The ambulance service has been seen as a natural monopoly within the NHS structure and it can make very reasoned arguments to be a public good. However in the economics of the 'New Right' the existence of a public good does not automatically exclude it being in a contestable market, a point which is taken up later in the discussion. In plotting the events that have facilitated the ambulance service to be able to become part of a competitive market, several avenues have to be followed. In economic terms the seminal work of Baumol et al (1982) on contestable markets has had a profound effect in areas such as differentiating fixed and sunk costs, and their affect on entry barriers to markets that in the past have been viewed as uncontestable.

An acceptance that fixed costs in ambulances are not sunk and competitive tendering from a larger organisation that has, or can show that it could have, economies of scale by taking over the incumbent, could win a contract for supply of A&E care. In fact, within the industry, amalgamation has already occurred. The National Audit Office Report (1990) quoted that many ambulance services were too small, while the head of the Association of Chief Ambulance Officers has estimated that in the not too distant future there will be only 25 ambulance services (Caple 1991). Lowered barriers to entry and the existence of economies of scale will in the long run assure that not just the firms within the industry, but that the whole industry itself is efficient.

According to Baumol et al (1982) high fixed costs do not particularly constitute a barrier to entering the market. A contestable market Baumol defines as 'A market vulnerable to costlessly reversible entry, even when it is currently occupied by an oligopoly or a monopoly'. This is a generalisation of pure competition. However in order for these conditions to apply there must be no barriers to entry. With entry barriers supernormal profits, inefficiencies, cross subsidies and non optimal prices all become possible. In a contestable market, which is perfectly consistent with the presence of high fixed costs which are not sunk, matters change drastically and government intervention can contribute far less, if anything, to the general welfare, all very much in keeping with the philosophy of 'Working for Patients'.

The construction of a contestable market implies by the nature of pure competition that supernormal profits, inefficiencies, cross subsidies, and non optimal pricing will not be possible. An efficient firm in a free market remains competitive. This is the same for the industry as a whole. Thus frictionless free entry has the power to enforce an efficient industry structure. For the same reason an incumbent firm is forced to adopt any new techniques capable of reducing costs, as failure to do so will invite entry by firms that do employ such cost saving innovations and those entrants will be in a position to take the markets away from the incumbents.

There can be little doubt that the ambulance service has made great strides in the adoption of new technology and innovations in order to reduce or contain costs. The separation of A&E work from PTS is an obvious example, as is the experiment with novel modes for A&E work such as motorbikes, helicopters and rapid response cars.

While the theory to date has shown a rather rosy picture for the creation of a contestable market in the ambulance service, there are problems. The very long run will lead to monopolistic tendencies. In theory this should not matter as the possible threat of entry into the market will keep the firm efficient. The nature of 'Working for Patients' with regards to the ambulance service is that the Local Health Authority will purchase A&E cover on a block contract basis. Similarly local hospitals will purchase Patient Transport Services from the ambulance service, or other bus/taxi services on a cost and volume contractual basis.

The Contracting Process

The existence of contracts can reduce the size of the entry barrier which the sunk cost would otherwise entail at the time that contracts are negotiated. In so doing they substitute a new and more formidable entry barrier during the life of the contract by precluding any further potential entrants from the business which the contract has tied up. The calculation of contracts must be optimal for consumers and society in balancing these two costs, as well as any other associated social costs such as those resulting from stultified innovation. As already pointed out, innovation in the ambulance service is far from stultified, the nature of A&E work is very specialised. After the initial round of contracts have been won what competition will exist? The second and third rounds may see take overs and amalgamation while the advantages of economies of scale can still be reaped, but eventually it would seem that a geographic monopoly will exist which cannot be threatened during the life of a contract, as potential entrants are excluded. By the time contracts come up for renewal there is not likely to be any competition left in the field! In this situation there is not a frictionless market and society could well end up paying more than under the present system.

This is also complicated by the varying nature of contracts available. DHAs can contract for A&E cover with the ambulance service alone, from the whole of primary care or from a common services trust. A tender from the ambulance service itself leaves little scope for any kind of cross subsidisation. The vertical integration approach of a bid from primary care as a whole gives definite scope for cross subsidisation, and hence inefficiency in terms of public resources within the remit of the libertarian philosophy. The horizontal integration of a common services agency also has pitfalls. Patient Transport Services may seem less of a problem as the work is not so specialised in terms of manpower or vehicles. In this context there is always likely to be a competitor lurking. However if hospitals start to compete for patients on a geographical basis, a degree of cross subsidisation may creep into ambulance contracts in order to increase the hospital catchment area and hence potential client base. While DHA contracts are for complete A&E cover of their area, those competing will note that it is more expensive to serve the sparsely populated rural areas than the urban and suburban areas. The eventual result of this will almost inevitably lead to a deliberate dropping in standards for rural areas in order to maintain a minimum cost service for the majority of the population. The ORCON standards already differentiate rural response from urban response. While many rural areas show ORCON response times which are reasonable, many hide deep pockets of deprivation not shown in aggregate as shown in Study One of this thesis and as shown by Haynes (1987).

Having looked at how the ambulance service has been transformed from what was, in effect, a nationalised industry to a competitive free market environment, the conclusion was that in its drive for efficiency, horizontal equity will be sacrificed in that there will not be equal treatment of equals for equal need. Local HAs, in their desire to keep costs down and ambulance services, in their desire to remain competitive, will gradually erode response standards in rural areas. The inequalities in geographical equity will sharpen as individual ambulance services need to accept a more business-like approach to survive in a competitive environment. This can already be seen in some services and is portrayed in a publication by the Association of Chief Ambulance Officers entitled 'Ambulance 2000: Quality in Pre-Hospital Care' published in August 1990.

Ambulance 2000 was produced in response to growing concern by the Association of Chief Ambulance Officers against a takeover by the fire service. The response gave no support for a fire service takeover, which could have led to overall economies of scale in base and communications equipment. The horizontal integration of the A&E ambulance service with the fire service is the norm in many countries and to an extent existed in Britain from the end of world war two until 1967 when the final separation of joint fire and ambulance services took place in the UK. This was greatly influenced at that time by the heavy non emergency workload of the ambulance service and the compromises it created in emergency work. The tiering of the service however has led some to reconsider merging the emergency ambulance service with the fire service. They both have to provide a twenty four hour emergency service and often have to work together at accident scenes. However, the ambulance service is increasingly developing a more symbiotic relationship with the health service regarding its communications equipment which is necessary to maintain a twenty four hour emergency service. The contracting of spare capacity to the health authorities allows more cost effective provision of support services to hospitals and GPs in these areas.

The Association of Chief Ambulance Officers very much wish to remain within the NHS and see the implications of the enactment of 'Working For Patients' (DHSS 1989) as a way of moving the service forward. Confirmation of this comes from Ambulance 2000 (Chief Ambulance Officers Association 1990) which under the heading of 'Goals and Values' states that 'Patient transport services will be provided economically recognising the varying needs of patient groups and purchasing authorities'. To achieve this, policies pursued will include 'Encouraging a cost conscious climate and ensuring best use of resources' and 'constantly pursuing efficiency saving and income generation to improve services provided to patients'.

There seems little doubt that the government's desired aim would be to produce a frictionless market in health care, which could eventually, when public opinion will allow, lead to a completely privatised ambulance service. The ambulance service has reacted to this and are trying to safeguard their position within the NHS by extending the services they can offer. These services are concerned with income generation by a mixture of diversification and market segmentation.

Diversification, Market Segmentation and Income Generation

In order to strengthen its links with the NHS, the ambulance service has diversified into two areas. The first area is a widening of communications service within the NHS and commercial sectors offering:-

a. A message handling service for GPs.

b. Wide area paging for GPs and other health care staff.

c. Radio communications for GPs and other health care staff.

d. An emergency bed bureau.

e. A telephone advice to the public on accidents and emergencies pending arrival of accident and emergency teams.

f. Integrated 24 hour telephone facilities for hospitals.

g. Hospital fire and security alarms linked by radio.

h. Radio communications for GPs in immediate care doctor schemes.

These services can be expanded to include:-

i. Alarm service radio links for the elderly.

j. Commercial radio paging and message service for pharmacists or any commercial or industrial premises.

The second area of fleet management expertise could be extended to cover all non ambulance service NHS vehicles and other transport services in the areas of vehicle procurement, vehicle servicing, and fleet management systems within the NHS and for commercial operators outside the NHS.

Most ambulance services maintain their own vehicles and all ambulance services have extensive radio communications equipment. Ideas of economy of scale and increased utilisation of existing equipment are immediately appealing, as are ideas of the NHS becoming more reliant on the ambulance service for a broader base of services.

This kind of diversification has many pitfalls. In the first instance 'Working for Patients' (DHSS 1989) has stated that the cross subsidisation of services will not be allowed, which in essence is what fleet maintenance and radio communications diversification would be doing, if they were to make a profit. The National Audit Office Report (1990) also notes that the ambulance service does not excel in these areas. However, market segmentation has already been extensively achieved between the A&E side and the non urgent patient transport. This acknowledges the fact that customers within the market for a given product are not homogenous, while the product, transport to health care, can face different demand curves from different segments of the market. Engel et al (1972) note that 'The concept of market segmentation gives recognition to the fact that customers within the market for a given product are not homogeneous. The idea is underpinned by three basic premises:-

a. Customers are different.

b. Differences in customers are related to differences in demand.

c. Segments of customers can be isolated within the overall market.

Smith (1972) defined market segmentation as 'An Adjustment of product and marketing effort to differences in consumer use or requirements'. The ambulance service has addressed this by outlining more 'products' that could be enhanced or introduced. Other than the already mentioned segmentation of A&E work and non urgent patient transport, segmentation can be achieved with:

a. Paramedic rescue - a new service for patients who are in dangerous situations and will lead to improved ambulance attendance at all major high risk incidents. Chief ambulance officers will be vested with the role of health emergency planning and site control for the NHS in their area of operation.

This would include incidents such as the Brighton bomb incident, the Kings Cross rail disaster and the M1 plane crash.

b. Improved standard of first aid assistance and medical facilities at major sporting events and other large gatherings. This follows in the wake of the Lord Justice Taylor Inquiry into the Hilsborough disaster.

c. Commercial training offered to industry to be expanded.

d. Maternity flying squads to be established.

e. Consultancy in safety at work issues to comply with new legislation on safety in the workplace.

It should be noted that the creation of market segments does not always imply a need for an increase in resources. Increased efficiency is often brought about by the identification that a segment exists, which concentrates the mind on how to meet that demand. The extra administration needed for each segment should be more than rewarded by increased efficiency and in the ambulance service many of the costs will be joint. In identifying and responding to different customer needs the ambulance service is becoming more sophisticated. The market segments so far identified are accessible, measurable, sustainable and actionable. This justifies the first stage of a normative approach to market segmentation of how customers should be grouped into segments. The second criterion of how available resources should be allocated between the segments is not answered. In looking at resource allocation in the ambulance service, the two questions which need to be answered are:-

a. Is the A&E ambulance service a public good.

b. If it is a public good, can it be in a contestable market.

Public Goods in a Market Environment

A pure public good has two distinct characteristics non rivalry and non exclusivity. A good has non rivalry if the marginal cost of providing it to another customer is zero. A good has non exclusitivity if people cannot be excluded from using it. There are diminishing levels of public goods such as being non rival but not non exclusive and vice versa.

It could be argued that the front line ambulance service has a large degree of non rivalry in that the demand for the service is unpredictable and therefore the service is geared to respond to irregular events, in which case the marginal cost of the next customer would be almost zero as the service has to be in place to cope with events. The law at the moment states that the Secretary of State for Health is obliged to provide an ambulance service and that in public places any member of the public can request its use for emergencies. This request cannot be ignored and in fact takes precedence over urgent requests from doctors. So within the confines of this argument the front line ambulance service is a pure public good. The granting of trust status contracts for A&E cover are for block areas coterminous at the smallest level of a DHA. As long as the provider of the service has enough resources to meet the guidelines laid down by the Secretary of State for Health and the local HA, then it does not matter that the service is a public good within the confines of a contract.

Baumol et al (1982) argue that public goods are simply a class of goods whose production has a large fixed cost component and for which there is a comparatively low marginal cost (in the sense of the cost of serving another customer rather than the cost of providing another unit of physical product) and relatively low sunk costs. The bulk of total cost is fixed, so that if the good is supplied at a price equal to its marginal cost, then the sale will involve a loss. This is precisely the problem that plagues the optimal allocation of any good whose production involves economies of scale. Problems of optimal allocation of resources due to the existence of economies of scale have already been discussed. It has been identified that the service has high fixed costs with relatively low sunk costs. Exclusion to consumption is to a large extent possible in that there is a formal process to initiate the use of an A&E service, the 999 call. This is unlike other often quoted public goods such as street lighting, which have no exclusion means. So it would seem that the A&E ambulance service is to a large extent a public good, but it is possible that public interest will not be harmed by having it supplied in a contestable market.

Effectiveness, Equity and Efficiency Within the Market Structure

To summarise, the early days of the ambulance service preparing for the internal market has focused the mind on allocative efficiency. Theoretically, contract prices to DHAs will have to be as close to the marginal cost of provision to deter geographic competition from services able to take advantage of economies of scale. Market segmentation of the service will help to identify costs associated with particular client groups and thus help to ensure true marginal costing of the whole service. The threat of competition would ensure that all segments were competitively priced.

Against this is the conflict that 'Working for Patients' suggests that cross subsidisation should not exist, yet the ambulance service will be indulging more and more income generation schemes which will blatantly cross subsidise the service. Almost certainly the quality of the service will fall in sparsely populated areas as competition to provide a cost effective service is heightened both in the ambulance service itself and in the contracts offered by health authorities. The nature of the contracts themselves provides a barrier to the market working efficiently without friction.

All assumptions to date are that the ambulance service is free to the consumer. However 'Working for Patients'(DHSS 1989) is about choice and one of the main areas of choice might be the facility to pay for an enhanced service. If it did not exist in public or private form then the victims of accidents or illness, or their relatives would be willing to pay substantial sums, relative to their own economic well being, to be transported to definitive care. The Chief Ambulance Officers' Association (1989) notes that 'Each year one in twenty people in the UK will require the A&E ambulance service. The cost of each A&E call is less than £5 per head of population'. The report goes on to note that 'This clearly demonstrates good organisational management and excellent value for money'. On this basis the ambulance service is effective, in that it already has in place a national taxi system tailored to such needs. It is also cost effective to the individual who pays little or nothing in contribution to the upkeep of the service in relation to what they would be willing to pay if their life depended on such transport. This argument makes good sense from the egalitarian point of view, particularly when the A&E service is regarded as a public good. However, equality in the libertarian sense would see the £5 taxation per head per annum of population to run the ambulance service as theft and that the service should be open to free market economics by letting the cost of provision of the service fall on the users. In such a situation the charges would be astronomic, but those needing the service are after all a captive market! If this approach were to be adopted, equity in the ambulance service would disappear as ability to pay became a criterion of use. It could be said that an A&E private ambulance service would have a very inelastic price elasticity of demand. Even if there were competition in the market a customer would not stop to haggle over the price as his life blood literally flows away.

This leads to many more questions. While it would seem obvious that segmentation for horizontal equity would be by income, and for vertical equity by the degree of sophistication needed to match the injuries (taxi drivers to skilled paramedics), this would involve cross subsidisation to succeed. But for what percentage of the population could insurance companies offer realistic premiums? Or could company sponsorship make a realistic contribution on a national scale? Many overseas private ambulance services are attached to private hospitals and are heavily subsidised by the hospitals. The ambulances literally act as predators bringing in accident victims which might otherwise be 'snatched' by other competing hospitals. This has been one of the main reasons for the growth of AAs in the USA. A possible scenario for the UK would be for a basic A&E service to be retained by the NHS, while enhanced services are offered to those with the ability to pay. Whatever any form of privatisation takes in the UK, the main question is what would happen in rural areas where over a large radius there may be only a few calls a week, but a 24 hour service has to be available to meet national response standards. It is doubtful whether the present system could be bettered in such circumstances. Whether society as a whole benefits from the present system of maintaining an ambulance service depends to a large extent on the value given to a life or limb saved by using the ambulance service as opposed to alternatives. This argument is developed further in Section Two.

Summary

To summarise the main issues, the ambulance service is now a two tiered service. The A&E side, which is the main area of interest for this thesis, involves some 65 per cent of the costs of the ambulance service while carrying fifteen per cent of the patients. There is tremendous pressure from the purchasers of healthcare to force down the cost of block contracts for A&E provision. The implications from this are that efficiency criteria now dominate.

Whenever a political decision has been taken to improve efficiency it tends to benefit those geographically at the centre. Policy on A&E departments and the building of DGHs have taken place in or near the greatest population centres. Casualty units, small hospitals and ambulance stations which have closed have usually been in less populated areas. The ambulance service may now have paramedics trained to a standard unheard of ten years ago, but there are fewer ambulance persons with fewer ambulances, carrying more patients many more miles to definitive care.

The front line ambulance service can claim that it has the properties of a public good, and it can therefore only be sensibly funded through central taxation. The free market view would question this. It has challenged that emergency patient transport is a contestable market which questions the assumptions of equality upon which the NHS was founded.

In conclusion it is not possible yet to predict whether the income generation and segmentation which a market system could accommodate will offer gains when transaction costs are taken into account. What is more certain is that the market approach is already encouraging larger structures of provider units. Larger ambulance services and more competitive contracting will increase the already intense interest of the ambulance service on rapid response vehicles such as AAs.

Section Two

Chapter Seven

Data and Methods

Introduction

This chapter, and the next four chapters, will describe and assess the operation of the AA service operated by the Cornwall Ambulance Service in terms of its effectiveness, contribution to equity and social efficiency in accordance with the aim on page 10. Three separate but inter-related studies were carried out. The first study, Chapter Eight, described the existing land-based and AA cover arrangements and modelled the effectiveness of the arrangements by considering the relationship between demand, standards and resources. The second study, Chapter Nine, investigated methods of defining a level of rurality in order to give an indication of the cost of achieving geographic equity at differing levels of rurality. The third study, Chapter Ten, aimed to determine whether the use of AAs in areas of sparsity, can be justified in terms of social efficiency. The effectiveness of the AA was determined by the degree to which it could improve ambulance service standards by reducing overall response times, and the journey time to hospital, where such times were excessively long. The achievement of improved response times and time to hospital could be viewed as equalising access and therefore improving geographic equity. The employment of the AA imposes costs and benefits on different sectors of society and study three attempted to identify the distribution of the costs and benefits among those sectors.

Before embarking on analysis of the empirical evidence, it is important to recognise a number of methodological problems involved in the evaluation. Consideration of these is one subject of this chapter. Before turning to them, however, the following discussion provides an assessment of the ambulance service in Cornwall to ensure that the methodological problems are set in their empirical context.

Background and Structure of the Ambulance Service in Cornwall

At the outset of this project the only AA which had been in service long enough to have overcome the teething problems inherent in any new venture, operated in Cornwall. It was, and is, funded by the charity First Air Ambulance Services Trust (FAAST) and is operated by the Cornwall and Isles of Scilly Ambulance Service.

The front line ambulance service in Cornwall employs 163 qualified ambulance people, plus their officers, working from seventeen ambulance stations across the county. The services' headquarters and communications centre is at Truro, close to the DGH. From here all ambulances across the county are monitored. During the survey period, there were 22 hospitals in the county, however, the majority of patients went to the nearest DGH at either Truro, Plymouth or Penzance. (See enclosures Map 1).

In operating terms there are several features which make Cornwall a difficult area in which to operate an ambulance service, as confirmed by the National Audit Report (1990). The main factors contributing to this are that Cornwall has one of the largest coastlines of any county in England, which imposes a large maritime burden on the ambulance service. This involves the transfer to hospital of sick or injured seamen brought ashore by lifeboat, or for people rescued by the coastguards or beach lifeguards. Parts of North Cornwall are further from a DGH than anywhere else in England and communications are generally bad. Poor roads and long distances from the main hospitals in Plymouth and Truro result in very long journey times to hospital. The population of Cornwall doubles at the height of the holiday season, which leads to extra pressure on the ambulance service both in terms of the number of calls they have to deal with and the increased congestion on the roads at the peak of the holiday season. Cornwall's small and only boundary with the rest of England reduces reciprocal help arrangements with neighbouring ambulance stations during periods of high demand, as described in Chapter Five, pages 60 to 67. The Cornwall Ambulance Service is also responsible for the Isles of Scilly upon which one ambulance is maintained to serve the cottage hospital on the main island of St. Mary's. The AA makes a specific contribution here as patients with serious injuries have to be transferred to Truro by the AA. Before the AA was employed, the journey would have been made by ship or, in an extreme emergency, by Royal Navy helicopter.

The AA service commenced in April 1987. The AA is based at Newquay airport and is in operation seven days a week during the twelve-hour day shift. From its base, it can reach all parts of the county within the nineteen minute ORCON response time. Currently a Bolkov B0105 helicopter is employed and is crewed by a pilot and two paramedics. The helicopter is controlled through ambulance service control centre and is explicitly considered as an extra ambulance to be used along with other land ambulances as available. There are no specific call-out procedures for the AA, but it operates under two identifiable principles. The first is that it should respond to emergency calls if this will reduce the 'therapy-free interval', which is the time from which an injury occurs to the time that primary care is administered. Secondly, if not responding to a call it can be used for the transfer of non urgent cases if this will significantly free other resources, such as land ambulances which might otherwise be tied up on long distance transfers. These criteria are employed by the control officer on duty (Sheen 1989).

The problems with the use of the AA are both practical and methodological. There are certain categories of patient for which the AA is not suitable. Obstetric complications cannot be carried as the legs of the patient are in the tunnel of the tail of the helicopter and are therefore not accessible. Patients with mental disorders would be an obvious risk to safety, as are patients who are drunk. There were a number of methodological problems in evaluating the service which are discussed in the next section.

Methodological Problems

The central methodological problem that confronted an attempt to assess the value of the AA was the separation of the impact of the various components of patient care upon patient outcome. To this end it was important to consider the overall framework of A&E provision and the contribution of the ambulance service to this system. There were three identified components to the system of care for A&E patients, each component of which contributed to patient outcome in terms of morbidity and mortality.

The first component was recognition of the need to get a person to hospital and is the only stage to involve the front line ambulance service. Once the ambulance crew is at the scene of an accident it may make little or no attempt to stabilise the patient, or spend time stabilising the patient's condition before proceeding to hospital. The level of monitoring and capacity for further intervention in transit will vary according to the space, the equipment, and the level of skill of the accompanying attendants. The patient is then delivered to an Accident and Emergency Department or medical ward, at which point ambulance service involvement ends. The second component of hospitalisation involves further stabilisation, surgical and/or medical intervention, possibly intensive care, and hopefully initial recovery. The third component of post hospital recovery may involve periods of further treatment or rehabilitation carried out at home by the primary care services and domiciliary care covered by Social Services or family.

Outcomes and hence the evaluation of the AA could have been affected by the time delay between an accident occurring and the ambulance service being called, whether or not the patient was trapped and had to be freed before care could be offered. Once a patient is delivered to hospital, outcome would be affected by the appropriateness of the receiving hospital in terms of facilities, and the expertise of the staff at hand. Post-hospital influences on outcome range from the desire of the patient to recover and the degree of support from family and friends to the environment in which the patient lives. The community care services offered, and the expertise of the individuals involved, influence outcome. There are therefore many conflicting influences outside the ambulance service which affect patient outcome. It was not possible to include these in this research. The variables within the ambulance service which affect outcome are: the speed of response, the quality of care administered, and the speed and comfort of the journey to hospital.

With the first variable, the speed of response to the scene of an accident, only about ten percent of emergency or urgent calls to the front line ambulance service are life threatening, in approximately 90 percent of cases speed of response is not critical to the survival of the patient, but could make a difference to morbidity. However, for the management of patients with serious injuries, as noted by Irving (1988), the speed of response can be critical. In such cases, response time was a useful surrogate for outcome. It is not possible to know in advance which calls will be serious trauma cases. Therefore, the greatest overall improvement that can be gained in response time from the scene of an accident to hospital for all emergency cases, must be the aim of the ambulance service.

The second variable, quality of care given at the scene, depends on the degree of training of the ambulance crews. (Wright 1985). Unlike ordinary crews, ambulance crews trained to paramedic standards are able to perform interventions that can have an effect on outcomes. Endotracheal intubation ensures the maintenance of a clear airway and the ability to aid respiration which is essential in cases such as severe asthma, brain damage, drug overdose and gross abdominal tumours. Defibrillation is used to counter cardiac arrest, and the use of intravenous drips counter shock and haemorrhage. The use of certain drugs such as heart stimulants can also be administered by paramedics. This was discussed at greater length in Chapter Three pages 29 to 31.

The third variable is the time taken, and comfort of the journey, from the scene of the accident to hospital. Care for serious trauma patients in need of multi-disciplinary definitive care can be critical. The further from the hospital that such an incident occurs, the greater the advantage of the speed of the AA over a land ambulance. The AA also provides a more comfortable vibration free ride which reduces transport trauma (Moylan 1988). The speed of the AA will also give it an expanded choice of receiving hospitals, enabling a choice to be made of the most appropriate hospital, rather than the closest, for dealing with the patients' specific conditions. Having outlined the ambulance service's contribution to patient outcomes within the A&E system, the study design is considered.

Study Design

In an ideal situation, the relevance of the contribution of the ambulance service to outcome could be established from a controlled trial that follows cohorts of patients through the system. Large samples would be necessary to detect changes. In order to have even a fifty percent chance of detecting a reduction in mortality, from ten percent to seven percent of all emergency major trauma cases to which an AA is called would need seven hundred cases and controls to be entered into a study (Fleiss 1981). Details such as trauma scoring, timings, and the nature of care would need to be collected at the scene of the accident and at the A&E department. An assessment of the patient's health and level of disability would be required when discharged from hospital and at a set number of weeks post-hospital. This was not possible within this study as there were neither the resources or ethical approval to conduct an outcome study.

In the absence of a controlled trial a simple, reproducible and valid methods of comparison of the ambulance system, with and without the AA were needed. Such methods had to incorporate monitoring the effects of AA use within the ambulance service as well as outside the service. Whilst the limitations of not being able to undertake a controlled trial were recognised, aspects of ambulance service provision in Cornwall were analysed to identify effects on the key issues of effectiveness, equity and efficiency. These key areas were first identified in Chapter Three during discussion of the ambulance service in Britain. In Chapter Four the literature on evaluative economics was reviewed to explore definitions of these key concepts and their use in an evaluation of an AA in terms of being identifiable and measurable. In Chapter Six it was noted that the current political ideology has changed the structure of healthcare provision and its interpretation by all concerned, which has affected the implications for effectiveness, efficiency and equity.

The definitions explored in Chapter Four are then applied to studies of effectiveness, efficiency and equity of AA use investigated using the case study area of Cornwall. The first looks at effectiveness in terms of access and quality, and is defined by responses times and the degree of training. It uses the survey data identified in the next section of this chapter. The results of this study introduce two hypothetical options of 'without AA use' and 'with AA use' to be set up to test the AA's contribution, within the changed organisational structures, to equity and efficiency.

Equity has been defined in terms of equal access for all to the A&E system. In practical terms the ORCON response standards discussed in the previous paragraph were taken as a reasonable measurement of access to the A&E system. In study one the AA was identified as an instrument that can be used to aid equality of access by reducing the response and journey to hospital times for the peripheral rural areas where the ORCON standards are not maintained by land ambulances. Study two investigates methods to highlight the differential costs necessary to maintain such equality of access for those in rural areas.

The third study is concerned with the social efficiency of AA use in terms of identifying to which sectors of the community the costs and benefits of AA use accrue. The evaluation techniques adopted for each study are discussed in detail after identifying the data sources.

Data Sources

The main data source was a two-year retrospective study of the Cornwall Ambulance Service. A data base was established from data collected for all emergency and urgent cases on the first week of each month for two years, starting on the first of March 1988, and ending on February the seventh 1990. The variables are listed and explained in Appendix C1. The survey data came from two sources. The first from a form filled in by the ambulance persons at the scene of an accident or incident, relating to time, place, number of patients and injuries. The second source from data recorded at the control centre. Once both sources were collated together it was then transcribed onto a database on the mainframe computer system at the University of Plymouth.

Data collection took place for one complete week of each month for two years in order to achieve a valid cross section for indicating the variation in the number of calls for each day of the week, and each month of the year. The same quantity of data could have been collected in a six-month continuous collection of all incidents, but it would not have contained a true cross section of the variability due to seasonality. During each sample week, all emergency and urgent calls in the county were recorded. This meant a 100 per cent sample of all calls during survey weeks, which represented a 23.07 percent sample of the population of all calls for the duration of the survey. The total number of calls responded to by land ambulances over the survey period was 11,174. Of these, there were 873 aborted calls (7.8 per cent), and 65 cases (0.59 per cent) of incomplete data. Calls were aborted or terminated for a number of reasons, the most common being that an ambulance was asked to respond to an emergency only to find that, within a few minutes, another ambulance had become available closer to the incident. The first ambulance was then 'stood down'. Other reasons were that a controller might be led to believe that there were many casualties and so send more than one ambulance only to find that one would have been sufficient. Also there were hoax calls when no accident had occurred, or an accident had occurred and no one was hurt but an ambulance had already been requested. The number of emergency, urgent and total calls for each month of the survey is shown in Appendix C2.

During the survey period the AA responded to only 350 calls, which provided a very small sample for some parts of the county. In order to account for this a further 479 AA calls were entered into a second data base using all AA calls for the twelve month period from the first of April 1987 to the thirty first of March 1988. There was no change in the circumstances of AA use during the extended data collection period. The second data base was checked to ensure that mean times from the accident to the destination hospital were significantly similar before the two data bases were combined to give 829 recorded AA missions. In fact most of the mean timings from all the comparable origins to destinations were identical or varied by only one minute. This is not really surprising given the speed of the AA and the relatively short journeys involved.

The database was created for the following reasons:-

1. To discover the demand levels for the ambulance service in different parts of the county.
2. To discover how much the demand varies by hour of day, day of week and month of year.
3. To monitor how well response times to the scene of an accident were achieved across the county.
4. To monitor the time taken to get from the scene of an accident to hospital from different parts of the county.

The answers to the above will outline the demand for the ambulance service in Cornwall. The methods employed to extract the information listed above are discussed latter in this chapter.

Electoral Wards

While the destination for all calls logged on the database was one of the DGHs which serve the county, a problem existed in deciding on the unit in which the origin of all calls could be described. Recording each incident by its specific location would have little purpose as this would result in a large number of data points with few timings from each point and a wide variation in journey times. The problem was exacerbated by comparing timings with the two transport modes of a land ambulance and an AA. The first travels at an average speed of forty miles an hour along winding roads and the second travels at speeds of up to one hundred and forty miles an hour in straight lines. Another consideration was that for the equity study there needed to be some way of matching performance targets of the ambulance service with the type of area in which the service was performing. The solution chosen was to identify the origins of all emergency and urgent calls by the electoral ward in which they occur. Electoral wards already exist and offer the advantage that no bias could be assumed in the base unit of the analysis with regard to this study. Electoral wards are well defined and this offered a further advantage.

The 1991 census was used to identify electoral wards, their size and their population. The physical size of each ambulance station area, its population and population density was calculated from the census data by aggregating the ward data which falls within each ambulance station area. Appendix C3 indicates the wards attached to each ambulance station, their size in hectares and population at the 1991 census. Enclosure, Map 1, indicates the wards in outline which make up the catchment area for each ambulance station area.

The use of wards to group the origins of calls overcame the problem of only a few data points, which would have occurred if a smaller spatial unit was used. This would have given excessive variation in variables looked at such as 'response time' and 'time to hospital'. However, for wards with a low population density, where the physical size of the ward is large, and the population is low, the problem of few data points still exists. While some rural wards may look very large in area, the majority of the calls tend to emanate from the most populous parts of the ward so that the variation around the mean is not as large as might be expected. A possible method of overcoming the problem of a high standard deviation on ward data would have been to use enumeration districts to identify each call. Enumeration districts (EDs) are the sub-units, or building-blocks which make up the electoral wards. Census data is available at this level, but not the area of each ED. The problem of small sample size would still exist as although there would be less variation in journey times from each ED, there would be many fewer journeys. In fact, many EDs would not be represented at all in the data. Therefore in this part of the analysis EDs were not used. However, EDs were used for the calculation of measures of sparsity in the equity study described later. For the equity study the area of each ED was calculated using the mapping package Map 91.

Ambulance Service Vehicles, Staff and Financial Information

The Chief Ambulance Officer of the Cornwall Ambulance Service made available details of the personnel and vehicles at each ambulance station and details of the costs for each ambulance station. The matching of workloads as calculated from the database with resource levels as provided by the ambulance service allowed the calculation of the utilisation of resources for each ambulance station to be investigated. This is discussed more fully latter in this chapter.

Hospital Services

As the ambulance service was not able to give patient names there was little help that the information department of the hospital could give in order to calculate any difference in outcomes from either mode of transport. The best they could do was to provide a summary figure of mean length of stay for patients who arrived by ambulance classed as either an emergency or a medical admission (urgent). From this they were able to calculate a cost based on their average cost per day for hotel provision and mean cost of treatment. While highly inaccurate to apply to any individual, it can be inferred that over a large number of patients over a long time period, such as two years, the figures do represent a reasonable average.

GP Services

In similar fashion, GP information on the number of visits after a hospital episode was very much an average figure which could not be applied to an individual but was representative of a population. It would be impossible to identify the number of surgery visits and visits by other agencies on patients brought in by the AA or a land ambulance by the examination of GPs records. However, a small consensus panel of GPs offered estimates of the number of home, surgery and social work visits that would be needed post hospital.

Costings for GP time were provided by the British Medical Association (1993), while prescription information was obtained from the Prescription Pricing Authority (1993). Costings for district nurses were supplied by the District Health Authority, and social workers' costs by the local Social Services.

Earnings

In study three local earnings data were used to calculate income losses to patients due to illness. This is discussed further in the next section, but the data source used for earnings in the county was the Department of Employment (1993).

Having outlined the methodological problems of the study and the data sources, the next section outlines in more detail the methods employed in each of the studies.

Outline of Methods and Approach to Evaluation

This section outlines the methods and approach to evaluation used for each study to achieve the overall aim of the evaluation of the contribution of an AA to effectiveness, equity and efficiency within the Cornwall Ambulance Service.

Study One

Introduction

The analytical framework for this study was concentrated on a detailed analysis of the relationship between the service standards achieved and the overall cost implications of land ambulance only provision versus land ambulance and AA provision in Cornwall. It involved exploring the relationship between demand, standards and resources to identify a 'target demand population' for the best use of the AA and setting up options to test it's contribution to effectiveness, equity and efficiency.

Patterns of Demand

The demand for the ambulance service in Cornwall was of interest for two reasons. The first was to identify the work load for the Cornwall Ambulance Service. The second was to use the demand rate in the construction of the two options of 'with' and 'without an AA' to test effectiveness equity and efficiency. Assumptions were made about what constituted a reasonable variation in demand by hour of day, day of week and month of year. As the aim was to provide a simple model of demand rate for each ambulance station for each twelve hour shift, the annual mean number of calls per station per shift appeared to be a reasonable guide if ninety five percent of calls were within two standard deviations of the mean. This accorded with the convention used in the planning of the Scottish Ambulance Service and the Wiltshire Ambulance Service (ORH 1990 and 1992).

Demand patterns were investigated by interrogation of the database set up from the one hundred and four weeks of data collected from the survey over a two-year period as described in data sources. All the origins of emergency and urgent call outs in the database were identified by electoral wards which were assigned to ambulance station areas as identified in Appendix C3 and previously discussed. The investigation into the variability of demand was achieved by the use of frequency routines on the database, using the statistical package SPSSX. During the two-year period of the survey for the whole county demand was investigated in terms of the following:-

1. The mean number of emergency and urgent calls per month.
2. The mean number of emergency and urgent calls by the 'day of week'.

3. The mean number of emergency and urgent calls by the 'hour of the day'.

Having established the overall pattern of demand, the distribution of patients to the hospitals in the county was investigated.

Distribution of Patients to Hospital

At the time of the survey there were 22 hospitals in the county. The use of a frequencies command on the 'hospital' variable identified the frequency of use of the DGHs compared to the community and cottage hospitals.

Ambulance Station Demographics

Before exploring the demand levels at each ambulance station, information was assimilated on the demographics of each ambulance station area in terms of:-

1. The size in hectares of the area covered by each ambulance station.
2. The population of the area covered by each ambulance station.
3. The population density of the area covered by each ambulance station.

The information for one and two was extracted from the 1991 Census while a simple division gave three. This information facilitated a more revealing interpretation of the pattern of demand and proved helpful in discussing standards and resources

Demand Patterns at Each Ambulance Station Area

Having identified the size, population and population density of each ambulance station area, a sub-routine was written to identify each ward with its relevant ambulance station area. It was then cross tabulated with the variable 'emergency' or 'urgent' calls and divided by the number of days to give the daily number of emergency and urgent calls in each ambulance station area. It was also tabulated with the variable 'hour of day', which was grouped into the two twelve hour shift patterns of 06:00 hours to 18:00 hrs, and 18:00 hrs to 06:00 hours. The total calls each shift were then divided by the number of days of the survey period to give the 'mean calls per shift' for each ambulance station. With the demand pattern established the attention turned to the standards achieved at each ambulance station area.

Standards

Ambulance service standards for response are laid down by the ORCON standards discussed in Appendix A1. The response time is the time it takes from the receipt of a 999 call to the time an ambulance arrives at the scene of the accident. The response time was calculated for each ambulance area by creating a frequency table of 'response times' for all wards in each of the respective ambulance station areas. From this was calculated the number of calls which achieves the 50 percentile target of 'response time' of eight minutes, and the 95 percentile target of 'response time' of nineteen minutes.

The variable 'time to hospital', which is a calculation of the time it takes from the scene of an accident or incident to hospital gives an indication of the areas in which the AA could improve the service. A 'time to hospital' of five minutes gives no scope for improvement by the AA. However, a 'time to hospital' of an hour gives great scope for improvement. The variable 'time to hospital' was calculated in the following way.

Ambulance stations comprise of N wards numbered 1, 2, 3,... N. For ward 1 the average time for a trip to hospital is:

$$\bar{t}_1 = \frac{\sum_{\tau=1}^{n_1} t_1[\tau]}{n_1} \qquad (1)$$

Where n_1 is the total number of trips made and trip number n_1 = tau takes t_1 (tau) minutes.

Similarly for wards 2, 3, ... N

$$\overline{t}_N = \frac{\sum_{\tau=1}^{n_N} t_N(\tau)}{n_N} \qquad (2)$$

In ward N the total time for all trips made is:-

$$n_N * \overline{t}_N = \sum_{\tau=1}^{n_N} t_N(\tau) \qquad (3)$$

The total time for all trips in all wards is therefore:-

$$t_T = \sum_{n=1}^{N} \left(\sum_{\tau=1}^{n_N} t_N(\tau) \right) \qquad (4)$$

The total number of trips in all wards is:-

$$N_T = \sum_{N=1}^{N} n_N \qquad (5)$$

Therefore the mean travel time for all the ambulance station is defined as:-

$$\overline{T} = \frac{t_T}{N_T} = \frac{\sum_{N=1}^{N} \left(\sum_{\tau=1}^{n_N} t_N(\tau) \right)}{\sum_{N=1}^{N} n_N} \qquad (6)$$

Which may also be expressed as :-

$$\overline{T} = \frac{\sum_{N=1}^{N} n_N \overline{t}_N}{\sum_{N=1}^{N} n_n} \qquad (7)$$

The above formula was also used to calculate the following variables:-

a. Emergencies - time from the scene to hospital.

b. Urgents - time from the scene to hospital.

c. Emergencies - total mission time.

d. Urgents - total mission time.

The resources which need to be deployed in an area to meet the ORCON standards are a function of the demand rate for that area and the total time an ambulance and crew are involved in responding to calls. The demand for the service has already been discussed. For an emergency call the time involved in response, treating a patient at the scene, transferring that patient to a hospital, and then being ready to accept the next call is known as the 'total mission time'. The 'total mission time' for urgent cases is taken from the time that the ambulances arrives at the patient's door to the time the patient arrives at the hospital. This is because a doctor summons the ambulance for an urgent case stating that the patient must be in hospital within a specified time period. It might be immediately, or within a few hours, depending on the patients condition. Because of this there is no element of response time and very little 'on scene' time as the patient would already have been stabilised for travel by the GP. Therefore the 'total mission time' for urgent cases differs very little from the 'time to hospital'. Again in accordance with ORH reports 1990 and 1992 an average 'total mission time' by emergency and urgent missions was calculated for each ambulance station area.

AA Pattern of Use and Travel Times

The process of establishing the pattern of demand and timings for each ambulance station for land ambulances was repeated for the AA. While at the peak of the day there were seventeen land ambulances working within the county, there was only one AA.

The AA variables 'day of week', 'month of year' were cross-tabulated with 'primary', 'secondary' or 'tertiary' mission, to give a breakdown of AA use. This was then followed by a breakdown of response times for each ambulance station area. Comparison was then made between the land ambulance timings and the AA timings. The variation around the mean in journey times over an ambulance station area for the AA, was too small to measure due to the speed of the vehicle. There was greater variation for land ambulances and the mean journey time provided a useful planning tool. It was not possible to predict precise journey times from the scene of an accident to a hospital for a number of reasons. First there was the variation due to the prevailing road conditions. Secondly, there was the far greater variation due to the nature of the call. This was affected by factors such as the patient being trapped, the level of stabilisation the patient needed at the scene, and which types of injuries were sustained. Back injuries need to be transported slowly, while in the case of patients suffering from trauma, speed is of the essence.

Resources (Staffing and Vehicles)

The data on the level of staffing and vehicle allocation for each ambulance station area were supplied by the Cornwall Ambulance Service. This information, in conjunction with the demand levels for each ambulance station, already discussed, and the mean time to complete each call, also previously discussed, indicated the effectiveness of the service at each ambulance station area. This analysis was achieved by calculating the utilisation of the available resources at each ambulance station area. The degree of utilisation of crew and vehicles was taken as the time that crews and vehicles were actually responding to calls in relation to the time spent providing cover. Ambulance crews while on duty perform two distinct functions. The first is to provide cover. This means that the ambulance crew sits in an ambulance at a location dictated by the controller of operations who has an overview of the current county wide demand. From this location they are able to respond to a request to perform the other function. The second function is responding to calls and getting sick and injured people to hospital as quickly as possible. The aim is to have ambulance crews spending as much time as possible responding to calls in relation to the time spent providing cover. This is the utilisation factor, which gives an indication of how efficiently vehicles and crews are being used. There are restrictions imposed by the geography and demography of the area in which the service is provided which limits this efficiency. The utilisation figure was expressed as a percentage of a shift that an ambulance responds to calls, in relation to the time that the vehicle was stationary, providing cover. There are accepted utilisation figures for urban and rural situations (Brismar et al 1984). Not to achieve a reasonable utilisation could be indicative of poor management or a particularly difficult area to serve due to factors such as very low population densities and extreme distance from hospital facilities.

The analysis to date has identified for each ambulance station area in Cornwall and the AA the demand for the service; the standards achieved in terms of ORCON; the resources available and their utilisation rates. The aim of this was to provide basic information for land and AA provision in the county. This information was used to investigate two hypothetical options of land ambulance only use and land ambulance and AA use in the county using the information explored to date. The aim of the two options was to identify a specific role for AA use in the county that could be used to test the definitions of its effectiveness, equity and efficiency as explored in Chapter Five.

Two Options to Discover the AA's Contribution to Effectiveness Equity and Efficiency

The thesis to date has identified the following issues concerning the identification of a role for the AA:-

1. Utilisation levels of existing land ambulances were low.
2. Response standards were not met.
3. Journey times to hospital were excessive.
4. Where the greatest time difference exist between land ambulance and AA use.

This part of the research identifies two options of 'with' and 'without' an AA to investigate the effects on effectiveness (study one) equity (study two) and efficiency (study three).

A problem in identifying areas of low land ambulance utilisation was that in the comparison of 'total mission time' of different ambulance service areas within the county like is not necessarily being compared with like. This was because the model assumed that an ambulance was ready to accept its next call as soon as it had delivered its patient to a hospital, and ignored the time taken for an ambulance to return to its own ambulance station area. If this time was included in 'total mission time' it would greatly reduce the utilisation figure for the remoter parts of the county. As an example, it takes 64 minutes to return to Bude from the DGH compared to nine minutes in the Truro area. While technically both ambulances are again on call once their patients have been delivered to hospital, it takes the Bude ambulance 55 minutes more to return to its base than the Truro ambulance, although this time is not taken into account in the utilisation figures for each ambulance station. This important point is illustrated in the schematic interpretation of ambulance use in Chapter Five.

A coterminous block of land needed to be identified in which the pointers indicated above apply. This was decided on the analysis of the data of the survey to date. Having selected a geographical area a mode of operation for the AA needed to be identified in terms of the potential calls that the AA could respond to from the demand figures for that area. Once this was calculated an estimation was made of the extra time that land ambulances would be available to respond to calls. A useful convention in calculating the time saved by the AA is the classification of AA calls as primary, secondary and tertiary. A call in which the AA is used exclusively is called a 'primary call'. A 'secondary call' is where the first vehicle to arrive at the scene is a land ambulance. If however, for logistical reasons, or the critical state of the patient, specialist hospital care was a priority, the patient can be transferred to the AA at a pre-arranged site. In this scenario the AA transports the patient to hospital and the land ambulance returns to being on call. The saving here was the difference in time from the secondary landing site to hospital as performed by the AA versus a land ambulance. 'Tertiary calls' are patient transfers from hospital to hospital. The AA performing this function in place of a land ambulance gives greater availability of land ambulances.

The aim of employing the AA was to utilise it within the area to its maximum in order to give the most relief to land ambulances and justify the standing costs of such a vehicle. The algorithm at Figure 7.1 illustrates an application of queuing theory to calculate the number of missions per day which the AA could undertake. It assumes constant mission times (which in practice will vary) and a random distribution of calls. The use of this algorithm describes the relationship between target demand, demand met and the utilisation/availability for planning purposes.

Fig. 7.1. Algorithm to Calculate AA Utilisation

The algorithm is in the form:

$$U_{n+1} = \frac{M * [N_n + 1 - U_n]}{S}$$

Where:_

U_n = Utilisation for potential n calls per day.

N_n = Number of calls for which AA is available out of potential n calls per day.

M = Average service time per mission (constant)

S = Length of shift (constant)

Note: N_0 =1 U_0 =1.

The above algorithm was used to allocate the mix of AA and land ambulance responses per day. The extra cover this provided for the day shift in extra minutes available to respond to calls was then calculated, and comment offered on the effectiveness of the AA in this situation. These options were tested in the next two studies in order to estimate the AAs contribution to geographic equity and social efficiency. This was also a useful study in its own right in using raw 'trip' data to build a picture of how an ambulance service functions with and without the contribution of an AA.

Study Two

Introduction

The aim of the second study was to assess the contribution to equity that the AA could make. In order to do this the following requirements for an acceptable definition of equity were formulated:-

1. The conception of equity should be easily comprehensible so that it allows the widest discourse and deduction of clear policy options.
2. It should be specific and rigorous in order that the concept does not generate misunderstanding in application.
3. The formulation should be readily susceptible to empirical verification and not be overburdened by excessive information requirements.
4. The definition should be intuitively and widely acceptable for the problem in hand.

Geographic equity was explored, which was defined as equalising access to the A&E system of emergency care by equalising as far as possible the response time of the front line ambulance service in urban and rural areas. The instrument to be used to reduce excessive response times and journey to hospital times in the rural areas was the AA as outlined in Study One. A method was required to calculate the resource implications in order to make the concept rigorous and accessible to empirical verification. It was believed that if the resource implications at differing levels of rurality could be made transparent, this would provide, an intuitive and acceptable measure. The policy implications for equity could then be discussed with the implications for effectiveness and efficiency.

Defining a level of rurality for each ambulance station area was achieved by calculating a level of sparsity, which is discussed in greater detail on page 119. The costs of serving each ambulance station area were determined, and then calculated on a per head basis with and without the AA serving the North Cornwall area. Simple linear regression models were then used to determine the relationship between the degree of rurality and the cost of service provision. The first step was to calculate the costs of ambulance service provision at each ambulance station for land ambulance use only, and for land and AA use at those ambulance stations where the AA was used. The cost of service provision per head at each ambulance station area was then calculated.

Ambulance Service Costs

Costs associated with each of the seventeen ambulance stations relating to station overheads, vehicle and staff provision were investigated. Vehicle costs were viewed as suggested by the Audit Commission Report, (1990). With the capital costs of vehicles an accountancy convention of straight line depreciation over a seven year period gave an equal sum of depreciation for each vehicle per year. Staff costs were calculated by the method used in the ORH Reports, 1990 and 1992. This approach took the salaries for the number and grade of ambulance personnel on each shift, and then added 17.5 percent for the costs of employment. A 25 percent addition was then given to the hourly rate to cover the cost of relief staff.

Calculation of Land Ambulance and AA Costs for Each Option

The costs of introducing an AA system were divided into fixed and variable costs. The fixed costs included the contract costs for the provision of the helicopter and pilots. The variable costs were those attributable to the flying of the aircraft such as fuel. The AA was only in service for the hours of the day shift, during which the peak demand occurs.

With regard to crew costs the pay scale used was that of a qualified paramedic ambulance person. The basic salary was £12,808 p.a. plus £400 for paramedic skills and a 17.5 per cent employers contribution gave an annual cost of £15,453. This equated to £297 per week, or £7.40 per hour. A 25 per cent increase in the hourly rate for relief costs made the rate £9.28 per hour.

The fixed costs attributed to the ambulances were calculated in the following way. The cost of a new, front line ambulance varied from £20,000 to £30,000 depending on the vehicle, the discount received for bulk orders, the equipment supplied and the layout of the interior. Here the figure of £25,000 was used for new vehicles depreciated over seven years, which is the maximum recommended life of an ambulance. Depreciation was allocated to all the vehicles based at each station, rather than just the vehicles used on each shift, as this number of vehicles has to be provided to support the vehicles on shift and meet backup regulations. This gave an annual depreciation per vehicle of £3,571.

The variable costs associated with land ambulance only cover were calculated on the basis that ambulance utilisation time assumed a speed of forty miles per hour, and a standard figure of thirty pence a mile for the variable costs of petrol, oil, tyres etc.

Calculation of AA Costs

The cost implications of integrated land and AA cover for North Cornwall necessitated that the fixed and variable costs of the AA be added to the existing land ambulance costs. The fixed costs for the AA were £29,000 per month, or £348,000 per year, for the lease of the helicopter. This covered the provision of the aircraft and a pilot for seven days a week for daylight hours. Above this was the cost of the paramedic crew of two. The same calculation was used as for the land ambulance personnel. This equated to £185.60 per day for the two paramedics which annually totalled £67,774. This brought the total fixed costs for the AA to £415,744 p.a. The variable costs for the AA were £295 per hour of flying time, for the two hours twenty minutes that the AA was calculated to spend in the air each day for option two. This gave annual variable costs of £250,195 and total annual costs of £665,939. These costs were then divided by the total population that the AA served in North Cornwall. With the AA service one ambulance station at Wadebridge became redundant. This station was chosen as it is currently only staffed during the day. The capital benefits of the sale of the station and the disposal of two ambulances are taken into account in study three. Many ambulance stations worked together in order to get a better utilisation of resources, this raised the question of how the fixed costs should be apportioned between the co-operating stations. The two obvious solutions were that it can be divided in proportion to the land mass that an ambulance station covers or the population that an ambulance station covers. Both were calculated, to identify which produced the better model.

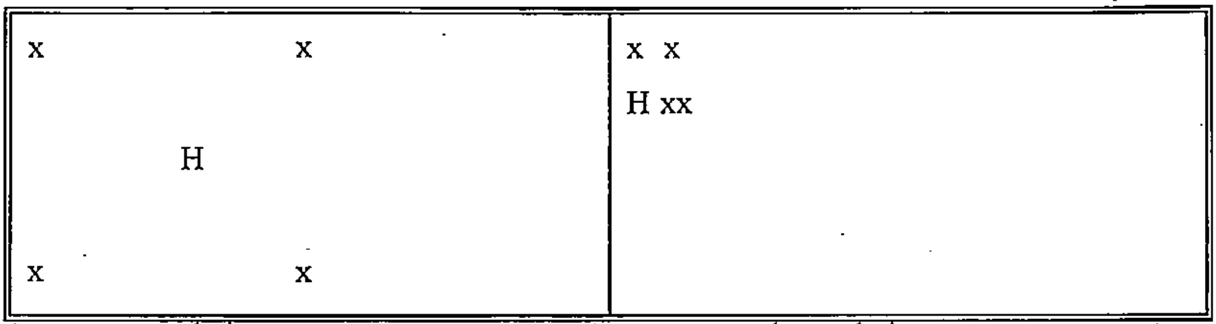
With the method of calculating the cost structure outlined, there was a need to measure the degree of rurality for each ambulance station area.

Measures of Rurality

One of the main influences on ambulance service costs outside management control was the pattern of population settlement, of which there were two elements, density and sparsity. Density refers to an average area of land space per head of population, while sparsity refers to how that population is dispersed over that land area. A given density may be associated with a high sparsity as in the left hand square of Figure 7.2 or a low sparsity as shown in the right hand square.

Fig. 7.2. Diagram to Show Sparsity

A B



A sparse population A concentrated population

The two rectangles of Figure 7.2 represent equal areas, each with a population of four and served by a hospital (H), and so have the same population density. However, in the right hand square all the population is in to the hospital, so the cost of servicing this population with ambulances, or any other service, is much less than the left hand square with the same population density.

Sparsity and the Craig Index

Sparsity draws attention to where people live in relation to each other. It was hypothesised that the cost of provision of such services as the front line ambulance service could be explained to a greater or lesser extent by a measure of population density or sparsity. The first measure of sparsity investigated was that produced by Craig (1989) who developed rank values of sparsity for every electoral ward in Britain which were made available through the Office of Population Census and Statistics, London.

Six divisions of sparsity were defined for wards categorised according to the urban/rural balance of their constituent enumeration districts. Table 7.1 below sets out the six categories and the all England mean population density for each level of sparsity.

Table 7.1. Craig's (1989) Classification of Sparsity

Ward classification	Number/proportion of urban enumeration districts in ward	Population density in persons per hectare. (All England mean).
1 Urban (wholly)	All	18.1
2 Urban (predom)	75% or more, but not all	5.2
3 Mixed urban	50% to 75%	1.4
4 Mixed rural	25% to 50%	0.9
5 Rural (predom)	1 or more but under 25%	0.6
6 Rural (wholly)	None	0.4

Craig (1989) noted that in England at densities above two point five persons per hectare urban wards were in the clear majority, and at over five persons per hectare virtually all wards were within this grouping. At the other extreme where densities of up to one person per hectare exist, rural wards were dominant. This leaves the range of one to two point five persons per hectare as a transitional range. Thus the rural wards were spread over a fairly narrow range of densities, the upper and lower decile being nought point two and one point two persons per hectare. The same measure for the mixed wards being nought point five and three point nine persons per hectare, and those for urban wards were between three point one and 55 persons per hectare. In relative terms the value of the upper decile was about seven times that of the lower decile for the rural and mixed wards. In the urban wards the relative difference between the value of the upper decile to the lower decile rose by eighteen times.

All the urban EDs together contain 89.6 percent of the population in the 1981 OPCS census in Britain, and ten point four percent of the population were contained in rural EDs. In Cornwall 35.8 percent of the population were contained in rural EDs. Of the 9,289 wards of England and Wales 75% are wholly urban or wholly rural. Of the remaining wards more than half are predominately urban or rural. Less than ten percent occur in the mixed category.

The above scale when applied nationally ranks the local authority area of North Cornwall as the twelfth most rural district in England and Wales, with 50.4 per cent of its wards totally rural. This gave an indication of the very rural nature of North Cornwall, particularly when contrasted against the next most rural Local Authority area in Cornwall which is Restormel. Restormel is ranked in sixty-eighth position, with no totally rural wards but 37.2 per cent mixed, while the remainder are urban.

Craig (1993) concluded that it was a reasonable application of his work to identify each ambulance station area in Cornwall in terms of a level of sparsity. The proportion of EDs in each category of urban rural or mixed wards gave a ranked sparsity index figure for each ambulance station area which are shown on Enclosure Map Three. The Craig index was useful in identifying the degree of rurality of each ambulance station. However, as a rank variable it could not be used in a regression analysis to define the degree to which the cost of provision of the service is explained by the degree of rurality. At ward level there would also be excessive variation within and between wards which would mask the validity of any results.

Population Density and Other Measures of Sparsity

Alternative methods, suggested by Hay (1993) for looking at sparsity have been explored by identifying the area and populations of all the EDs for each ambulance area. The area of each ED was calculated with the aid of the mapping package Map 91 as this information is not supplied in the census. The population of each ED was obtained from the 1991 census data. Models of population density and sparsity were explored in the following way.

The population density D, of each ambulance station was found by using the following formula:-

$$D = \frac{\sum_{i}^{n} P_i}{\sum_{i}^{n} A_i} \qquad (9)$$

Where P_i is the population and A_i is the area of the unit i which represents a subdistrict of the ambulance station comprising n such districts.

The problem of a population density measure is that it is not sensitive to clustering or dispersal of the population across the ambulance station area. Hence it is necessary to look at sparsity which is a measure of where people live in relation to each other. A sparsity factor S, for each ambulance station was found by using the following formula:-

$$S = \frac{\sum_{i}^{n} P_i^2 A_i^{-1}}{\sum_{i}^{n} P_i} \qquad (10)$$

where P_i and A_i are the population and area of each enumeration district (ED) of the ambulance station area which comprises n such districts.

Two models were examined, one using population density and the other sparsity. Looking firstly at population density, a linear regression model was used for the cost per head C, such that

$$C = a + bD \qquad (11)$$

where a and b were constants to be determined and D is as defined in equation (1). The cost per head is obtained from

$$C = \frac{T}{\sum_{i}^{n} P_i} \qquad (12)$$

where T is the total cost for an ambulance station.

The second model examines sparsity using a linear regression such that the cost per head C is now assumed to be:-

$$C = f + gS \qquad (13)$$

where f and g are the constants to be determined and S is as defined in equation (2).

The aim was to find a simple measure that will define the relationship between the level of rurality and the cost of service provision 'with' and 'without' the AA. It was assumed that the cost of provision of the service is dependent on the level of rurality and it is assumed that such a relationship is linear. The options for the independent variable were population density or sparsity. It was expected that sparsity would be more sensitive to where the population of an ambulance station area live in relation to each other, and thus be a better predictor of the cost of serving that area. It is this model that is explored in greater depth.

The other side of the equation is that of costs, here many more options existed. The first to be considered was whether fixed, variable or total costs would be the best predictor of costs at each ambulance station area. It could be argued that variable costs of fuel, tyres and oil for land ambulances and the AA best reflect the cost of serving a population within a given level of rurality. Similarly it could be argued that the fixed costs are more appropriate because it reflects such factors as the crew costs and depreciation on vehicles and thereby reflects the number of vehicles and crew required at a particular level of rurality. Within this research the total costs were chosen. The reasons being that in the first instance total costs reflect the both the fixed and variable components of ambulance service provision at each ambulance station area. Secondly, the costs identified as fixed and variable costs would more appropriately be termed quasi fixed and variable costs. As an example staff costs are treated as fixed. It could be argued that as staff costs could be tailored to demand they could be treated as variable.

The next decision regarding costs was the allocation of quasi fixed costs to ambulance stations that share resources. Two approaches were considered. The first was that the quasi fixed costs should be divided between the ambulance stations that share resources on a basis proportional to the population of each ambulance station area. The logic of this was that an ambulance station with more people to serve should receive more of the joint funding. As the discussion to date has shown that the physical area covered is a major problem for effective service provision, the quasi fixed costs are apportioned in relation to the land area covered by each ambulance station.

Before pursuing in greater detail the model of sparsity as the independent variable against the dependent variable of total costs, a simple straight line regression analysis was carried out on the following to identify the proportion of costs explained by:-

a. Population density with costs divided by population.
b. Population density with costs divided by area.
c. Sparsity with costs divided by population.
d. Sparsity with costs divided by area.

The results of working through these models and the implications of sparsity as a predictor for ambulance service costs given the data set for Cornwall are discussed in Chapter Eight, as are the ramifications for equity.

Study Three

Introduction

The ambulance service is funded mainly from the public sector, and it could be thought that the resources needed to achieve its statutory response times have a higher opportunity cost elsewhere in the NHS. This could be a misconception as it is possible that an inefficient ambulance service could impose greater costs on the rest of the NHS, industry and individuals. The failure to respond to emergency calls with sufficient speed and expertise can lead to the death of patients who would have survived had the response been quicker. (Irving 1989). The premature death of individuals imposes great costs on society in terms of lost productivity, insurance claims, pain and suffering. While death from delayed treatment may not be a frequent event, the number of patients whose recovery can be delayed or who may suffer disability due to delayed treatment is greater. These patients impose increased costs on other sectors of the health service, such as the hospital service and the caring professions as their recovery takes longer. Similarly they may have disabilities that reduce their productive power and impose more costs on society. While Study One looked at the effectiveness of AA use in rural areas and Study Two investigated issues of equity, the aim of this study was to examine the consequences for efficiency with the introduction of an AA system in a rural environment.

The evaluation starts with an outline of what could be thought to be the ideal study, followed by the reality, given the information available, and a brief discussion on valuing benefits.

The Ideal Study

In an ideal situation a controlled study of patient outcomes would entail a comparison of the values placed on the total cost consequences of the service to society with its benefit measured in terms of reduced fatality and improvements in health status.
The resources that would be costed in to the economic evaluation are:-

Public Sector Costs

These would be defined in costs to the following sectors:-

Ambulance service.

Hospital service.

Primary care.

District Health Authority.

Social Services.

Costs to Families and Society

Direct costs of illness to families.

Costs attributable to loss of productive activity.

Costs attributable to pain, suffering and death.

Benefits

Two approaches can be taken to the calculation of benefits. The first approach is to identify and quantify the costs that would have been avoided if the illness or accident had not taken place. Cost of illness studies have aided the quantification of costs incurred on individuals and families from this approach. However, from an economic perspective it does not reveal the subjective values that people are willing to pay for the avoidance of illness or accidents. The second approach, willingness to pay, as the name implies is based on what people are willing to pay to avoid accidents or illness, and to economists it is the method that most closely reveals the subjective values that the analysis seeks. One of the main problems of willingness to pay is for control groups of well individuals to accurately perceive and value the risk which affects their life chances.

As valuation of all the above was not possible within the scope of this research, the study has used the evidence available.

Available Information

The Ambulance Service

The information available within the ambulance service relating to the costs was virtually complete as identified in Study Two. The benefits to the ambulance service can be viewed in terms of the time freed up by use of the AA which could improve the response time to calls as indicated in Study One, and allow greater flexibility of resources on a daily basis.

The costs of the control centre at Truro were divided equally between all ambulance stations. This meant that for the first option the costs were divided between seventeen ambulance stations and in the second option, which involved the sale of the

Wadebridge ambulance station, the costs were divided between sixteen ambulance stations.

The only capital costs involved were in option two involving the sale of the Wadebridge ambulance station and the two ambulances stationed there. An estimated value for the site as a light industrial unit in the area was used. The value of the redundant ambulances were taken at estimated trade value as assessed by the fleet manager.

The staff costs for each scenario were calculated by the number and rank of staff needed at each station for each option, multiplied by the relevant salary scale plus seventeen point five per cent costs of employment.

The fixed costs for land ambulances required for each option were valued at the new market value for a middle of the range vehicle. The accounting convention of depreciation was taken on a straight line method over seven years. The variable costs for land ambulances had been calculated using a District Finance Department figure of 9.93 pence per mile and an annual cost of £1875 per ambulance for repairs, spares and tyres for the first option. These costs were adjusted accordingly for the option two in relation to the reduced mileage.

The mileage of each ambulance was calculated by the annual number of missions for each shift divided by the number of ambulances working each shift. For each journey to hospital the mileage was calculated from a central point in each ambulance station area to the nearest DGH and back, plus a ten percent factor to allow for ambulance movements within its own area.

The costs of the AA in option two were taken as the standing costs plus all the variable costs. The information not available from the ambulance service concerned the identity and nature of injury of the patients transported to hospital. This information was obtained by personal communication with the A&E consultant at Truro Mr. Nigel Sellwood. It was his estimation that only ten percent of the patients brought in by ambulance had life threatening conditions.

The Hospital Service

Hospital Costs

In an ideal situation details of injury or medical condition would have been recorded at the scene of the accident or incident and again on admission to hospital using a recognised scoring system for trauma and also a measure of physiological state at the scene of the accident and on arrival at hospital. This would then be checked on leaving hospital and at follow up intervals after discharge. The costs that in an ideal situation would have been included are:-

a. The costs to the A&E department of space and equipment used and personnel employed.

b. The marginal costs to the rest of the hospital in terms of investigations, drugs, operations, general services and consultant episodes.

The only two pieces of information obtained directly from the hospital were the annual mean daily cost of hospital care inclusive of treatment and hotel costs, and the average length of stay in hospital. For emergency patients this was two point nine days per patient, and for urgent patients it was five point four two days per patient that it was possible to get directly from the hospital was that of the average length of stay in hospital for emergency patients, defined as a response to a 999 call, which was two point two nine bed days per patient.

A study by Biege (1987) noted that the German experience of AAs indicated that in life threatening cases, the speedy use of the AA reduced hospitalisation by three days. This evidence was used to estimate possible savings from the use of the AA. Ten percent of AA missions in Cornwall were regarded as life threatening and therefore may reduce hospitalisation by three days (Sellwood, 1989). This assumption was used in the second option for ten percent of the patients flown to hospital by the AA.

Primary Care Costs

In a controlled trial post hospital, the patients' use of resources would have been calculated. This would include GP costs, prescription costs and the cost of necessary nursing. The available information in this area came from three GP practices in the county who were approached and agreed to review their patient lists to give an indication of post hospital involvement for patients who had been taken to hospital by ambulance as an emergency or urgent case.

At a panel meeting with these GPs a consensus was agreed on the following. The mean time off work seemed to be about one month. While most cases were shorter periods, the occasional bad road traffic accident or industrial accident extended the mean where such individuals were under care for up to twelve months. A GP home visit was required by 50 per cent of cases while all cases made one visit to a GP's surgery.

It was estimated that on average the district nurse would be involved once with each case. This reflects many cases of no nurse involvement, but a number of cases with three or more visits from the nurse.

Social Services

Outside the Health Service the only other public sector body to have substantial input were the Social Services. The GPs who provided information on the rate of their use estimated that social workers were involved with between about ten percent of the cases, mainly with the elderly.

Costs to Families and Society

Direct costs of illness to families

Again in the ideal study the direct cost to families would have included the costs resulting from hospitalisation, the largest of which would likely to be loss of earnings, visits to the doctor, payments for prescriptions and the cost of visiting relatives in hospital.

The largest direct cost to a family of hospitalisation, other than income loss, dealt with below, was likely to be the travel costs for visiting. While prescription costs to the state were estimated, the cost to the individual was not, as the Prescriptions Pricing Authority would not release this information. Similarly, while GP's time was calculated, the cost to the individual of getting to the GP's surgery in Cornwall was not estimated.

Again with no controlled trial to calculate the cost to patients and relatives a number of assumptions were made. One of the main costs to the patient in hospital was the loss of income. In this analysis the average earnings for the county were used. The 'New Earnings Survey 1989 to 1992' produced by the Department of Employment gave the mean weekly earnings in Cornwall during 1989 as £219.2 for men, and £155.4 for women. In 1990 the figures were £241.9 and £166.8 respectively. An assumption was made that the county average for employed persons over the two years of the study would reflect the cross section which contributes to the county's average wage. Adjustment would need to be made for the elderly who would be retired. From a children's perspective it was assumed that lost productivity would emerge from a parents work being interrupted.

An important cost to friends and relatives was the cost of hospital visiting. This was particularly difficult from rural areas where there was often no public transport. In this evaluation it was taken that friends and relatives visited each day in one car. The fuel cost only is calculated, representing the marginal cost of the visit. No consideration was taken of possible time off work, or child minding needs that might be encountered to visit a friend or relative in hospital.

Costs Attributable to Loss of Productive Activity

Society might contend that the lost productivity of the person in hospital should be valued, but that assumes that there is a loss of productivity. If the individual was replaced by someone else, the final effect of this removal from the work force may have been that one more person was removed from the ranks of the unemployed. Thus the final loss to the community may have been much less than the earnings attracted by the position occupied by the individual originally removed. Short absences from work might not result in production losses of the value indicated by wages. It may be the job, or the position, that has the productive capacity rather than the individual. Alternatively, if the sick or injured person was a key worker then the effect would be different. A loss of productivity would occur which could be harmful to production.

The human capital approach values people in terms of their productive ability. If it is taken that in a competitive market situation productive ability equates to ability to earn, then the theory that values individuals on this basis is flawed with distributional problems as the discriminating element becomes earnings, such as in a private healthcare system. As the NHS was designed to compensate for inequalities in income such an approach would seem illogical. There is also little reason to believe that the amount an individual, or that individual's family or friends would be willing to pay for health care would have any direct relationship with potential loss of earnings. While earnings themselves would not appear therefore to provide a good measure of value, individuals do take account of loss of earnings associated with ill health. Similarly, if there is any residual gain in productivity from an individual's health, this investment externality should be taken into account with other factors in the computation of societies benefits.

As it was not possible to recognise individuals in this study there was no certain way of estimating the loss of productive activity to society.

Costs attributable to pain, suffering and death

While the use of an AA may have logistical benefits to the ambulance service, much of its value to society stems from the possibility that it could reduce loss of life or aid in the completeness of recovery from a major accident or illness. Therefore the potential number of lives saved and the value attributed to those lives are crucial in the estimation of the efficiency of an AA. In health service planning, which is the primary emphasis here, valuing life or even livelihood was seen not to be the issue. What is to be valued in this context was not the life saving per se, but more accurately a relatively small reduction in the risk of death. Three approaches of estimating the value of life are:-

1. Implied values.
2. Human capital.
3. Estimates of willingness to pay.

The implied values approach was based on the premise of public behaviourial or socially implied values obtained from teasing out the real preferences for safety in mortality reducing endeavours of the public sector. The 'human capital' approach equates the value of life of an individual with the present value of future lost output (as proxied normally by the earnings and other labour costs). Some examples of this approach were provided by Jones Lee (1976) and Mooney (1977).

The main comments to be made about the approach beyond its relative ease of application were that it measured livelihood rather than life per se, and no attempt is made to reflect willingness to pay either on the part of potential victims or society more generally. While individual earnings and income will effect their demand for safety (i.e. risk reduction), it is unlikely that there will be a simple one to one accounting relationship.

The human capital approach gives a basis of value based on the capital sum equivalent to net earnings of those lives who would be saved, which suggests that those who do not work have no value. This is inconsistent with the general basis of cost benefit analysis. Economists favour what people would pay to avoid a slight increase in the probability of death. The arguments are concerned with the amount worth spending to prevent death when welfare of all taken into account, including those who might themselves die as a result of the decision. They are not limited to the compensation to be given to relatives of a particular person who has been killed. Thus the amount worth spending to prevent a death should be considerably greater than costs awarded to the next of kin. Marin (1983) suggested that two million pounds is not unreasonable.

The correct question in valuing life for cost benefit analysis is how much an individual would be prepared to pay in order to avoid the extra risk of dying prematurely. In terms of conventional economic theory, the most defensible approach to valuing life was that of willingness to pay for reduction in mortality risk on the part of potential victims. The approach was first suggested by Dreze (1962). Schelling (1968), Mishan (1971) and Jones Lee (1976) have contributed to and extended the work. Jones Lee assumed an individual would be prepared to forfeit some of his present wealth to effect a reduction in the probability of death. While the willingness to pay approach was one which is defended and applied by the majority of economists, there were some critics of this approach. Thus Broom 1978, for example, suggested that the willingness to pay criterion is unsatisfactory for the losers, as those whose deaths were associated with any project, could not be compensated. While this study has not been able to identify any lives that have been saved by the use of the AA, a hypothetical situation is looked at using different values for the value of life.

Summary

In summary the approach taken for this evaluation has been to identify and sum the costs associated with the two options of 'land ambulance only' and 'land ambulance with the AA'. The land ambulance costs were then withdrawn and the additional costs of the AA were compared with the estimated benefits, with reduced costs being taken as benefits. It has been possible to calculate certain benefits from information provided by the ambulance service and the hospital service. Other benefits, such as the reduced hospital stays for trauma patients through AA use, have been imputed from other studies.

The calculations to this point have not included a value for any life saved by the 'land ambulance with AA' option over the 'land ambulance only' option. To counter this the value of life from different previous studies is taken to identify the effects if between one and five lives were saved by the 'land and AA' option.

Chapter Eight

Ambulance Service Effectiveness

Introduction

In this chapter the results of study one are presented and discussed. The study concentrated on a detailed analysis of the relationship between the service standards achieved and the overall cost implications of 'land ambulance only' provision versus 'land ambulance and AA' provision in Cornwall. This involved exploring the relationship between demand, standards and resources to identify a 'target demand population' for the best use of an AA, and setting up options to test its contribution to effectiveness, equity and efficiency.

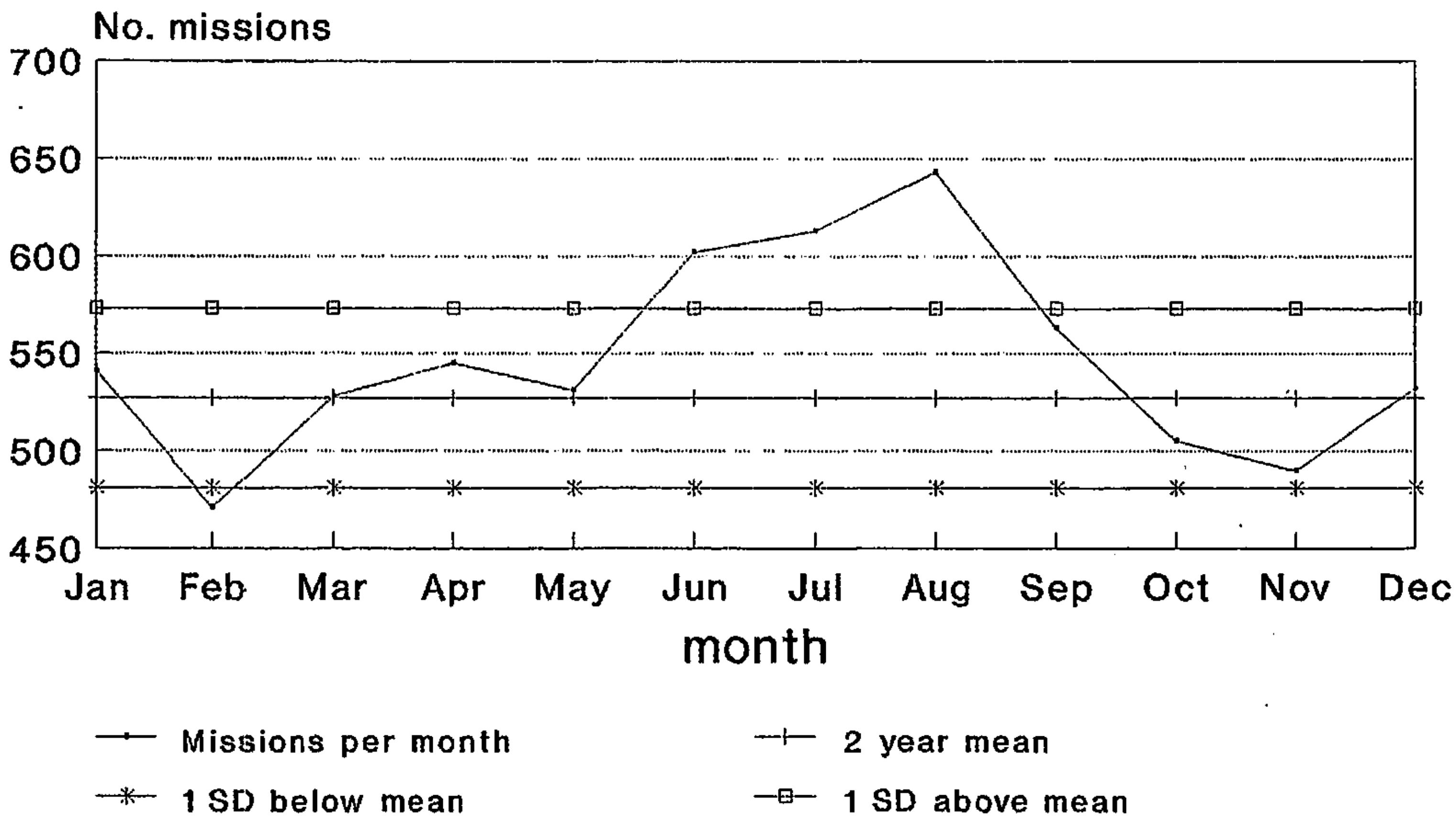
Patterns of Demand for Emergency and Urgent Calls

The county wide demand for emergency and urgent calls was explored in order to identify the peaks and troughs of demand and to establish whether the mean number of calls per hour of day, day of week, and month of year reflected an accurate picture for the land and AA options discussed on page 154.

Fig. 8.1. shows the mean number of calls per month over the two year span of the survey. The mean number of calls per month for the whole survey was 527 with a standard deviation of 46.2. Nine of the twelve months were within one standard deviation of the mean. The July and August peaks fall outside one standard deviation of the mean, but are within two standard deviations. The largest outlier, August was 16.47 per cent above the mean, or interpreted another way, 14.7 calls more than the mean over the whole county, over a 24 hour period. For each ambulance station this reflected an increase of 0.036 calls per hour. The peak number of calls during July, August and September, probably reflected the increase in the county's population due to tourists, and coincides well with the school holidays. The Management Advisory Services report (1986), indicates that the population of the county doubles during August. If this was the case then the increase in demand for the ambulance service would not appear proportional to the increase in population. The extra demand of the high summer affected some ambulance stations more than others. The coastal resorts showed a greater increase

Fig. 8.1

Mean Number of Calls per Month



in demand than the inland urban centres such as Redruth. The demand was also centred more on the hours of the day that tourists were mobile rather than spread over a complete 24 hours. However, if the extra demand of 14.7 calls per day were spread over only nine stations, and confined to only 12 hours of the day, the increased demand rate is still only 0.136 calls per hour.

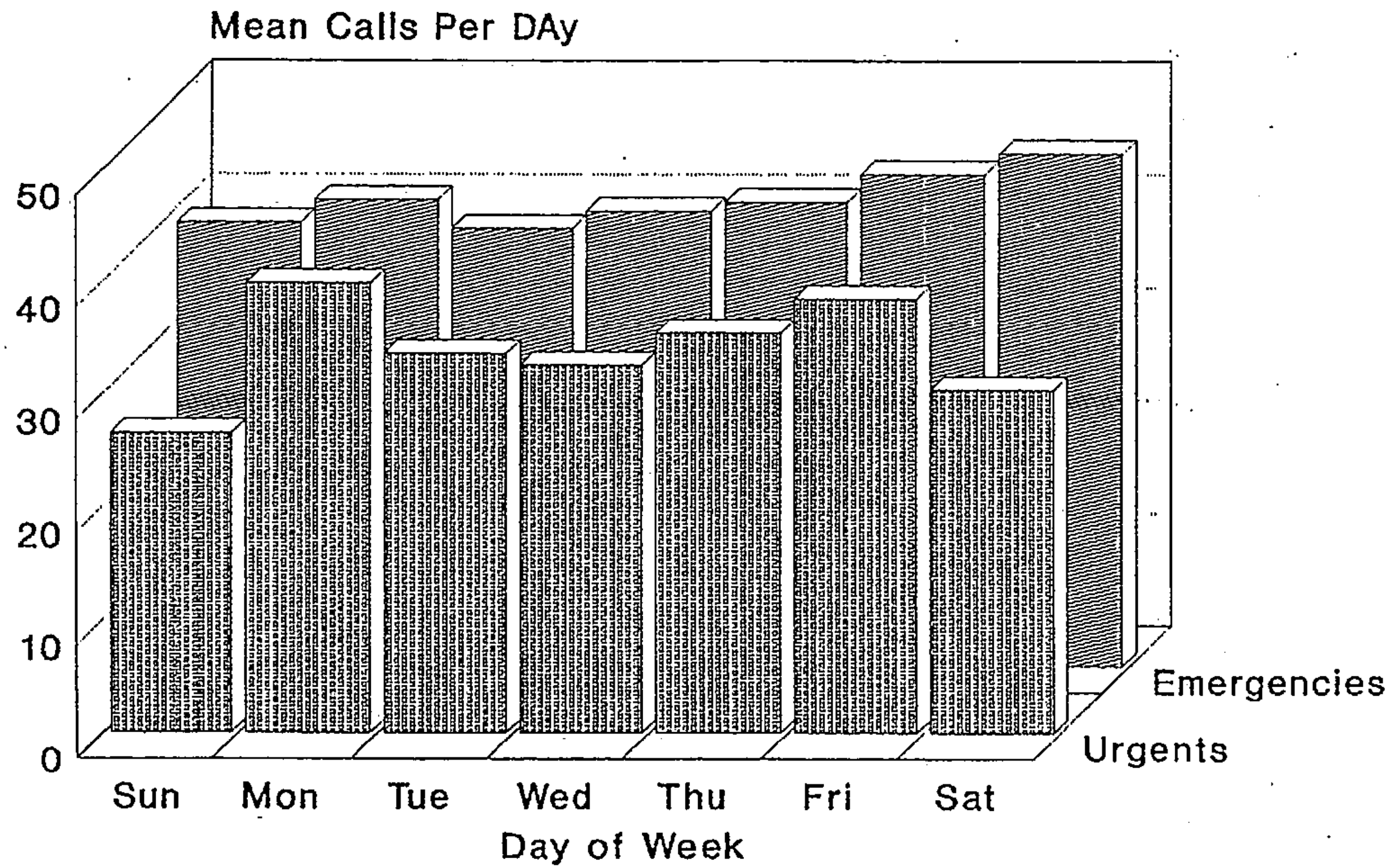
Fig 8.2 shows the difference in calls per day over the 'all survey' period. Urgent calls for the 'all survey' had a mean of 33.89 calls per day with a standard deviation of 2.19. The highest demand was the 45.46 calls per day on Saturdays, and 38.75 calls per day on Tuesdays. With regard to the emergency calls, the mean number of calls per day were 38.89, with a standard deviation of 4.26. The low point was Sundays at 26.58. The reason for this could be that a certain number of people who are ill on Sunday do not call the doctor until surgery resumes on Monday. The very high urgent figure for Mondays could also be due to hospital doctors transferring patients from the DGHs to cottage hospitals after their rounds, and/or GPs referring patients to hospital on their rounds after a weekend break.

Fig 8.3 shows the mean total calls per day for the 'all survey' period, the mean of March and the mean of August. The heightened peak for Mondays was due to the all year round Monday high for urgent cases, and the increase of emergencies in the early part of the week particularly in Aug.

Fig 8.4 explores demand by the hour of day for the 'all survey' mean. The low point of demand was between three and five am when movement was at its minimum. The sharp rise in urgent calls through the morning was a result of doctors going out on their rounds to see patients too sick to visit a surgery, and then referring them to hospital. It can be seen that the emergencies have a much more even distribution than urgent

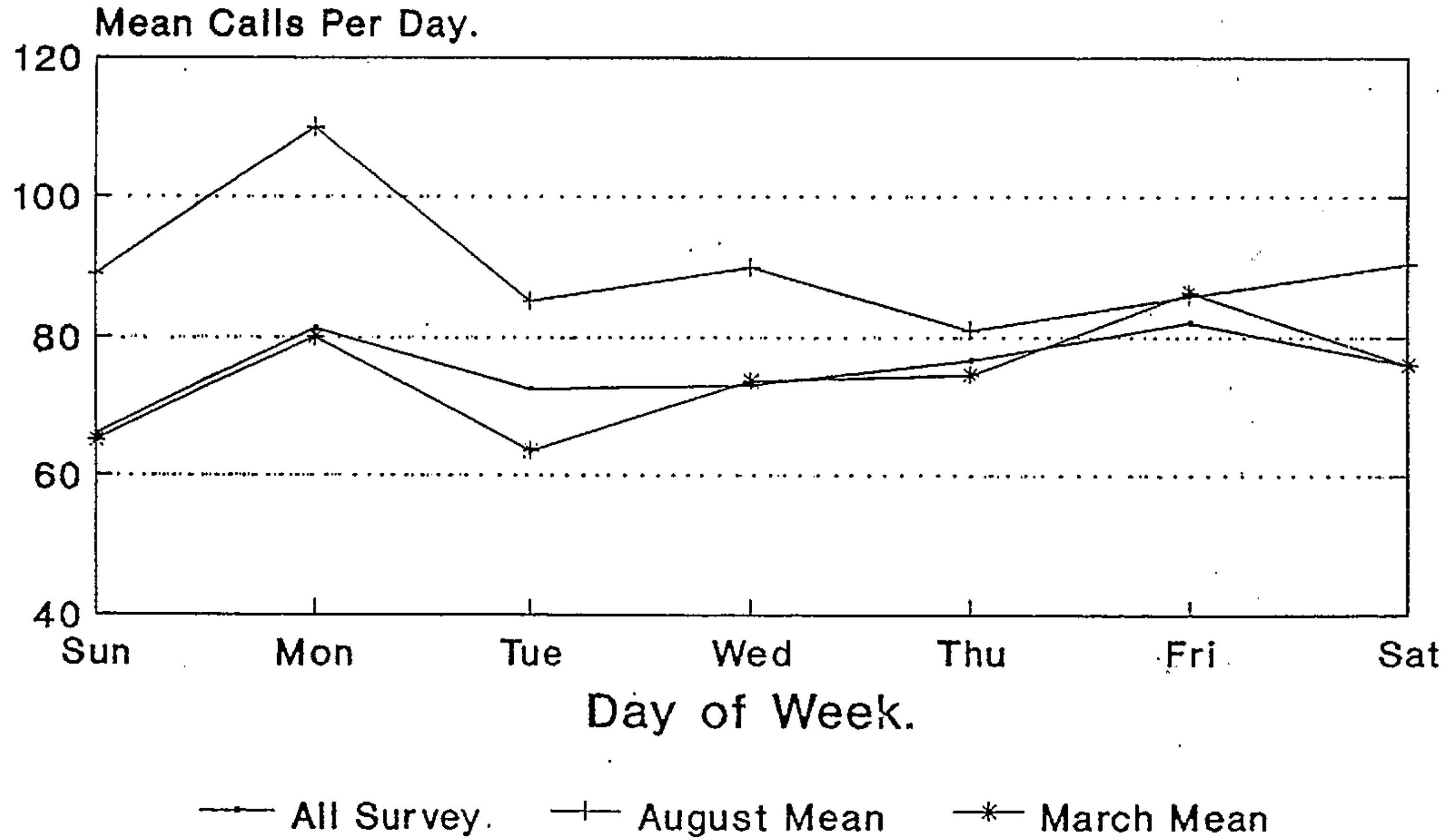
Fig.8.2

Emergency/Urgent Calls Per Day.



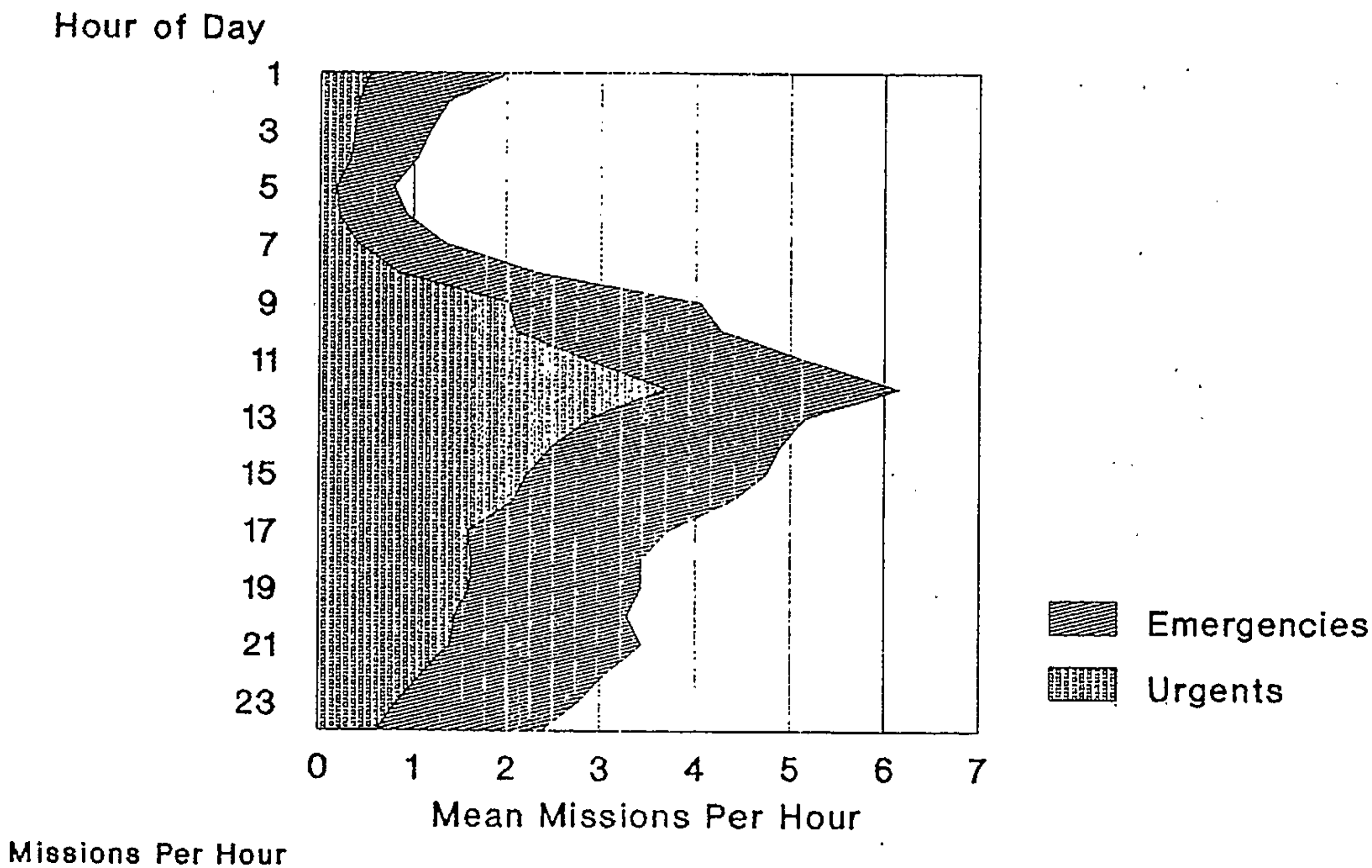
Mean For All Survey Period.

Fig. 8.3
Mean Calls Per Day



Comparison of Winter/Summer & All Survey

Fig. 8.4
Survey Mean.



calls with a low point at 5 am, rising to a peak at 9 am. Then there was a remarkably constant demand of around two calls per hour until midnight. Urgent calls also had a low point at 5-6 am, but rose to a peak at 12 noon from which there was a gentle decline.

Having looked at the three aspects of variability of demand in the data from the survey, the conclusion was that variability was not so excessive that the 'all survey' mean of 'calls per day', and 'calls per shift' could not be used as the basis for the options that will be devised to reflect the Cornwall Ambulance Service, and tested for effectiveness, equity and efficiency.

Distribution of Patients to Hospital

The vast majority of patients are taken to the three DGHs that serve the county. The distribution of patients to the hospitals is shown in Table 8.1.

Table 8.1. Distribution of Patients to Hospitals

Hospital	Number of patients during survey	% of patients during survey
Truro	6381	58
Plymouth	1527	14
West Cornwall	1166	11
*Others	1903	17

* A comprehensive list of the exact numbers taken to each hospital are contained in Appendix D1.

Truro has 58 per cent of patients in the county, because it is the main DGH in the county and two thirds of the county's population live within relatively easy reach of Truro. Plymouth hospitals have a catchment area ending in a line just west of Liskeard and arching up towards Camelford. While this is quite a large area, it has a much lower population density than the area surrounding Truro. The third DGH at Penzance, known as the West Cornwall hospital, is not so well equipped as the other two DGHs and therefore if there is any doubt in the ambulance person's mind regarding the seriousness of the condition of a patient, the patient would be taken to Truro DGH.

In fact the A&E facilities at the West Cornwall hospital are currently under threat of closure as the improved road system.has decreased the travel time to Truro, and the new A&E department there can cope with the greater volume of patients.

Ambulance Station Demographics

The area and population of electoral wards in Cornwall used as the base unit of analysis in the origin of incidents or accidents and the allocation of wards to each ambulance station in the county are listed in Appendix C3. This information was derived from the 1991.

Fig 8.5 shows the extremes in the area of each ambulance station catchment area, from the largest at Liskeard in the East of the county at 45,991 hectares to Looe at 2,632 hectares. The mean area of the seventeen ambulance stations was found to be 20,858 hectares.

Fig 8.6 shows the population of each ambulance station catchment area. It can be seen that the relatively small ambulance stations in terms of area coincided with a similarly low population. This was seen in such areas as Wadebridge, Looe, Carbis Bay and Torpoint. The relatively large stations in terms of area in the North and East of the county, such as Camelford, Launceston, Bude, and Liskeard, all had much smaller populations in relation to their area. This is shown in Fig 8.7 which indicates the population density in people per hectare. The North Cornwall ambulance stations of Camelford, Launceston, Bude and Wadebridge have particularly low population densities ranging from 0.37 in the Camelford area to 0.72 in Wadebridge. Liskeard in the East of the county also has a relatively low population density of 0.5 people per hectare. The four smallest ambulance stations in terms of area identified in Fig 8.5, Looe, Carbis Bay, Torpoint and Falmouth, all have a high population density figure, ranging from 2.21 persons per hectare in Looe, to 3.59 persons per hectare in Falmouth. Also the Western third of the county, west of a north/south line from Truro, contains the greatest population density

Fig.8.5

Hectares Per Station (in thousands)

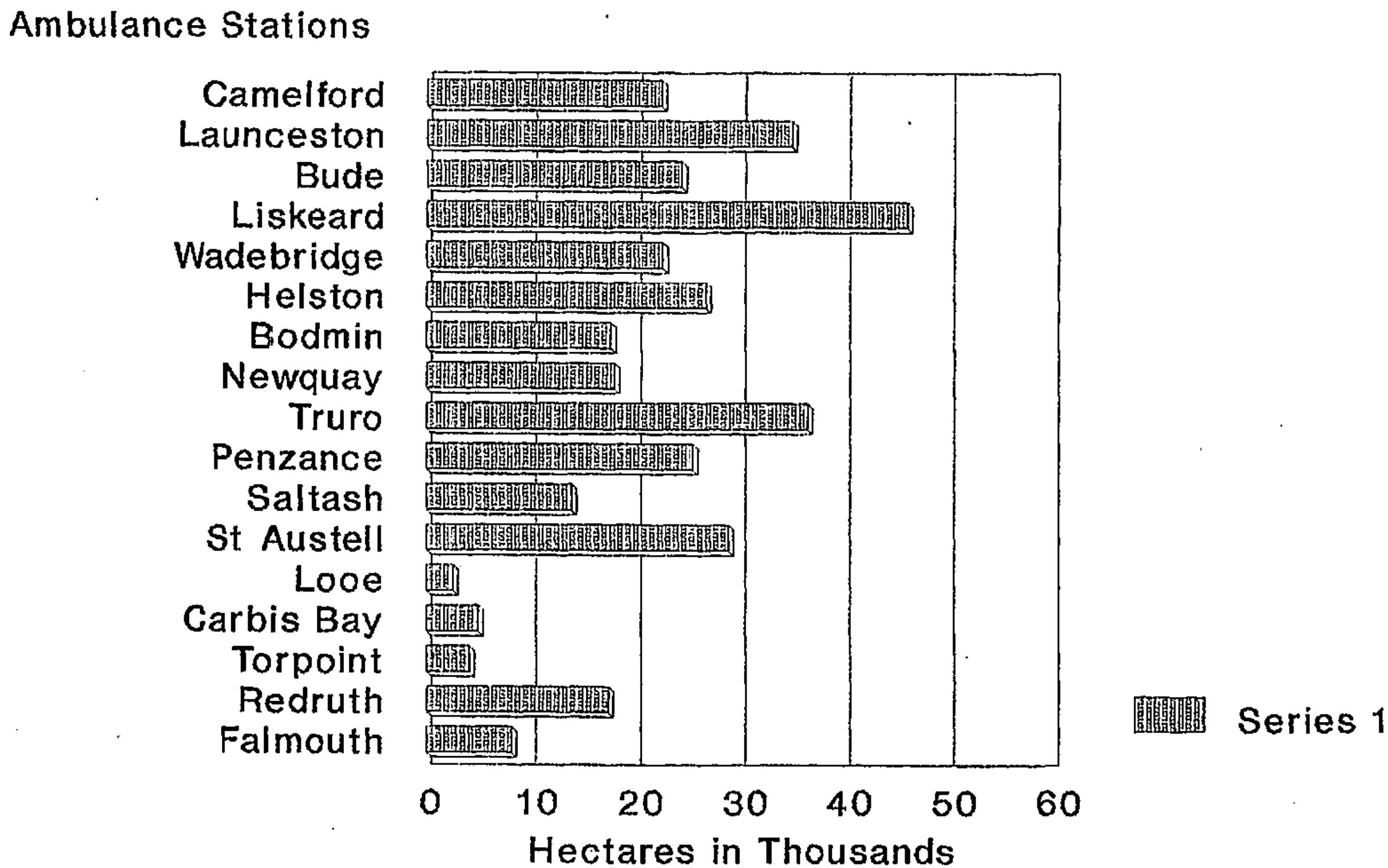


Fig.8.6

Population Per Station (in thousands)

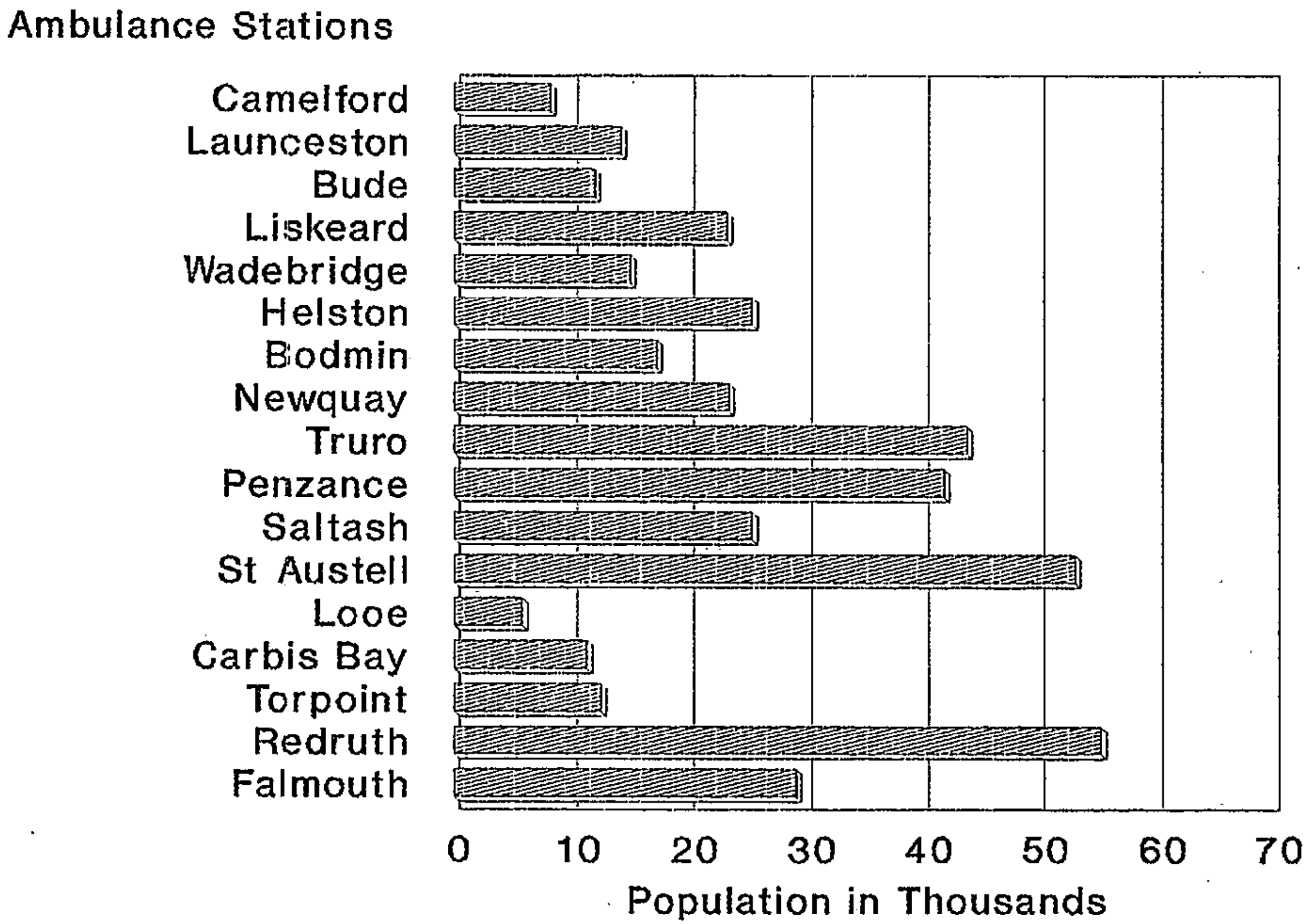


Fig.8.7

Population Density Per Ambulance Station

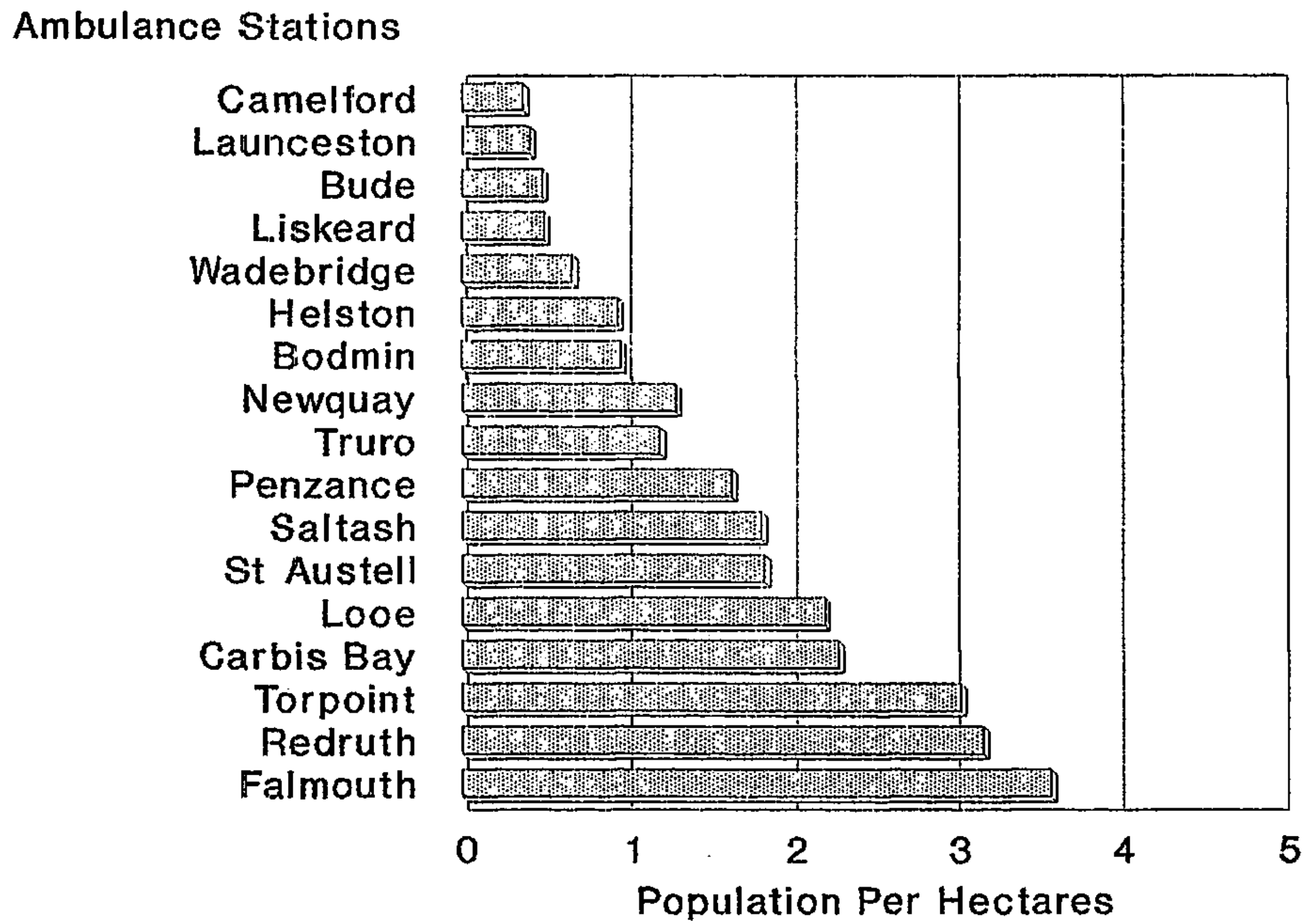
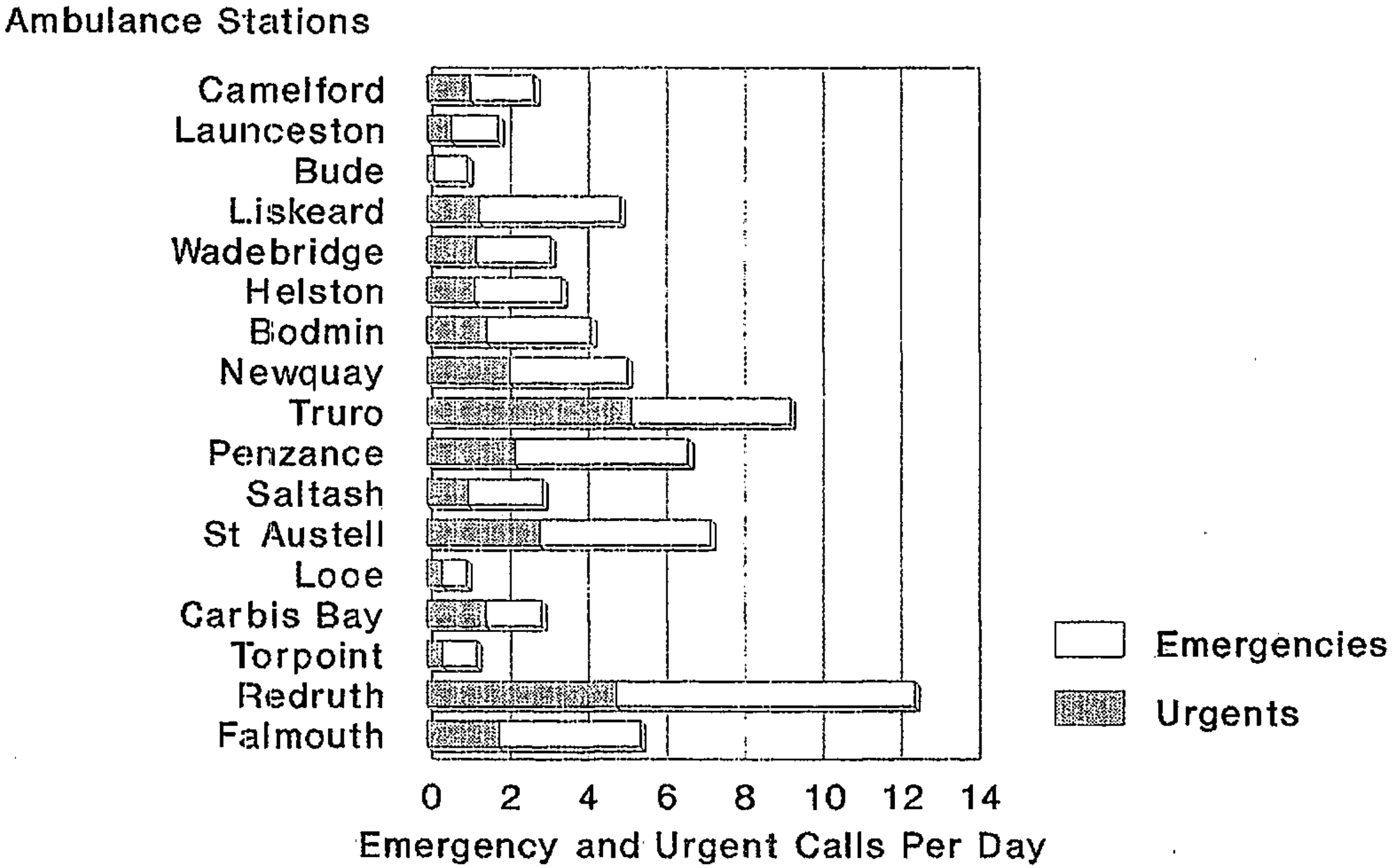


Fig.8.8

Calls Per Day Per Ambulance Station.



in that two thirds of the county's population live in that area. It is notable that in general the higher population density ambulance stations are closer to the main DGHs than the more rural stations.

Demand Patterns at Each Ambulance Station Area

Fig 8.8 shows the mean number of calls per day at each ambulance station, divided into emergency and urgent calls. The stations which handled the most calls are the urban areas of Redruth, Truro and St. Austell respectively. There was a large variation in the range of calls with Redruth at 12.5 calls per day, against Looe with just 1.02 calls per day. Again the ambulance stations of North Cornwall, (Camelford, Launceston, Bude and Wadebridge) received fewer calls than the stations in the Western part of the county. Torpoint and Looe which appear high on the population density graph, had amongst the lowest number of calls per day. This is because both stations have relatively small total populations. Appendix D2 shows the mean calls per shift for emergency and urgent calls by ambulance station for the 'all survey' period. This shows two quite distinct trends. The first is the higher rate of calls during the day shift in relation to the night shift. The day shift being 06.00 to 18.00, and the night shift being from 18.00 to 06.00. The second point was the greater number of emergency calls compared to urgent calls occur in almost every station, with the exception of Carbis Bay and Truro.

Standards

Table 8.2 gives a reflection of the ORCON standards for the county. It can be seen that it was only the larger urban areas of Penzance, Redruth, Newquay and Falmouth which achieved the ORCON standard of fifty percent of calls responded to within eight minutes. The only stations that approached the ORCON target of ninety five percent of all calls responded to within 19 minutes were the far western urban ambulance stations of Penzance, Carbis Bay, Falmouth Newquay and Redruth.

Table 8.2. Land Ambulance ORCON Figures by Ambulance Station

	All survey 50% Orcon	All survey 95% Orcon
Bodmin	41.4	85
Bude	43.2	82.7
Carbis Bay	48.6	94.9
Camelford	27.3	74.4
Falmouth	69	96.4
Helston	42.9	91.2
Launceston	46.6	84.1
Liskeard	35.5	86.1
Looe	32.1	89.5
Newquay	58.9	95.1
Penzance	57.3	94.7
Redruth	54	93.8
St Austell	42.5	89.2
Saltash	40.9	86
Torpoint	36.2	89.8
Truro	44.3	89.5
Wadebridge	35.6	86.6

The mean time to hospital for emergencies and urgent cases from each ambulance station area are given in Table 8.3. The number of missing cases for the above tables were four or nought point one percent for the emergencies, and nine or nought point two percent for the urgent cases. It can be noted that the longest journey times to hospital are from the North Cornwall stations of Bude, Camelford, Wadebridge, Bodmin and Launceston. This was due to the sheer distance from the DGHs and the poor quality of roads in those areas.

Table 8.3. Mean Time to Hospital by Land Ambulance for Emergency and Urgent Calls

	Emergency	Urgent
Ambulance stations	trip time (mins)	trip time (mins)
Bodmin	42	93
Bude	64	92
Camelford	57	123
Falmouth	22	85
Helston	29	95
Launceston	41	96
Liskeard	20	83
Looe	38	111
Newquay	21	96
Penzance	21	77
Carbis Bay	21	90
Redruth	18	77
St. Austell	27	83
Saltash	21	95
Torpoint	30	89
Truro	9	68
Wadebridge	44	108

As can be noted from Table 8.4 the 'total mission time' follows very much the pattern of the variable 'time to hospital' in that it is the remote rural areas in the North of the county that display the longest times and the more urban Western parts of the county that display the shorter times.

Table 8.4. 'Total mission time' For Each Ambulance Station For Emergency and Urgent Cases

Station	Emergencies	Urgent
	Time in minutes	Time in minutes
Bodmin	68	108
Bude	85	113
Camelford	98	129
Falmouth	62	88
Helston	71	112
Launceston	75	114
Liskeard	70	89
Looe	86	113
Newquay	56	82
Penzance	46	87
Carbis Bay	61	95
Redruth	54	81
St. Austell	65	98
Saltash	63	99
Torpoint	67	96
Truro	44	74
Wadebrige	92	120

AA Travel Times

The AA averaged 1.31 cases per day during the survey period. The calls in terms of 'day of the week' are displayed in Table 8.5.

It can be noted that the AA would appear to be used more at the end of the week and at weekends than in the middle of the week which is in line with the total demand pattern. Similarly, the AA use reflects the peak of demand in the tourist season of July and August.

Table 8.5. AA Calls by Day of Week Over Survey Period

Day of week	Number of missions	% of total missions
Sun	128	15.4
Mon	108	13
Tue	83	10
Wed	105	12.7
Thur	132	15.9
Fri	135	16.3
Sat	138	16.7

Table 8.6. AA Calls by Month of Year

Month of year	No. of missions	% of missions
Jan	69	8.1
Feb	49	5.3
March	49	5.3
April	78	9.2
May	73	8.6
June	57	6.5
July	107	12.7
Aug	107	12.7
Sept	76	8.8
Oct	59	6.7
Nov	62	7.1
Dec	43	5.0
TOTAL	829	100

Table 8.7. AA Calls by Type

Mission type	cases	percentage
Primary	522	63
Secondary	170	20.5
Tertiary	135	16.3
No data	2	0.2

Table 8.8. AA Response Times

Ambulance station	Response time
Bodmin	13
Bude	15
Camelford	16
Falmouth	16
Helston	8
Launceston	6
Liskeard	7
Looe	9
Newquay	6
Penzance	14
Carbis Bay	11
Redruth	8
St. Austell	9
Saltash	5
Torpoint	5
Truro	10
Wadebridge	12
Scilly Isles	28

The AA was used 63 percent of its time on primary missions (this is when the AA is the only vehicle involved). This would not necessarily be because they were remote locations. It could be because no land ambulance was available closer, or the nature of the injury gave the controller the opinion that speed was essential, rather than desirable, in getting the patient to hospital. The secondary missions (20.5%) occurred when a land ambulance came across an accident where several people were hurt, such as a multiple car crash, and/or where a patient needs particularly speedy transit to hospital, and/or has the sort of injuries which travel better in an AA, such as spinal injuries. Conversely it may be that the ambulance which answered the 999 call was booked to answer an urgent call in an hour's time, hence the AA can enable the land ambulance to carry this out. The essential factor is that the distance from a hospital has to be great enough to make such transfers worthwhile, which tends to indicate a rural environment. Sixteen point three per cent of its missions involved moving patients from one hospital to another.

The AA is highly manouverable and quite small but it is still not ideal in urban situations. Whilst it can land in parks or on a road which the police have cleared in advance, it invariably needs to be supported by a land ambulance to transfer the patient from its home or scene of an accident to the AA. As most incidents happen in an urban area this precludes the AA from a number of potential primary missions. Most accidents happen on or close to a road, such as in the home or in the workplace so there are very few occasions when a land ambulance cannot get as close to the patient as the AA. Conversely, there are many occasions when the AA cannot get as close to a patient as a land ambulance.

As there is only one AA, the opportunity cost of its use is high. Once committed to a call that could be achieved as easily by a land ambulance, a call may arise for the AA in one of the identified areas in which a land ambulance cannot easily substitute. On remote beaches and cliff top locations and certain areas of the moor the AA can achieve a level of access that a land ambulance cannot. The AA is also used for the small number of emergency or transfer calls from the Scilly Isles to the DGH in Truro. Similarly, patients with conditions that need treating in more distant specialist hospital, such as Papworth in Bedfordshire, Woodstock in Hampshire are often transported in the AA.

The speed of the AA gives it the added advantage of being able to choose the most appropriate hospital for the condition, rather than the closest. A patient picked up on the Lizard peninsula will not automatically be flown to Truro, the closest DGH, if it is thought that the specialist treatment provided at Plymouth is more relevant to the patients need.

While care has to be taken by the controllers not to use the AA indiscriminately, it is still unlikely to have a significant affect on serious trauma cases in the county. An OPCS survey report for 1988 showed 150 deaths due to injury in Cornwall that year. A report by Irving (1988) stated that approximately half these deaths would have occurred within a few minutes of being injured and were inevitable. The same report also suggested that thirteen per cent of the remainder of these deaths (one per month) might, under the most favourable circumstances, have been preventable. The likelihood of these injuries occurring during daylight hours when the AA was available were remote. There were occasions of lesser injury than serious trauma where speed and choice of the right hospital would mean a reduction in morbidity if not mortality, in which the AA contributed a useful service.

Resource Level at Each Ambulance Station

As there are many tables in this section a number of them have been relegated to the appendices. In order to identify the resources available at each ambulance station, staff numbers were explored first. The number of ambulance staff employed at each ambulance station is displayed in Appendix D3. It is a complex task to get the right balance of trained ambulance persons and paramedics on each shift and at each station. Therefore, in order to optimise the cost of cover, certain stations pooled vehicles and staff and any one shift will be made up of personnel from any of the stations within the pool. Penzance and Carbis Bay worked together to cover the extreme west of the county. Saltash, Looe, and Torpoint worked together to cover the extreme east of the county, and in the north of the county Bodmin, Launceston, Camelford, and Bude pooled together to supply the day shift, adding Wadebridge to the group for the night shift. The remaining stations were of sufficient size and/or work loads to be self-sufficient. Crews from Redruth are used to cover sickness and leave at other stations.

The number of ambulances allocated to each station and the number of ambulances used on each shift are displayed in Appendix D4. Vehicles are pooled between stations in the same way as staff. However, each station, with the exception of Torpoint and Looe, must have at least two vehicles on station in case one will not start at the beginning of a shift. Looe and Torpoint pooled with Saltash which is close enough to be able to provide backup if needed. There also needed to be at least one more vehicle per station than was needed on any one shift to allow for a late returning vehicle. For instance if an ambulance was attending at 17.00 hours an emergency that takes two hours, the shift coming on at 18.00 hours needed to have a vehicle in which to start their shift.

Utilisation of Vehicles Per Shift

The time involved in responding to calls for the day shift, at each ambulance station is displayed in Appendix D5. This table showed the mean number of minutes that crews of each ambulance station spent each day answering emergency and urgent calls. The total time answering calls was then expressed as a percentage of the day shift. Appendix D6 displays the same information for the night shift.

While Appendices D5 and D6 show the percentage of time that each ambulance station area was involved in responding to calls from its own area, it does not take into account the complicating factor of shared resources for certain stations. Appendix D7 and D8 takes this into account for the day and night shift respectively. The column 'Minutes of wheel turn' refers to the number of minutes responding to calls at each ambulance station. However, the column 'Percentage wheel turn per vehicle' refers to the percentage of time the ambulances were involved in responding to calls, rather than providing cover. This figure differs for a number of ambulance stations from the figure displayed in Appendices D5 and D6 in ambulance stations where vehicles are covering more than one ambulance station. The number of vehicles pooled for the different combinations of ambulance stations is shown in the second column of Appendix D7 and D8.

The mean fleet utilisation figures of 36.17 per cent for the day shift and 28.72 per cent for the night shift could possibly be improved by reducing the number of ambulance stations. The trend of ambulances having greater utilisation in the urban areas was apparent with Truro, Falmouth, and St.Austell having the highest figures, and being the biggest urban sections of the county. Redruth, a large urban area, had a lower utilisation figure as it was used to provide cover for its own area, and anywhere else in the west of the county that a need might arise.

Brismar et al (1984) conducted a study of ambulance utilisation in rural and urban districts in Sweden. The study looked at ninety districts with varying population densities, but with a population size of between 10,000 and 40,000. They found that ambulance utilisation in the urban area was higher (0.37 calls per hour) than in the rural area (0.22 calls per hour). Time in use (i.e. while on a call) for ambulances, expressed as a percentage of time available, was also higher in the urban area (31 per cent) than in the rural area (18 per cent). The Cornwall figures accorded well with those of Brismar et al. The highest time in use figure for the day shift was 31.85 per cent at St.Austell, an urban area. On the night shift the highest utilisation figure was at Truro where 38.23 per cent utilisation was achieved. The lowest day shift utilisation figure was at the Saltash, Looe, Torpoint area which was 17.22 per cent. The lowest for the night shift was 14.55 per cent at Helston. Although the figures accorded well with those of Brismar, the lowest figures of ambulance utilisation did not come from the most sparse regions. This is because in the most sparsely populated areas the wheel turn per vehicle was higher because each call was of greater distance. However the rate of calls per hour from these areas was lower than those of the combined Saltash, Looe and Torpoint, and Helston stations.

The call rate per hour from individual ambulance areas varied greatly. In the day shift the highest was the urban area of Redruth with 0.65 calls per hour, while the lowest was in the very rural area of Bude with 0.06 calls per hour. The night shift at Redruth again came top with 0.6 calls per hour, while the lowest was Looe at 0.04 calls per hour. In large rural areas of low demand the two man fully equipped land ambulance had difficulty in achieving the goals of acceptable 'response times' and 'travel times to hospital'. It was in these areas that the relatively new innovation of AAs should be tested.

Two Options to Discover the AAs' Contribution to Effectiveness, Equity and Efficiency

The results given in this section were used to identify the physical area in the county where the AA had the most to contribute. This information was used to develop two options of 'land ambulance only' use, versus 'land ambulance and AA use'.

Table 8.9 identifies the magnitude of difference in the 'time to hospital' between land ambulances and the AA. North Cornwall is the area where the greatest percentage of calls did not meet the ORCON standards as shown in Table 8.10.

Of the 663 calls outside the ORCON standard during the survey, 208 (31 per cent) emanated from the North Cornwall block, a further 124 (19 per cent) were accounted for in the neighbouring blocks of Liskeard, Saltash and Newquay. The remaining 50 per cent came from the rest of the county. Calls not answered after 25 minutes followed a similar pattern with 71 (34 per cent) out of a total of 208 occurring in the North of the county, while the same neighbouring blocks of Liskeard, Saltash and Newquay accounted for another 41 calls or 20 per cent. North Cornwall as a block of land, whilst having the worst ORCON response times, also had the longest journey to hospital times in the county as shown in Table 8.9.

Table 8.9. Comparison of 'Time to Hospital' & 'Total Mission Time' for Land Ambulances and the AA

	Time to hospital			Total mission time		
Ambulance station	land ambulance	AA	Time saved by AA use	land ambulance	AA	Time saved by AA use
Bodmin	42	20	22	68	60	8
Bude	64	21	43	85	68	17
Camelford	57	15	42	98	69	29
Wadebridge	44	11	33	92	53	39
Launceston	41	10	31	75	61	14
Looe	38	16	22	86	65	21
Liskeard	20	11	9	70	63	7
Falmouth	22	9	13	62	54	8
Newquay	21	11	10	56	50	6
Penzance	21	11	10	46	94	-48**
Carbis Bay	21	10	11	61	47	14
Redruth	18	9	9	54	43	11
St. Austell	27	9	18	65	51	14
Saltash	21	5	16	63	50	13
Torpoint	30	6	24	67	55	12
Truro	9	9*	0	44	74	-30
Helston	29	9	20	71	50	21

* The true mean of AA calls from Truro ambulance area is 23 minutes. As Truro is an urban area close to the DGH the only AA calls that emanate from this area for the AA are for inter-hospital transfers to Plymouth.

** This particularly long 'total mission time' for the AA was due to inter-hospital transfers from the Scilly Isles being recorded under the ambulance area of Penzance. The mean mission time of the neighbouring station of Carbis Bay time of 47 minutes would be a more realistic mean.

Table 8.10. Percentage of Calls in North Cornwall Outside ORCON Response Times

Ambulance Stations	Percentage outside ORCON
Bodmin	15%
Bude	17%
Camelford	25%
Launceston	15%
Wadebridge	13%

Table 8.11. Response Time Within North Cornwall for Land Ambulance and AA

Ambulance station	By land Ambulance (minutes)	By AA. (minutes)
Bude	17	15
Camelford	16	16
Wadebridge	16	12
Bodmin	14	13
Launceston	16	6

The AA produced the greatest time savings on 'time to hospital' from the scene of an accident in the North Cornwall area. The largest savings per mission being made in Bude, Camelford, Wadebridge, and Launceston respectively. The smallest savings were made in the west of the county with the exception of Helston, which has the sparse Lizard peninsula in its patch. In the earlier part of this chapter the travel times and workloads for each ambulance area for land and AA use in Cornwall were established. The North Cornwall area fitted the criteria in which the best improvement to services could be offered by using the AA. The two options outlined to establish the effectiveness, equity and efficiency of AA use within North Cornwall were:-

1. The existing four land ambulances cover without an AA.
2. Three land ambulances and the AA.

The two options are now described in more detail.

Table 8.12. Demand Rate for North Cornwall

	Day shift		Night shift	
	Emergency calls	Urgent calls	Emergency calls	Urgent calls
Bodmin	1.42	0.95	1.25	0.58
Bude	0.4	0.2	0.43	0.13
Camelford	0.86	0.73	0.78	0.36
Launceston	0.46	0.34	0.74	0.27
Wadebridge	1	0.79	0.91	0.45
Total emergency/urgent calls	4.14	3.01	4.11	1.79
Total call per 12 hr shift	7.15 (54.79%)		5.9 (45.21%)	
Total calls in 24 hrs	13.05			

Option One

This looked at the North Cornwall area with land ambulances only, as an alternative to the second option in which the AA was used in conjunction with land ambulances. The demand rate for each station during the day shift is shown in Table 8.12 The land ambulance day shift vehicle allocation, utilisation, and number of vehicles pertaining to option one are outlined in table 8.13.

Table 8.13. Vehicle Allocation and Utilisation for Day Shift at Each Ambulance Station

Station	Vehicles on day shift (% utilisation)	Minutes utilisation day shift
Wadebrige	1 (24.63%)	177
Bodmin	3 (23.19%)	199
Camelford		178
Bude		57
Launceston		67

Option Two: Full time AA

This option envisaged the employment of the AA full time and the closure of Wadebridge ambulance station, which at the present time covers only the day shift. This would reduce the land ambulances on call in North Cornwall from four to three during the day shift, and reduce the number of front line ambulances owned and kept by the stations from twelve to ten. The existing state of three land ambulances on call in North Cornwall at night would remain in both options. The land ambulance paramedics displaced by the closure of Wadebridge would be employed on the AA and therefore make no difference to the ambulance personnel levels.

If the AA provides cover for North Cornwall there will be an increase in availability of the land based vehicles. The schematic representation in Chapter Five pages 60 to 68 shows that this could have been achieved by the AA for the whole area while the land ambulances were involved in answering calls. Similarly, the time savings of the AA responding to calls that in option one would have been performed by a land ambulance, gave the land ambulances more time to provide cover. The difference in total journey time of the two modes being the time saved.

Table 8.14 shows the results of using the algorithm explained in the methods chapter on page 113. The average 'total mission time' for the AA operating in North Cornwall would be 61 minutes. This is taking the 'total mission times' indicated in table 8.9, and the proportion of missions per day in North Cornwall as shown in table 8.12. If the aim was for the AA was to respond to five calls per day, the probability is that it would have be able to perform 4.12 missions, due to not being available when certain calls came in. A realistic aim would have been three primary/secondary or tertiary missions in the North Cornwall area, and one mission in the rest of the county.

Table 8.14. Predicted Utilisation & Availability for Different Demand Levels

Potential AA calls per day	No. of calls for which AA available	Minutes per day answering calls	% utilisation	% availability
1	1	61	10.16	89.83
2	1.90	115.8	19.30	80.70
3	2.71	165	27.50	72.50
4	3.43	209.2	34.87	65.13
5	4.67	284.7	47.44	58.50
6	5.19	316.7	52.79	47.21
7	5.66	345.5	57.59	42.41
8	5.68	346	57.74	42.25

If the AA performed this number of calls each day this would easily have covered for the loss of the Wadebridge station but would have an effect on Newquay where the Wadebridge ambulance could have assisted. This would have been offset by the AA being able to perform one call per day in the rest of the county, and also while the AA was not actually flying, it would have been assisting with cover in that area.

Comments on the Effectiveness of Each Option

It was shown in table 8.10 that none of the North Cornwall ambulance stations complied with the ORCON standards. A problem with comparing each option was the quantification of the likely degree of improvement in ORCON standards of option two over option one. The only way to resolve this problem would be a dynamic simulation study of the area. This is not part of this study, but the development of such a model would be a most useful tool in the quantification of the advantages of AA use. The model would need to be dynamic, as outlined in Chapter Five. The most difficult concept to deal with in a static model would be the changing locations of the ambulances on call as they move to maintain cover where other vehicles have responded to emergencies. Below is one iteration of a static simulation to try to aid the intuitive assumption above that option two will improve ORCON.

The proportion of calls from each station for each day, as shown in table 8.12, were given values between nought and one in relation to the percentage of demand from each station. This is shown in table 8.15.

Table 8.15. Demand rate for Calls in North Cornwall

Station	% of calls per day	Proportion for random No.
Bodmin	33.15%	0-0.33
Bude	8.0%	0.34-0.41
Camelford	22.23%	0.42-0.63
Launceston	10.66%	0.64-0.75
Wadebridge	25.03%	0.75-1.0

A random number generator is then used to identify in which ambulance station areas each of the seven calls of any one day originate. The second set of random numbers in table 8.16 generates which three calls are responded to by the AA, remembering that the results of the algorithm in table 8.14 suggested that three calls per day within North Cornwall would be the optimum. As such nought to nought point four three would be an AA call. Nought point four four to one would be a land ambulance call. While only one iteration is shown as an example this process would need to be repeated many times until a steady state was achieved with the results. However, the results would not take account of the dynamics of the system regarding the positioning and availability of ambulances as displayed in Chapter Five, pages 60 to 68. The random numbers that were generated are shown in table 8.16.

Table 8.16. Random Number Simulation: One Iteration.

Location	Mode	Location & Mode
0.274	0.701	Bodmin - land ambulance
0.476	0.649	Camelford - land ambulance
0.705	0.429	Wadebridge - AA
0.962	0.617	Camelford - land ambulance
0.615	0.303	Wadebridge - AA
0.902	0.870	Camelford - land ambulance
0.441	0.318	Launceston - AA

Three calls were generated for the 'sample' day from Camelford, two from Wadebridge, one from Launceston and one from Bodmin and none from Bude. The AA responded to the two calls from Wadebridge and the one call from Launceston. Table 8.17 indicates the time saved by option two with the AA over option one without the AA for the three variable of 'response time', 'time to hospital' and 'total mission time'.

Table 8.17. One Iteration of Option One

Ambulance station area	Lnad ambulance or AA	Response time saved by AA in minutes	Time to hospital saved by AA in minutes	Total mission time saved by AA in minutes
Bodmin	LA			
Camelford	LA			
Wadebridge	AA	4	33	39
Camelford	LA			
Wadebridge	AA	4	33	39
Camelford	LA			
Launceston	AA	10	31	14
		18	97	92

In a more complex analysis another set of decisions would need to be introduced regarding whether the AA was a suitable vehicle for a particular response. The time the AA can save on response time over land ambulances for each ambulance station in North Cornwall is shown in table 8.11. Similarly the time the AA can save over land ambulances in 'time to hospital' and 'total mission time' is shown in table 8.19. With one iteration representing a typical day in North Cornwall as portrayed in table 8.17, it can be seen that the use of the AA saves 18 minutes on response time and 97 minutes on time to hospital. With regard to the three patients involved in these three calls the marginal reduction in response time would only be significant if the patients were suffering from severe trauma or were in acute pain. However, the saving of just over half an hour on each journey to hospital is significant for a much wider spectrum of patients other than trauma patients or patients in severe pain. The time saved reduces anxiety for almost all patients and provides a much more satisfactory journey for patients with back or head injuries or burns. In this instance the AA is effective with a scope to possibly affect avoidable mortality and morbidity.

The reduced mission time of 92 minutes over the day means that during this period more vehicles are on call at any one time to respond to an emergency. When the AA is on call the distance involved within North Cornwall are irrelevant, so all calls answered by the AA will be within the ORCON time. When the AA is involved responding to a call it achieves it quicker than a land ambulance so giving longer periods of the day with all vehicles ready to respond to calls. With the AA providing cover the land vehicles are more likely to be able to respond within the ORCON time. In this context the use of the AA within the ambulance service is effective in enabling the whole system to offer a better response. However there is no way of quantifying this without a full dynamic simulation.

The next chapter looks at land ambulance only provision versus land ambulance and AA provision in terms of equity in North Cornwall. The aim of the last study is to test each option for social efficiency through the use of CBA framework.

Chapter Nine

Results of Study Two: Equity

Introduction

The aim of this chapter was to investigate means of identifying the cost of ambulance service provision at different levels of rurality. This will facilitate discussion of the projected cost of any improvement in geographic equity brought about by AA use, and it will be achieved largely through the use of correlation and regression analysis.

The first step in this process was to investigate the costs of service provision for each ambulance station area. This was necessary because the ultimate aim of the regression investigation was to generate linear regression models explaining geographical variations in costs.

Calculation of Ambulance Station Area Costs

Total costs are achieved by summing the variable and fixed costs for each ambulance station area, each of which is shown in Appendix E3. The personnel costs and the annual ambulance depreciation costs for land ambulance provision at each ambulance station area are shown in Appendix E1. The allocation of fixed or variable costs is somewhat arbitrary because fixed costs include staff and vehicles and the contract cost of the AA. It could be argued that these are quasi fixed costs that could be changed in the medium term. However, here they are treated as fixed costs to differentiate them from the more obviously variable costs such as fuel, oil and tyres.

Having calculated total cost for each ambulance station area, this cost can be converted into a cost per head for each ambulance station area. However, as was discussed in the previous chapter, certain ambulance stations share staff and vehicles. This offers the problem of what proportion of total costs should be allocated to the ambulance station areas that share resources. The ambulance station areas in question are Penzance and Carbis Bay; Looe, Saltash and Torpoint; and Wadebridge, Camelford, Bude, Bodmin and Launceston.

Two alternatives for the allocation of total costs between these stations were considered. The first was to allocate them in relation to the percentage of land mass covered by each ambulance station area. The case for this is that the physical area of each ambulance station dictates the resources needed to provide a service in that area. The second alternative was to allocate total costs in relation to the population of each ambulance station area. The reasoning for this is that demand for the ambulance service should be related to the population served. To give an example, Carbis Bay and Penzance work together and share

Table 9.1. Alternative Allocations of Joint Fixed Costs Between Ambulance Stations Sharing Resources

Ambulance station	Allocation by land area (%)	Allocation by population (%)
Wadebridge	19%	25%
Bodmin	21%	25%
Camelford	19%	13%
Bude	21%	18%
Launceston	20%	19%
	100%	100%
Saltash	51%	55%
Torpoint	10%	22%
Looe	39%	22%
	100%	100%
Penzance	84%	64%
Carbis Bay	16%	36%
	100%	100%

crews and vehicles. Carbis Bay ambulance station covers 6,177 hectares and had a population of 20,985. Penzance covers a land area of 32,974 hectares, with a population of 38,071. If joint fixed costs are allocated by the percentage of population each station serves, the costs would be divided in the ratio of Penzance 64 percent and

Carbis Bay 36 percent. If the joint fixed costs were allocated as a proportion of the land area of each station it would be in the ratio of Penzance 84 percent and Carbis Bay sixteen percent. Table 9.1 shows the percentage allocation of joint fixed costs for each ambulance station area allocated (1) in proportion to land mass, and (2) in proportion to population. This process was undertaken twice, once on the basis of 'land ambulance only' and once assuming 'land ambulance and AA' for those areas in which the AA operated. The costs per head for this are shown in Table 9.2. The bold type indicates the areas in which the AA operates.

Table 9.2. Apportionment of Costs by Area and Population of Each Ambulance Station. (Costs in £s per head of population)

	Land Ambulances		Air Ambulance	
	Area	Population	Area	Population
Camelford	14.66	10.76	**23.02**	**17.55**
Bude	10.26	9.05	**16.8**	**15.85**
Looe	8.39	5.06	8.39	5.06
Wadebridge	7.82	9.72	**12.26**	**16.18**
Liskeard	10.53	10.53	10.53	10.53
Launceston	9.65	9.24	**15.66**	**15.95**
Helston	7.63	7.63	7.63	7.63
Bodmin	8.5	9.85	**13.31**	**16.37**
Truro	5.7	5.7	5.7	5.7
St. Austell	5.07	5.07	5.07	5.07
Saltash	4.62	5.0	4.62	5.0
Redruth	6.12	6.12	6.12	6.12
Newquay	5.06	5.06	5.06	5.06
Carbis Bay	3.72	6.57	3.72	6.57
Falmouth	7.05	7.05	7.05	7.05
Torpoint	2.66	5.06	2.66	5.06
Penzance	7.12	5.55	7.12	5.55

The outcome of this is four dependent variables; Land ambulance costs by area, AA costs by area, land ambulance cost by population and AA costs by population.

Derivation of Independent Variables

The second stage of the analysis was to generate two independent variables related to population distribution which could be used to test the cost of achieving geographic equity.

One possibility considered was the index of sparsity (Chapter Seven) created by Craig (1989). However, this was discarded because although it gave a good visual indication of the gradations of rurality in the county (See Enclosure Map Four), as a rank variable it has limited predictive power in modelling and regression analysis. Also its use was called into question because wards were too large a base unit for this type of analysis and, as a direct result, would therefore introduce too much 'noise' into the investigation.

As an alternative two independent variables were chosen based on EDs rather than wards. The two measures were the population density of each ambulance station area and the population sparsity of each ambulance station area. These are shown on page 119 of the methods chapter, while the values of population density and sparsity are shown in the Table 9.3.

Analysis

Using the four dependent and two independent variables, eight regressions analysis were then conducted, as detailed in Table 9.4.

These indicated that for both 'land ambulance' option and the 'land and AA' option the best explanatory model available was provided by the relationship between sparsity and cost per head in relation to land mass. In both instances sparsity appeared to explain rather more than half the variance of the dependent variable. Because of this, it was decided that the remainder of the analysis should focus on these two relatively strong relationships.

Table 9.3. Population Density and Sparsity Values for Each Ambulance Station

Ambulance Station	Population density (persons/acre)	Sparsity
Camelford	0.41	2.02
Bude	0.52	4.22
Looe	0.81	8.5
Wadebridge	0.75	8.61
Liskeard	0.66	8.98
Launceston	0.55	10.74
Helston	1.0	14.79
Bodmin	0.70	15.78
Truro	1.27	17.08
St. Austell	1.95	18.28
Saltash	1.54	18.4
Redruth	2.23	19.86
Newquay	1.74	22.64
Carbis Bay	3.4	22.13
Falmouth	4.14	30.76
Torpoint	3.01	32.03
Penzance	1.15	33.92

Table 9.4. Result of the Proportion of Variance Explained from Regression Analysis

Independent variable	Dependent variable	Proportion of variance explained
Population density	Land ambulance cost by area	43%
Population density	Land ambulance & AA costs by area	43%
Population density	Land ambulance costs by population	26%
Population density	Land ambulance & AA costs by population	33%
Sparsity	Land ambulance costs by area	**54%**
Sparsity	Land & AA costs by area	**56%**
Sparsity	Land ambulance costs by population	42%
Sparsity	Land ambulance & AA costs by population	45%

Assumptions for the Model

Regression analysis is an important research tool which allows us to measure the strength of a relationship and determine the predictive accuracy of a line. However, before proceeding further it was recognised that it was important to ensure that data for the model did not seriously violate the assumptions of linear regression. This was necessary even though the technique has a robustness in that a few violations of the assumptions will still produce sample results quite close to the population parameters (Dometrius 1992).

A first assumption of regression is that the error term is uncorelated with the independent variable. This assumes the absence of a confounding variable in that the error term is the residual variation in the dependent variable not accounted for by the dependent variable. A second assumption is that the error term has a mean of zero and is normally distributed. To assume that the error term is normally distributed is equivalent to assuming that the dependent variable is normally distributed for every value of the independent variable. A third assumption is that the error term has a constant variance, or that the prediction errors do not get larger or smaller as the value of the independent variable changes.

It can be seen from Figs 9.3 that, considering there are only seventeen data points, sparsity (the independent variable) does not appear to depart substantially from the normal distribution. However, there does appear to be skewness in the dependent variables, the costs for 'land ambulance only' and 'land ambulance and AA' costs. Because it was suspected that models might be affected by skewness, two safe guards were explored. The first was that correlation and regression were repeated with unusual values excluded. When sparsity was regressed with 'land ambulance only' data, this meant removing data for the Penzance and Camelford ambulance station areas. When sparsity was regressed with 'land and AA' data, the Penzance ambulance station area was excluded. Re-running the regressions without these points reduced the proportion of variance explained to 45.7% for the 'land ambulance only' model and to 47.9% for the 'land ambulance and AA' model. Because this exercise reduced the r squared values, but did not change them dramatically, it was assumed that skewness was not seriously influencing the results for the full data set. The second safeguard was that the residuals were tested to identify whether they were significantly correlated with the independent variable in the original models. The outcome to this was that in neither instance did there prove to be any correlation between the residuals and the independent variable (Figs 9.4 and 9.5). In fact the correlations were very low and well below the levels necessary for statistical significance. When sparsity was tested against the residuals for the 'land ambulance only' model the correlation was 0.011. Sparsity correlated with the residuals for the 'land ambulance and AA' model correlated at 0.007. However, when the dependent variable was tested against the residuals a correlation of 0.66 was found with the 'land ambulance only' model and a correlation of 0.55 was found with the 'land ambulance and AA' model. At this point it was assumed that this was due to the skew of the data. This will be returned

Fig. 9.1 Histogram of Land Ambulance Only Cost per Head

Midpoint	Count	
3	1	*
4	1	*
5	3	***
6	2	**
7	2	**
8	3	***
9	1	*
10	2	**
11	1	*
12	0	
13	0	
14	0	
15	1	*

Fig. 9.2. Histogram of Land Ambulance & AA Cost per Head

Midpoint	Count	
2	1	*
4	2	**
6	4	****
8	4	****
10	1	*
12	1	*
14	1	*
16	2	**
18	0	
20	0	
22	0	
24	1	*

Fig 9.3 Histogram of Sparsity

Midpoint	Count	
0	1	*
5	1	*
10	4	****
15	3	***
20	3	***
25	2	**
30	2	**
35	1	*

Fig 9.4 Land Ambulance Only
Independent Against Residuals

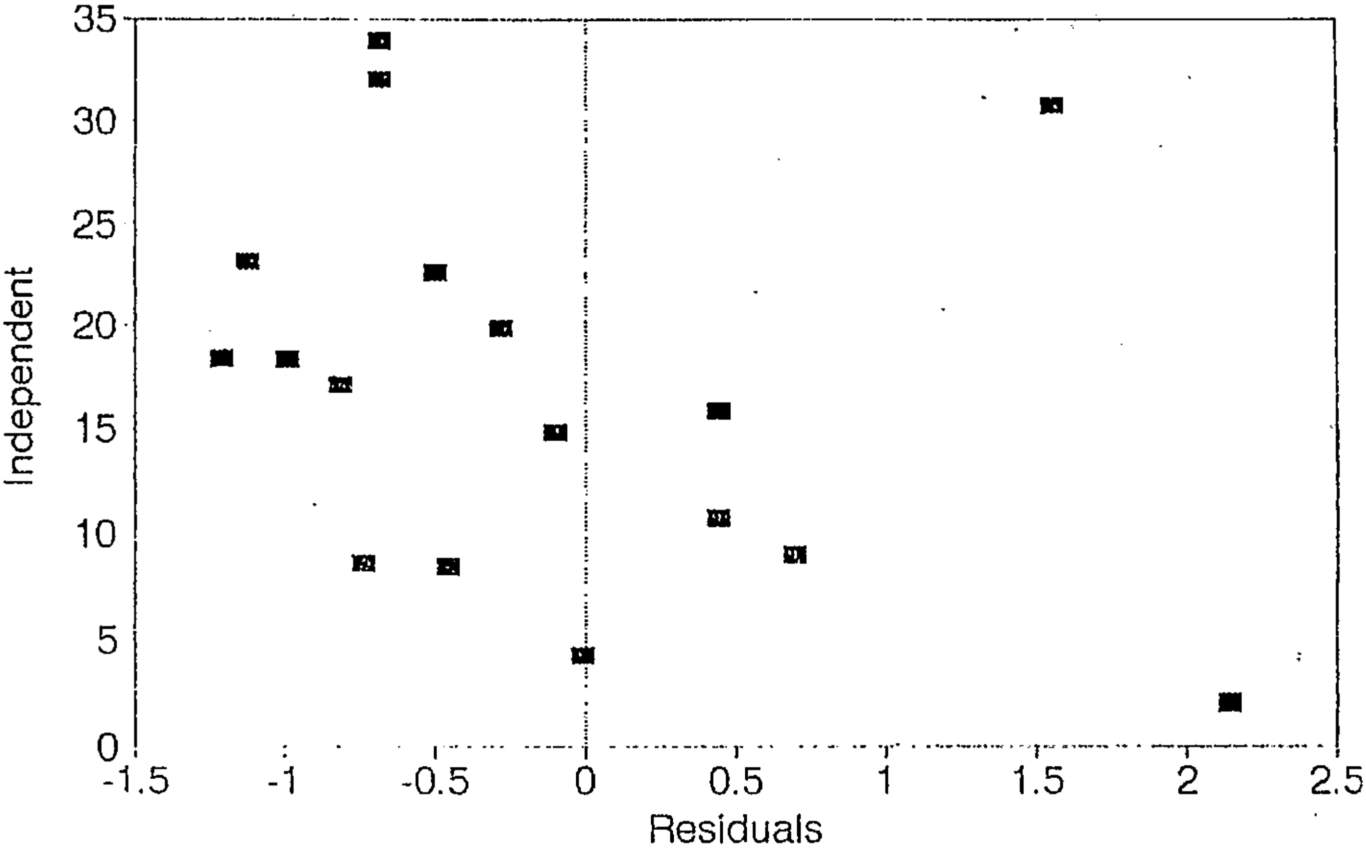
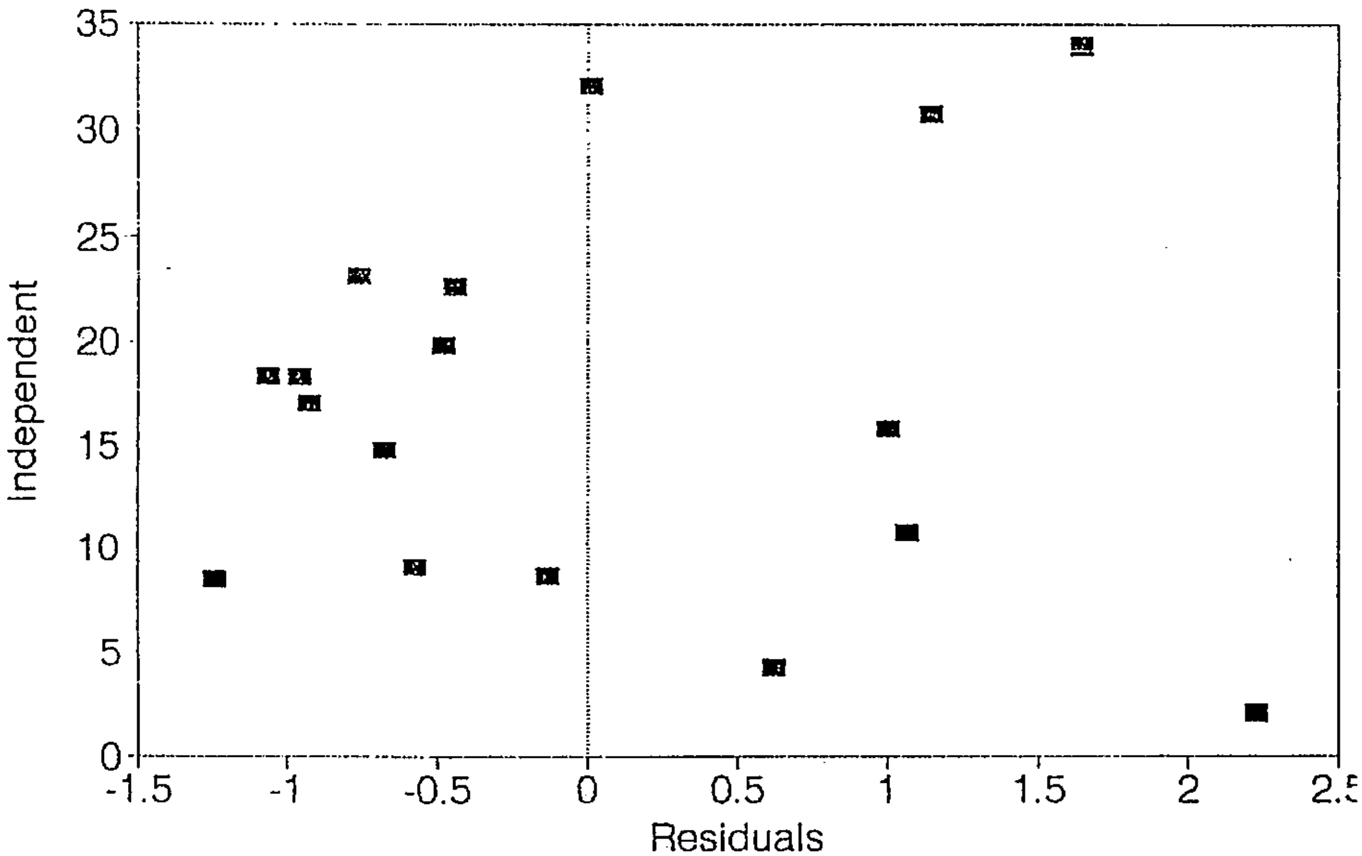


Fig 9.5 Land Ambulance & AA
Independent Against Residuals



to at a later point in the analysis.

These results indicated that there was little evidence that any violations of the assumptions of regression were serious. On this basis therefore, it was considered appropriate to analyse in greater detail the two models selected above.

Regression of Sparsity and Shared Ambulance Station Costs by Area

The details of the two regression analysis are reproduced in Appendix E4 and E5, while Figures 9.6 and 9.7 present graphical plots for both models. Figure 9.8, finally superimposes the regression lines for the two models to facilitate their comparison.

Fig. 9.6. Plot of 'Land Ambulance Only' with Sparsity

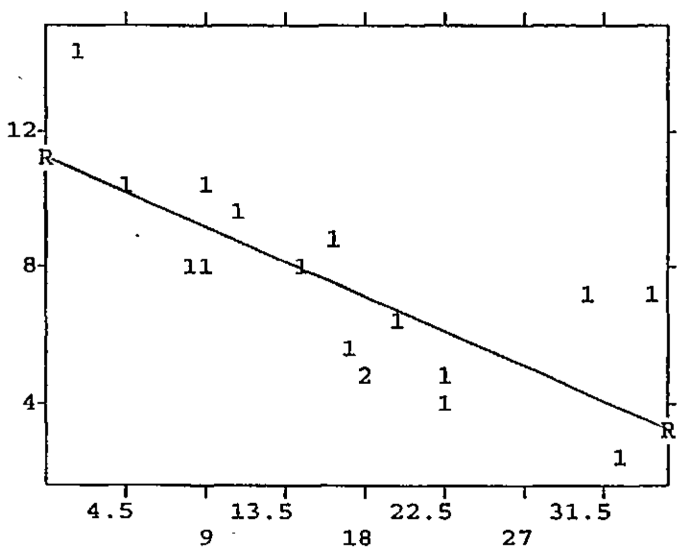
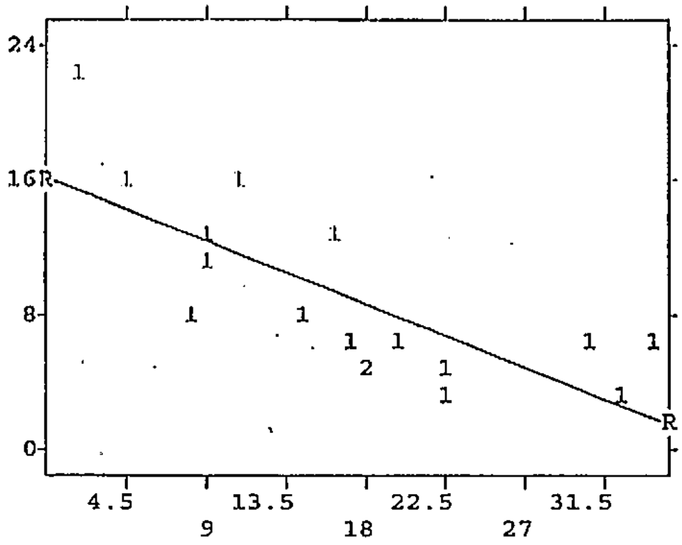


Figure 9.7. Plot of 'Land Ambulance with AA' by Sparsity



Results of Regression Analysis

As previously stated 54.2 percent of the variance in the dependent variable appears to be explained by the independent variable in the 'land ambulance only' model. For the 'land ambulance and AA' model the equivalent figure is 55.6 percent. The correlation coefficients plot of both regression lines associated with these figures are 0.74 percent and 0.68 and with fifteen degrees of freedom the t values are -4.21 and -4.33. Using two tailed testing, these results indicate with better than 99 percent certainty that the relationships identified are reliable. There is strong evidence that sparsity explains rather more than half the cost of providing the front line ambulance service in both models.

Interpretation of Results

Figures 9.6 to 9.8 clearly indicate that additional costs accrue from the use of the AA as population sparsity becomes an increasing feature of the areas in which it operates. This is particularly true in districts where the sparsity index is less than twenty. However, interpretation of the graphical summaries shown in Figs. 9.6 to 9.8 can be more effectively

Figure 9.8 Plot of Regression Analysis Sparsity v Cost per Head.

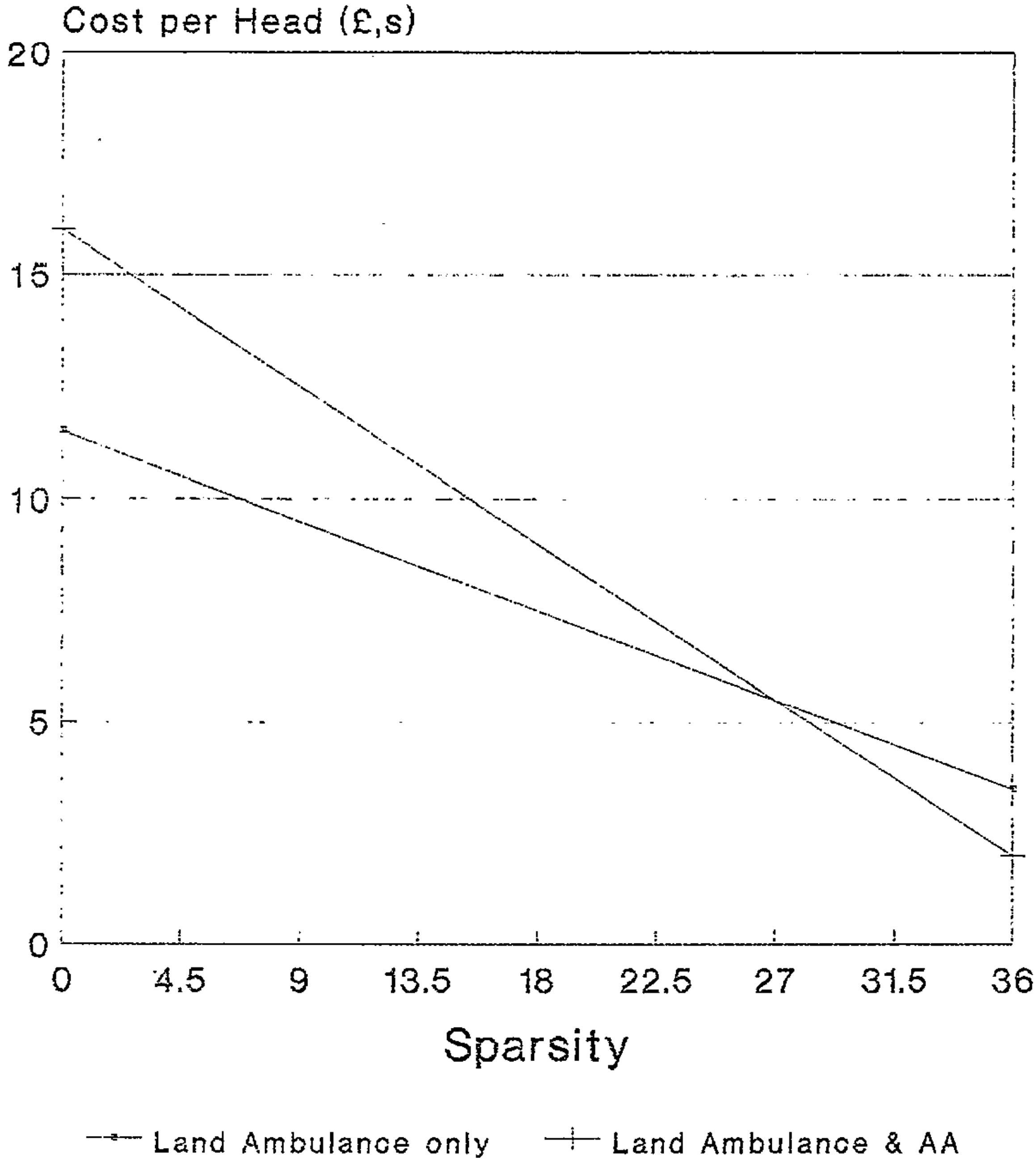


Table 9.5 Fitted Values for Land Ambulance Only and Land Ambulance With AA

Sparsity	Cost in £s per head		Absolute difference (£)	% Difference
	Land Ambulance Only	Land Ambulance with AA	Increased cost with AA	Increased % cost with AA
5	10.08	14.32	+4.24	+42.1
10	8.94	12.15	+3.21	+26.4
15	7.94	9.99	+2.05	+20.52
20	6.65	7.82	+1.17	+14.96
25	5.51	5.66	+0.15	+2.65
30	4.36	3.49	-0.87	-19.95
35	3.22	1.32	-1.92	-59.01

achieved if the regression equations are solved in two complementary ways. The first method is to show more precisely the manner in which per capita costs rise as sparsity becomes more marked, as shown in Table 9.5. Here the fitted values reveal how the two costs are very similar around a sparsity value of 20, but the AA costs rises to plus 42 percent as the sparsity value falls to five. Secondly, this abstract analysis can be related to the real world of Cornwall by showing what it means for areas on the ground. This is shown in Table 9.6, which focuses on the ambulance station areas where the AA is actually used. These results suggest that, in the Bodmin area, where the population sparsity problem is least, the use of the AA adds approximately two pounds per capita costs each year. This is an increase of 21 percent. In the very sparsely populated area of Camelford, meanwhile, the premium rises to almost five pounds per head (+31%).

Table 9.6 Predicted Values for land Ambulance Only & Land Ambulance with AA.

Ambulance Station	Spar-sity	Predicted Costs Per Head			
		Land ambulance only	Land Ambulance & AA	Absolute diff	% diff
Camelford	2.02	10.76	15.63	4.87	+31.16
Bude	4.22	10.26	14.67	4.41	+30.06
Wadebridge	8.61	9.25	12.77	4.01	+27.56
Launceston	10.74	8.76	11.85	3.09	+26.07
Bodmin	15.78	7.61	9.67	2.06	+21.30

Criticism of the Model

At this point it must be recognised that, as an exploratory aid the sparsity model works quite well in explaining over 55 percent of the variance with one variable. However, more work is needed to order to explore other factors controlling the remaining variance. This is underlined by Figures 9.9 and 9.10 which plots the dependent variable (costs per head) against the residuals generated by the 'land ambulance' and 'land ambulance with AA' models. In both these plots, a clear tendency towards a

Fig 9.9 Land Ambulance Only

Dependent Against Residuals

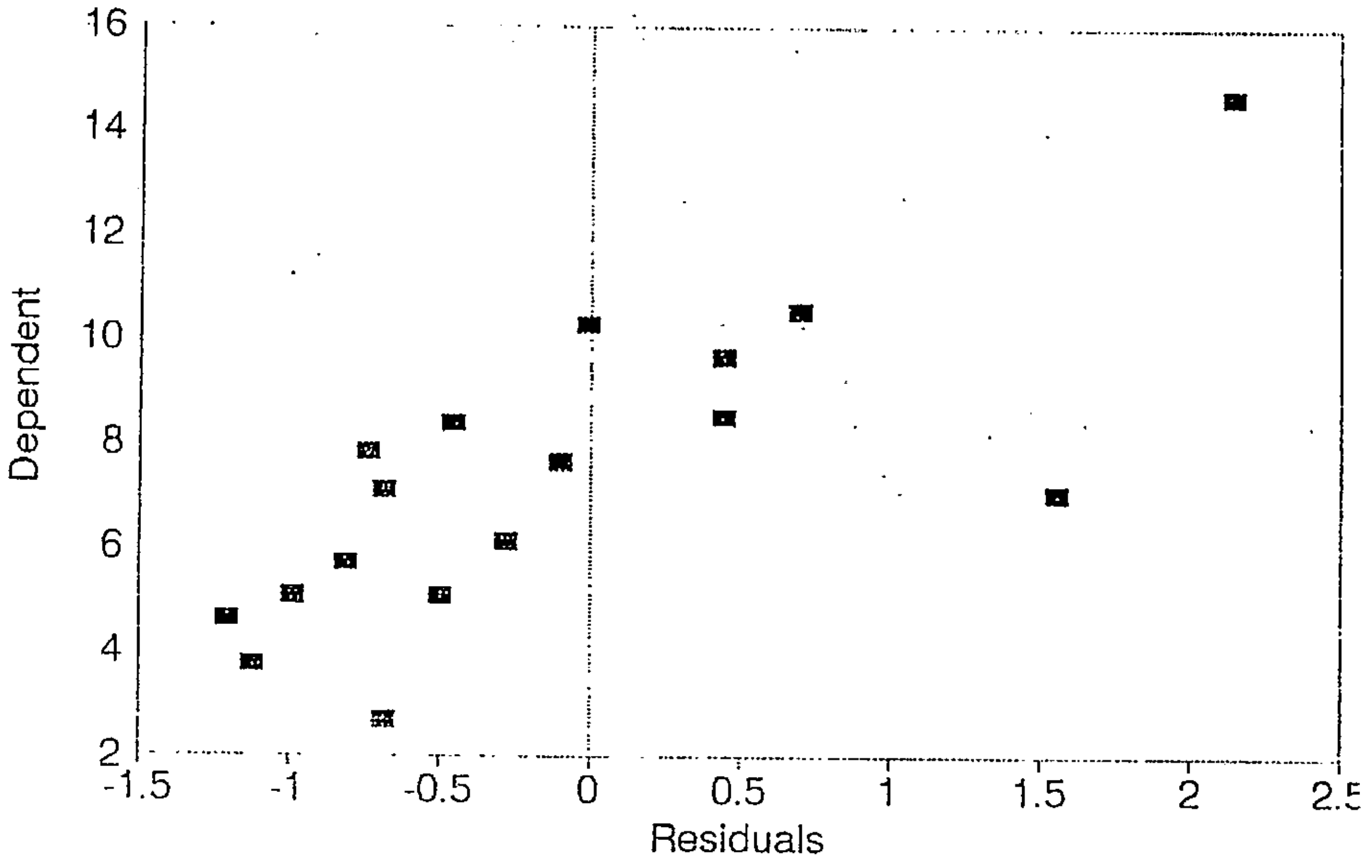
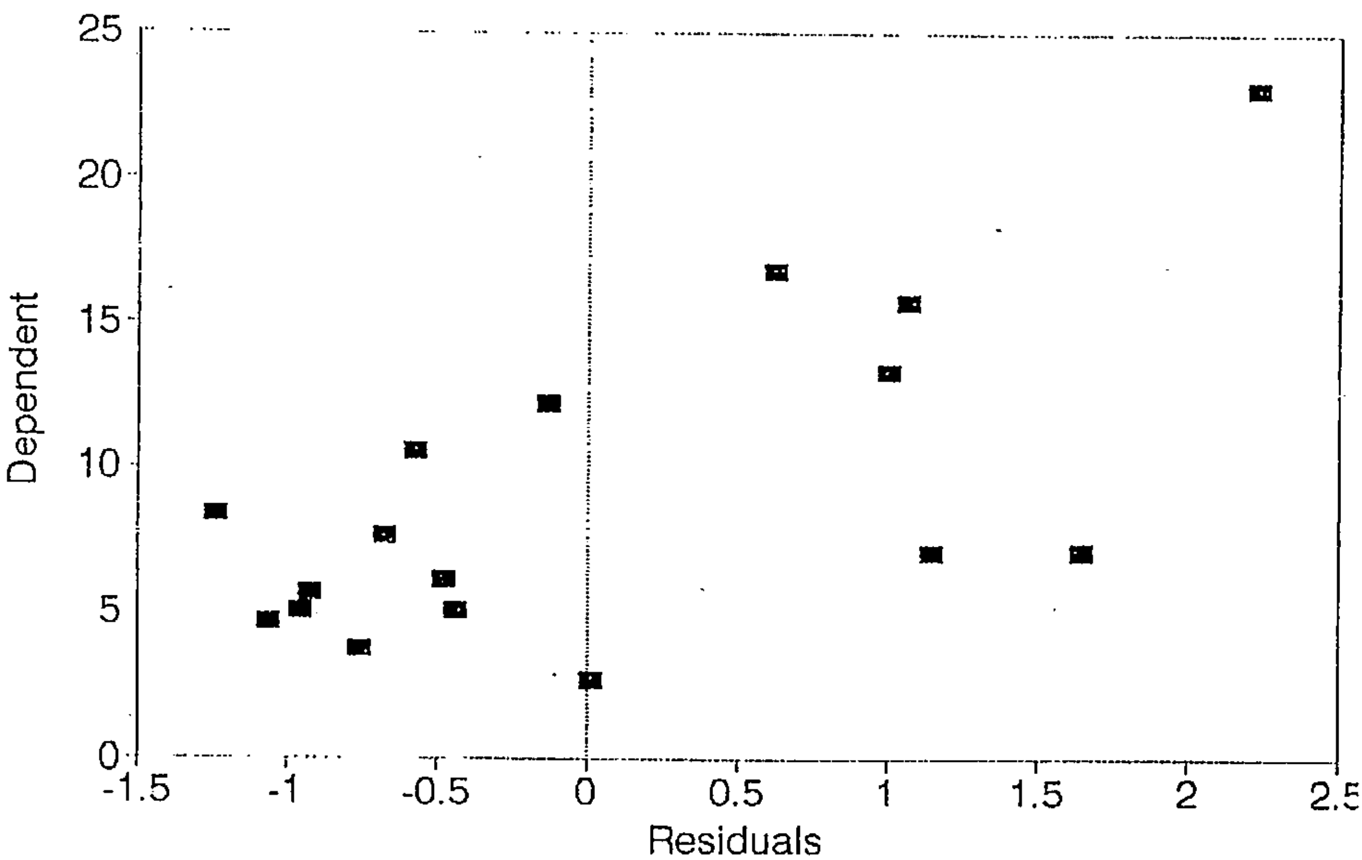


Fig 9.10 Land Ambulance & AA

Dependent Against Residuals



linear relationship is evident, and is borne out by correlation coefficients of 0.669 an 0.661. With linearity such as this between the dependent variant and the residuals, at least one term other than sparsity is likely to be involved in the definition of costs. This in turn suggests that further analysis could usefully employ multiple regression techniques. If this were done, a wide range of other variables identified elsewhere in this study could be considered in the analysis. These include the absolute size of each ambulance station area, as well as 'response time' and 'total mission time', as discussed in Chapter Eight. Similarly, attention might usefully focus on the number of backup vehicles kept at the smaller ambulance stations, and of the geographical locations of these stations. So far the number of vehicles is concerned, an important point to consider is whether small stations are costly because, relative to their larger counterparts, stand-by vehicles account for a larger proportion of the fleet available locally. With respect to the question of location, it must be recognised that the current pattern reflects numerous past decisions, and therefore does not necessarily represent the optimum pattern so far as cost minimisation is concerned. Ideally, a station that is poorly located, relative to its area, could incur substantial additional costs because of suboptimality.

Equity and the Model

Although it is capable of refinement, the model did show the increased gradient in the cost of service when the AA was used to bring up the standard of response for the rural areas. This clearly underlines that for geographic horizontal equity (equal treatment of equals) in terms of response times, and 'time to hospital' a vertical equity policy of funding needs to be applied. In other words unequal treatment is appropriate in the form of higher funding for those in areas of greater sparsity. The aim of reconciling equal access to the emergency services, has led to a requirement for a method that will effectively relate inputs for access. For the methodology a system is required that will define and measure the characteristics of a region so that the benefits derived from a volume of inputs or expenditure can be graded in line with the barriers to access. The method of sparsity developed in this model can fulfil this need at different geographic territorial levels from enumeration districts through to wards, to the county and regional levels.

Conclusion

While accepting that equity has many goals, not all reconcilable with each other, Figure 9.8 indicates the reality of the different funding needed to produce geographic equality of access to the emergency care system. The 'without AA' line of costs for each level of sparsity showed an increase in unit cost in line with increasingly difficult levels of access. However, the 'without AA' option, fails to meet response standards in the most sparsely populated regions. The technical innovation of the AA helps to a large extent to overcome the access problems of the very rural areas, but as the models presented in this chapter have indicated, there is a price to pay. In the areas in which it was at the time of the investigation, the price ranged from in the areas that it was used the percentage increase in costs ranged from 21.3 percent to 31.16 percent, relative to the use of land ambulances alone.

It could be argued that people make a conscious choice of where they live, and as such should bear the consequences in the level of service they receive in relation to the cost of providing a service at the geographic periphery. However, this argument is the same false accounting as saying that individuals should be responsible for their own health care. The service would then work in favour of those with greatest income, due to their greater ability to make choices about healthcare. In those circumstances the principle of equity would not be maintained. The use of sparsity levels as explored in this study is a good basis on which to measure geographic need in terms of the front line ambulance service.

This chapter has shown that to achieve equity of access to the A&E service, the service must receive differential funding in terms of a greater cost per head in rural areas, this could conflict with the utilitarian point of view. Utilitarians would argue that resources should be used to achieve the greatest access to the largest number of people. As the majority of people live in urban areas the utilitarian approach would see it as unreasonable to provide higher funding for a minority of people. However, this argument could be refuted if the improved equity achieved through greater funding in rural areas could also be shown to be efficient. Whether this is possible is the concern of the next chapter.

Chapter Ten

Results of Study Three: Efficiency

Introduction

This chapter looks at the results of the efficiency of AA use in rural areas by reviewing the two options of land ambulances only in North Cornwall, and the full time employment of the AA in the North Cornwall area during daylight hours. The format for identifying the costs and benefits was in the following defined areas:-

Public Sector Costs

Costs associated with the ambulance service.

Hospital costs.

Primary care costs.

Costs that fall on other public sector bodies such as Social Services.

Costs to Families and Society

Direct costs of illness to families.

Costs attributable to loss of productive activity.

Costs attributable to pain, suffering and death.

Ambulance Service Costs

In option two the AA would have performed 1460 journeys per year (4 per day) with 35 minutes actual flying time per call. At between 120 and 140 mph the difference in flying time per mission in any part of North Cornwall was not very great and analysis of the data suggested that thirty five minutes was the mean flying time per call in that area.

An assumption was made that the AA would have responded to calls in the same proportion as they occur for each station for land ambulances. In fact the aim was to try to use the AA for the more distant journeys, but in order to get the utilisation required, the long run would probably have approximated to the proportion from each station. The proportions and numbers of calls for each option are set out in the Table 10.1 below.

Table 10.1. Proportions and Numbers of Missions to each Ambulance Area in North Cornwall for Option Two

	No. of calls	% of Calls
Bodmin	467	32%
Bude	132	9%
Launcseton	204	14%
Camelford	307	21%
Wadebridge	350	24%

The main structural change to the ambulance service in North Cornwall at the introduction of the AA was the closure of the Wadebridge ambulance station. The station was only operational during the day shift, and the increased cover given by the AA working full time in the area during the day shift would have made the station and the two ambulances stationed there redundant. The sale of Wadebridge ambulance station should have realised £50,000 for the site, either as a building site or a light industrial unit. In a more favourable economic climate the opportunity cost of this site might well be higher. It was equally likely that the continuing recession might have pushed the value even lower. The release of two ambulances would have raised a further £1000. The sale of the ambulance station and the two redundant ambulances were one off transactions but would have affected the joint costs of running the North Cornwall ambulance stations.

Of the seventeen ambulance stations in the county the North Cornwall area operated five, namely Bodmin, Wadebridge, Camelford, Launceston and Bude. The data available for ambulance service expenditure for running the ambulance stations was aggregated between the seventeen stations. In the North Cornwall it would seem reasonable to take five seventeenths of this budget as representative of the five stations of the area, and four sixteenths for the option two, in which the Wadebridge station was not included. Although the area had a similar mixture of large and small stations to the rest of the county, it was noted that size made little difference to the running costs such as electricity and telephone charges. The ambulance service expenditure had been extracted from District Finance Department, (1990) and appears in Table 10.2.

Table 10.2. Expenditure for Cornwall Ambulance Service 1989/90

Item	Cost
Administration	£93,378
Control services	£308,489
HQ officers	£67,155
Control officers	£215,882
Control assistants	£106,860
Training & staff officers	£45,000
Fleet manager	£14,500
TOTAL EXPENDITURE	£851,264

This total expenditure divided between seventeen stations gave a figure of £50,074 per station, and divided between sixteen stations would be £53,204 per station. The costs each option were as follows:

Option One

Expenditure for North Cornwall = £50,074 * 5 = £250,370

Option Two

Expenditure for North Cornwall = £53,204 * 4 = £212,816

Staffing

The largest single cost to the ambulance service was that of its staff. There was surprisingly very little difference in staffing levels for the two options.

The headquarters and central control staff would not have been altered by either of the options. The relevant grades of staff involved were leading ambulance persons, qualified ambulance persons, and ambulance persons. Leading ambulance persons acted as line managers for an ambulance station, or group of ambulance stations.

Qualified ambulance persons had completed their A&E training (but not necessarily paramedic training) and had spent at least 12 months on the front line. Both leading and qualified ambulance persons may have had full or partial paramedic status depending on how many of the modular units of the paramedic course they had taken. Ambulance persons had come from the second tier and had taken their exams but not spent 12 months on the front line. The staff numbers required for each grade for each scenario are shown in the Table 10.3.

Table 10.3. First & Second Option North Cornwall Ambulance Area Staffing

	Leading ambulance person	Qualified ambulance person	ambulance person	Total
Bodmin/Wadebridge	0	17	2	19
Camelford	1	8	0	9
Launceston/Bude	1	12	3	16
Total	2	37	5	44

The second option staffing level remains the same as for option one as the staff displaced from the Wadebridge station would have crewed the AA.

The relevant salary scales and costs of employment are:-

Leading ambulance persons £13,735 +17.5% cost of employment £16,070

Qualified ambulance persons £12,729 +17.5% cost of employment costs £14,892

Ambulance person £ 6,982 +17.5% cost of employment £8,169

The total staff costs which are the same for each option are indicated below.

Table 10.4. Staff Costs of Both Options

	Number	Cost
Leading ambulance persons	2	£32,140
Qualified ambulance persons	37	£551,004
Ambulance persons	5	£40,845
Total	44	£623,989

Vehicles

The introduction of the AA has had the following effects on the number of ambulances in each option

Table 10.5. Ambulances Per Station in North Cornwall For Each Option

Station	Option 1	Options 2
Bodmin	2	2
Wadebridge	2	0
Camelford	2	2
Launceston	2	2
Bude	4	4
TOTAL	12	10

The purchase price of a fully fitted and equipped ambulance was between £20,000 and £30,000. This price could have varied depending on such factors as make of vehicle. The interior lay out of the vehicle, and discounts for bulk purchase. The National Audit Office (1990) recommended a seven year life span, therefore using an accounting convention of a 7 year straight line depreciation vehicles were depreciated at £2,857 p.a. per vehicle.

The mileage covered by each ambulance was governed by the number of calls performed by the AA. The miles generated in each option are indicated in the Tables 10.6, and 10.7. The mileage from each station was taken from a central point in each ambulance area and represented a return journey to the nearest DGH for each station.

A factor of ten per cent was added to account for the ambulance movement from its 'on call' position to the scene of the accident or incident, and to allow for another ambulance to move to cover the area left unprotected while a patient was transported to hospital. The mileage was worked out in relation to the proportion of calls arising in each ambulance area.

In order to calculate the second option mileage the number of journeys performed by the AA over a year were subtracted from each ambulance area, again in proportion to the rate in which calls arose in each ambulance area.

Table 10.6. Option One. Annual Ambulance Mileage for North Cornwall

Ambulance station	Cases per year	DGH return journey (miles)	Annual mileage	Annual mileage adjusted for response
Bodmin	1533	52	79,716	87,687
Bude	423	100	42,300	46,530
Camelford	996	80	79,680	87,648
Launceston	661	60	39,660	43,626
Wadebridge	1150	54	62,100	68,310
		Total Annual mileage		333,801

Fuel costs for the ambulances were 9.93 pence per mile (District Finance Department, 1990) while repairs, spares, and tyres cost £1875 p.a. per vehicle for option one mileage. (Calculated from District Finance Department, 1990 data). This figure was adjusted accordingly for the second option. The total costs for the land ambulances appear in Table 10.8

Table 10.7. Option Two. Annual Ambulance Mileage for North Cornwall

Ambulance station	Cases per year	DGH return journey (miles)	Annual mileage	Annual mileage adjusted for response
Bodmin	1066	52	55,432	60,975
Bude	291	100	29,100	32,010
Camelford	689	80	55,120	60,632
Launceston	457	60	27,420	30,162
Wadebridge	800	54	43,200	47,520
		Total Annual mileage		231,299

Table 10.8. Land Ambulance Costs

Option	Number of vehicles (land)	fuel	depreci-ation	oil, tyres, repairs	total
1	12	£33,146	£34,284	£22,500	£89,930
2	10	£21,510	£28,570	£12,180	£62,260

AA

Against the reduced land ambulance costs for option two the costs of the AA were added. Standing charges for the AA at this time were £20,544 per month, with a flying cost per hour of £275. This gave the following costs per annum for the AA:-

Standing charges = 12 @ £20,544 = £246,528

Flying hours = 852 @ £275 hr = £234,300

Total costs = £480,828

Table 10.9. Sensitivity Analysis (costs in thousands of pounds) of Two Options of Ambulance Service Costs

	%+-		low	high
Option 1				
Ambulance service costs	10	-964.29	-867.86	-1060.71
Option 2				
Asset sales	10	51.0	45.9	56.1
Ambulance service costs	10	-1379.9	-1241.91	-1517.89
Annual cost difference				
year 1		-364.61	-328.15	-401.08
Subsequent years		-415.61	-374.05	-457.18

A sensitivity figure of ten percent was used and the assets' sales for the first year of operation of the AA were ignored. The cost to the ambulance service of option two, with the AA, cost the service between £374,000 and £416,000 more than option one, without the AA. The changes in other sectors will now be explored.

Hospital Costs

Other changes in NHS resource needs for each scenario were hospital costs. There were 4,763 patients transported to hospital from North Cornwall, 2,620 were emergency cases while 2,143 were urgent cases. With emergency cases at 2.29 bed days per patient the total bed days for emergencies was 6,000 p.a. Urgent cases had 5.42 bed days per patient for 2,620 patients resulting in 14,200 bed days per annum. The bed days per annum from North Cornwall total 8,620 for option one. (Source, Information unit Derriford).

The 1989 total patient cost per day for all treatments was £200 including hotel costs, and a visit to an outpatients' department post discharge. This was taken as a reasonable figure even though it will hide great variation between the different consultant episodes involved. The number of cases over the year would have made this figure quite relevant.

The German experience of AAs indicated that in life threatening cases, the speedy use of the AA reduced hospitalisation by three days. Ten percent of AA missions in Cornwall were regarded as life threatening and therefore might have reduced hospitalisation by three days. Assuming a saving of three days hospitalisation per life threatening case carried by the AA, it would have meant that option two would have saved 441 bed days. Assuming that the AA was accurately placed with the most needy cases, this would have given reduced totals for option two of 8,179 bed days. The total hospital costs per day for bed and breakfast and all treatment is £200 per day. The total hospital costs for each option were calculated (and are presented as follows).

Table 10.10. Hospital Costs for Each Option

Scenario	Annual bed days	Cost per day	Total
One	8,620	£200	£1,724,000
Two	8,179	£200	£1,635,800

The use of these costing conventions and the assumptions from Biege 1989 on the saving of bed days means that the use of the AA would save up to £89,000 per annum.

Primary Care and Social Services'Costs

It was very difficult to make accurate assumptions regarding the costs involved treating patients after hospital. Three GP practices were approached and agreed to check back through twelve months data on patients released from hospital. While it was very difficult to make generalisations regarding the different conditions, outcomes and age of the patients a consensus view of the GPs decided that over all cases post hospital would involve:-

a. One home visit from a GP in 50% of cases.

b. One visit to a GPs surgery for all cases.

c. One visit from a District Nurse for all cases.

d. A visit from a social worker in 10% of cases.

Estimates such as one visit for a district nurse from each case reflected that while many patients would not have a visit, other patients would have had several. It was decided that these costs would not have significantly altered for either of the two options outlined. While it could have been argued that the AA could have saved three days hospitalisation, the probability was that once released from hospital they would still have sought the same level of care from the primary services. However, the costs were indicated here to give an indication of the scale of costs in this area so that the scale difference in option one and option two costs for the ambulance service could be seen in the light of all the other costs which it might have affected.

GP's time is valued at £85.50 per hour (BMA 1993). This for a surgery consultation was equivalent to £8.50, and for a twenty minute home visit was equivalent to £28.6. There was also prescription charges, which for Cornwall amounted to £75.7 per person per annum. (Prescription Pricing Authority 1993)

Costs of social workers and district nurses have been calculated by taking a basic grade salary of £17,000 per annum, and adding twenty eight percent for the costs of employment, relief and national insurance. This gave an hourly rate of £11 plus £1 travelling costs, so each visit of a social worker and/or a district nurse of an hours duration would have equalled £12. The costs involved for each of the above are shown in Table 10.11.

Table 10.11. Primary Care and Social Services' Costs

Cost per visit	Number of visits	Cost
GP home visit	2,381	£68,097
Prescriptions		£66,682
GP surgery	4,763	£40,866
District nurse	4,763	£57,156
Social worker	476	£5,712
TOTAL		£238,513

Costs to Families and Society

Direct Costs of Illness to Families.

It was indicated by the GPs that the average time off work was one month. This covered a range of a few days to over twelve months. In this analysis the average earnings for the county were used. The Department of Employment 1993 (New Earnings Survey 1989 to 1992) gave the mean weekly earnings in Cornwall during 1989 as £187.30

Table 10.12. Loss of Earnings for Patients for Each Option Per Annum

Option	Weeks off work	Cost
One	8,029	£1,503,831
Two	7,968	£1,492,406

The mileage for relatives to visit patients was taken as the same as the ambulance round trip, and worked out in the proportion of calls to each of the five stations. An assumption was made that one car will visit each patient once per day as public transport from any of these areas to the DGHs was virtually non-existent. It did not matter if the car was a taxi or a privately owned vehicle, the opportunity cost to society of the resources used was the same. The ratio of emergency to urgent cases was 55 per cent to 45 per cent respectively. The mean stay in hospital for all urgent cases was 5.42 days. The mean hospital stay for emergency patients in hospital was 2.29 days. (Source- Derriford Hospital Information Unit) This figure enabled estimates of relevant mileage for relatives and total days in hospital. However, the mean figure of stay hid the fact that approximately 70 percent of cases were sent home after treatment in the A&E department. Twenty percent of patients would have been kept in overnight for observation, while ten per cent of patients would have had life threatening conditions and would have remained in hospital for much longer periods.

Table 10.13. Option One.Urgent Medical Cases, Miles Covered by Relatives Visiting

	No. cases	Return journey to hospital	All case 1 day	All cases 5.42 days
Bodmin	689	52	35828	194187
Bude	190	100	19000	102980
Camelford	448	80	35856	194339
Launceston	297	60	17847	96730
Wadebridge	517	54	27945	151461
	Miles per annum to visit			739,697

In option one, the total mileage generated visiting patients in the DGHs from the North Cornwall area was 1,122,239 miles. As relatives drove their own cars the rate per mile needed only cover the marginal cost of the journey in petrol, oil and wear and tear. A rate of 25 pence per mile was used to give an annual cost of £297,131.

Table 10.14. Option One. Emergency Medical Cases, Miles Covered by Relatives Visiting

	Cases p.a.	Return journey to hospital	Annual mileage @ mean hospital stay 2.29 days
Bodmin	844	52	100503
Bude	233	100	53357
Camelford	548	80	100393
Launceston	364	60	50013
Wadebridge	633	54	78276
		Total annual mileage	382,542

The second option assumed the saving in bed days indicated earlier. The table below indicates the reduced number of miles covered by visiting relatives.

Table 10.15. Option Two. Miles Saved by Relatives Visiting Patients

	Return journey (miles)	Option 2
Bodmin	52	7332
Bude	100	3900
Launceston	60	4800
Camelford	60	5580
Wadebridge	54	5832
	Total	27,444

Total mileage for visiting patients for the second option was 1,094,795. At 25 pence per mile the cost of relatives' travel for the second option was £273,698.

Table 10.16. Costs to Family and Society

	Option 1	Option 2
Loss of earnings	£1,503,831	£1,492,406
Cost of visiting	£297,131	£273,698
TOTAL	£1,800,962	£1,218,708

The difference between the costed items for family and society were that option two reduced costs by £582,254.

Benefits Outside the Ambulance Service

The above table shows that the increased costs operating the AA is £415,610 per annum. All this cost is met by fund raising from the local community. It costs the ambulance service virtually nothing and hospital sector, and the Health Service overall make a gain of £88,200. This perhaps partly explains the reluctance of the Department of Health over directly funding AAs.

Table 10.17. Savings in Other Areas For the Second Option [in thousands of pounds]

	Option 1	Option 2	Effect of Option 2
Ambulance costs	0	+415.61	+415.61
Hospital costs	1724	1635.8	-88.2
Primary Care & Social Services	238.51	238.51	
Family and society 's costs	1800.96	1218.71	-582.25
		Saving	254.84

The people of Cornwall contribute voluntarily over £416,000 per annum to support the AA. They are also contribute to national taxation for the basic ambulance service. However, the calculation from Table 10.17 suggests the gain to society from supporting the AA is £582,250 per annum. This raises two interesting conceptual issues regarding willingness to pay. The first issue is that the community have been willing to fund the AA for its perceived benefits, but is this an informed choice, or the result of a good media campaign? The second issue is that charitable contributions within a community are finite. The excellent funding given to the AA is, to a large extent, at the expense of other charities in the county. The hardest hit charity has been the Royal National Lifeboat Institution, which was the county's 'favourite' charity before the AA. What is the opportunity cost of the charitable donations in terms of potential lives saved or lost? These points are returned to in the next chapter under further research.

Benefits Difficult to Value

The benefits of the AA to the ambulance service are easy to list but difficult to value. The attainment of the ORCON standards in the extreme rural areas were almost certainly achieved at less cost than if conventional land ambulances had been used, even if the ambulance service had to fund the AA. Other benefits that accrue to the ambulance service with AA use were its availability to help in a disaster, and the increased motivation of the paramedics.

The Hospital System

The benefits to the hospital system of reduced bed days had been noted in the analysis. A more refined analysis of the effect on the hospital system would have had to take into account at each speciality, the amount of spare capacity that existed. If there was capacity in the system then the only saving would be the marginal cost of the next patient. If however the system was running at full capacity the reduction in hospital days might have prevented the need for investment to increase capacity. A problem of this type of evaluation is the identification of the marginal costs, and the apportionment of joint costs. The distinction of any benefits would be affected by the contractual arrangement in place.

Primary Care

The benefits to the GP of the AA system stemmed from being more able to plan the transfer to hospital of urgent cases, particularly in the more rural areas. The use of the AA either to undertake a transfer, or to provide cover while a land ambulance undertook a transfer meant that it was much less likely that the vehicle about to attend an urgent case was transferred to an emergency call. While emergency calls by law took priority, they are often trivial in nature, whereas urgent calls are often heart attack victims which a GP is trying to get into intensive care.

Family and Society

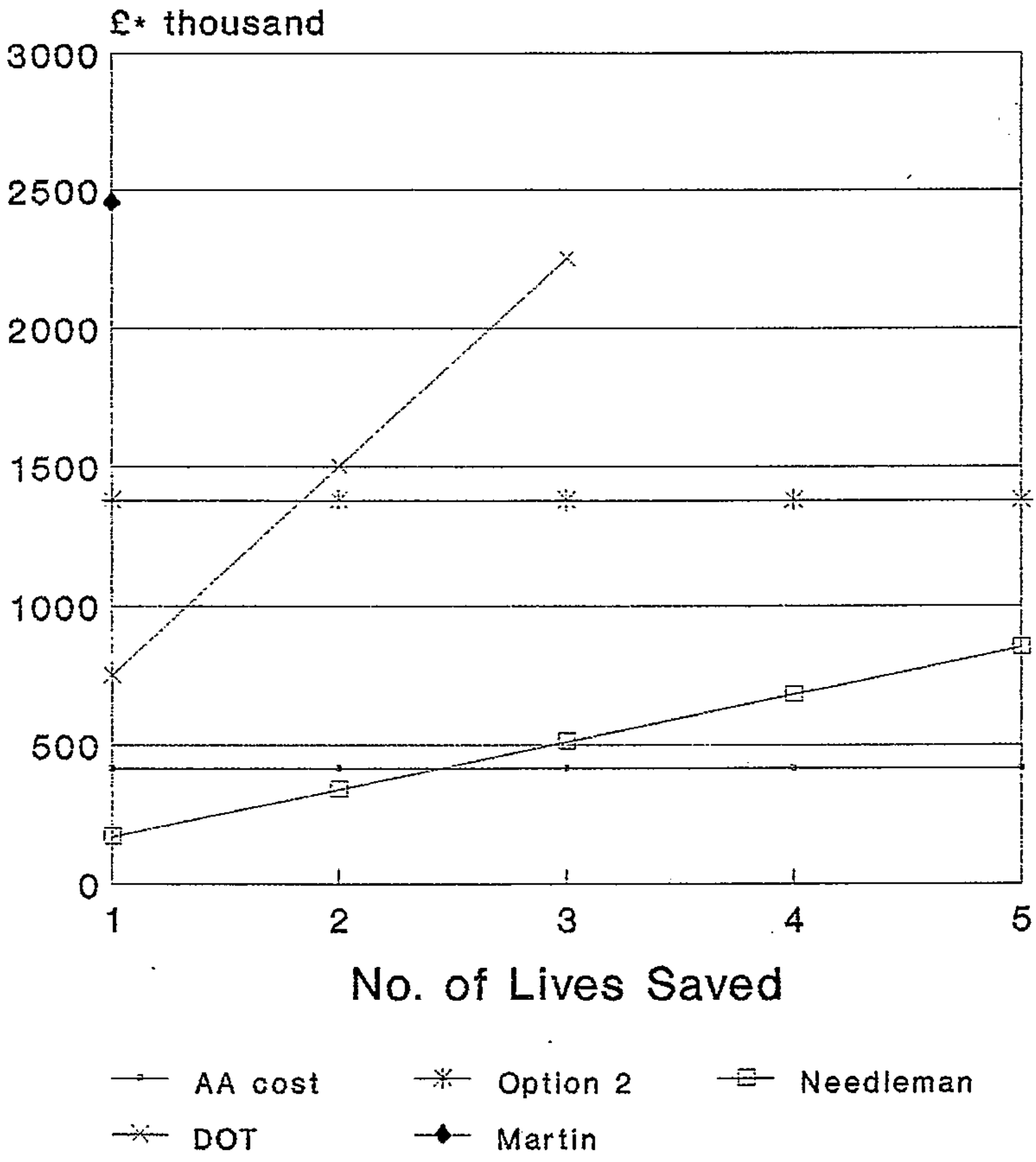
Benefits which accrue to relatives and friends in reduced travelling have been costed. However, the reduced anxiety to relatives and friends cannot be ignored, even if it cannot be costed in this study. The anxiety of waiting for an ambulance when a loved one is ill or injured is very real, and the ability of the AA to reduce this time and worry is significant. This stems not just from its use at the time of a response, but also that local people know that the AA exists which gives a large, perhaps false, measure of reassurance to the rural community it serves.

The relief of pain and discomfort achieved by the AA because of the quicker response to emergencies, faster journeys to hospital and a smoother ride cannot be ignored, particularly for major trauma, back injuries and burns.

While the increased cost of using the AA could have been interpreted as a vertical equity cost to achieve geographic equality of access, and there was a justification in this area alone, it is the improvement in patient outcomes in terms of social efficiency which would make the justification complete. While it would have needed a controlled study to estimate any improvement in outcomes, Chapter Seven indicated that the use of the AA not only improved response and time to hospital in its own use, but freed up the land ambulances with which it worked. Hence improved response would have come from all vehicles and the ten percent of patients whose injuries or conditions were critical could have significantly different outcomes. The benefits to the community of stopping a patient reaching a vegetative state are huge. Any reduction in permanent disabilities will reduce the cost of illness or injury by minimising the cost of treatment and the productivity saved by a patients' return to work or normal functioning. The speed of response and the combination of being able to deliver patients to the most appropriate hospital for the condition of the patient could also have a significant affect on the morbidity of certain patients. The converse of this argument is the possibility of saving grossly impaired lives. This aspect of the service needs a greater exploration.

The particular area so far not enumerated, quantified and valued is the contentious area of benefit from reduced mortality in the second option over the first option. The Economic Advisers to the Department of Health will not value a life. Their argument is that each patient with which they deal is a recognised individual and as such, no value could have been placed on that life. While it could be accepted that

Fig.10.1 AA Costs v Lives Saved Using 3 Differnt Values of Life



life itself cannot be valued, willingness to pay surveys exposed the value that a sample population were prepared to pay for a reduced risk of death. Needleman (1980) estimated the value of a statistical life at £170,000, while Martin and Psacharopoulos (1982) calculated a value of £2,460,000. The Department of Transport however in its calculations for road improvement valued a life at £750,000.

Fig. 10.1 gives a graphical representation of the trade off of lives that need to be saved at different values to equate with the cost of different levels of ambulance service provision. The three values of life discussed in the last paragraph have been used and can be identified on the graph. The lowest of the three horizontal lines on the graph indicates the additional cost to the ambulance service of providing the AA. The next horizontal line up indicates the total cost of ambulance service provision for option two.

If Neddlemans value of life of £170,000 is taken then the AA needs to save at least five lives to meet the additional cost of its provision. With the Department of Transports value the saving of two lives produces a net benefit over the whole costs of ambulance provision for option two. At the value given by Martin and Psacharopoulos the saving of one life shows a net benefit over the total cost of ambulance provision for option two.

This ignores all other benefits which have been discussed whether valued or not. Unsupported evidence from discussions with A&E consultants, anaesthetist and GPs would suggest that at least one life per year was saved, and the figure could have been as high as five. On the lowest value of life alone this gave credence to the use of the AA, and this was before any consideration of reduced morbidity for patients.

Conclusion

Section two of the thesis has taken an in depth case study in which the overall conclusions are now given. The initial analysis investigated the potential areas to compare the percentage of all calls that an AA could meet faster than land ambulances. The populations of each ambulance station area had been analysed to identify the mix of categories of call and demand. For each population the expected daily frequency and variation were analysed and the associated service times for land ambulances were estimated to allow the degree of cover offered to be measured. From this two options were investigated. The first option was 'land ambulance only'. This gave a poor response and long journey times to hospital for the sparsely populated areas of North Cornwall. The second option tested how the introduction of an AA would improve this situation.

The first study resolved that the AA contributed to making the whole system of front line ambulance provision in North Cornwall more effective by providing improved cover, a faster response to accidents and speedier journeys to hospital. The problem of analysing the cost-effectiveness of AA support is not just to do with increased coverage, rapid paramedic response and shorter times to or between hospitals, it involved an overall appraisal of the integrated use of air and land based resources. Such an integration will have organisational, operational and control implications for the Cornwall Ambulance Service in the area of North Cornwall.

Approximately fifty percent of calls in North Cornwall during the day shift would be expected to be dealt with by the AA. There is little alternative to improving the standard of service to such very rural areas. The typically small and scattered populations and the size of the workload precludes cost effective deployment of land ambulances in sufficient numbers to guarantee a maintenance of the ORCON standards.

The second study looked at the implications for geographic equity with the introduction of the AA. While it was concluded that geographic equity was improved by the use of the AA, the cost per head increased rapidly as the target population became more sparsely populated. The crude model developed indicated the scale of the increase in costs with the increasing rurality. However, it would be a political decision to identify whether the cost of improving access to a small population was acceptable on equity grounds alone.

The third study on the efficiency of the AA concluded that on the evidence available the use of the AA is socially efficient. Although substantially more detailed investigations are needed, there is some evidence to suggest that at least one life a year is saved by the use of the AA, which even at the lowest current calculation for the value of a life negates the marginal cost of running the AA. If a high value of life is taken, the AA scenario would not only show a marginal improvement on the first option, it would offer positive benefits.

Other benefits of the AA not measured are its invaluable use as a response to a major incident. On a lesser scale where any emergency incident occurs involving more than one casualty, and hence a response from several land ambulances, cover in the area of the incident will be temporarily lowered. In these circumstances, the AA can provide good backup cover and in this way will directly effect strategic resource planning for the service. A longer term benefit of establishing an AA will be to aid development towards the provision of a trauma centre in the region. There are also occasions when the use of the AA will be essential for the fast transfer of transplant organs in the review area and perhaps further afield.

The evaluation techniques used in this study have shown the use of the AA to have improved equity and increased the effectiveness of the operation of the ambulance service as a whole. There is also the high probability of its use being socially efficient. Therefore it is recommended that further research should refine the methods of evaluation outlined in this thesis and that the adoption of helicopters as AAs in highly rural areas is recommended as long as this form of analysis proves positive.

Chapter Eleven

Conclusions

Introduction

The first part of this chapter summarises the conclusions of the work undertaken in this thesis, highlighting how the aims and objectives of the research have been met. This is followed by a review of the policy implications which can be derived from the work and the contribution to knowledge it has made. Finally the chapter offers an overview for further research.

The first discovery was that prior to introducing an AA in Cornwall there was no preparatory work carried out. It became apparent that neither the Health Authority nor the ambulance service within Cornwall had ever documented the need for an AA. There was also no evaluation of the planned use of such an expensive resource and no defined role. Since the Cornwall Ambulance Service has assumed control of the helicopter, guidelines have been formulated to aid its deployment (see page 96) but it is often used in a very ad-hoc manner. Performance objectives were not set by either the ambulance service or the charity which sponsors the helicopter. It has operated with only the minimal supervision and a very rudimentary surveillance system which is clinically and epidemiologically meaningless.

This study has attempted to address some of these underlying issues. An expensive new resource must have a defined role. Without this, its chances of being used effectively, efficiently and equitably are extremely limited. There was therefore a need to derive measures of evaluation which were quantitatively adequate but also which were relevant to the new structure of the NHS. How well this has been achieved is now discussed.

Aims and Objectives

The aim of the thesis was 'To evaluate the potential contribution of AAs to health care in Britain in terms of effectiveness, equity and efficiency within the new internal market for healthcare'. This was achieved by three inter-related studies.

The analytical framework for the first study concentrated on a detailed analysis of the relationship between the service standards achieved by, and the overall cost implications of, 'land ambulance only' provision versus 'land ambulance and AA' provision in Cornwall. It involved exploring the relationship between demand, standards and resources to identify a 'target demand population' for the best use of the AA. This was done by establishing options to test the AA's contribution to effectiveness, equity and efficiency.

The effectiveness of the AA was determined by the degree to which it could improve ambulance service standards by reducing overall response times, and the journey time to hospital. The methods employed were to make a robust quantitative comparison of two options: The ambulance service 'with' and 'without AA'. The 'with AA' option was found to be more effective due the ability of the AA to complete more patient journeys faster in rural areas than conventional road ambulances. This could confidently be predicted from investigation of the survey data. Thus the number of calls the AA could cope with each day, the number of expected calls and the time taken to deal with them (in terms of 'response time' and 'time to hospital') could be shown to be significantly improved. However, what could not be categorically shown was the actual improvement in meeting ORCON standards in terms of minutes saved. This would need the development of a complex simulation model, which was beyond the scope of this project.

Study two, taking the definition of equity to be equal access for all to the A&E system, investigated methods to highlight the differential costs necessary to maintain equity. The AA was identified as an instrument that can be used to aid equality of access by reducing the 'response' and 'journey to hospital' times for patients in the peripheral rural areas where the ORCON standards are not maintained by land ambulances. The costs involved to the ambulance service were calculated and used with measures of rurality, primarily population density and sparsity, to identify which was the best predictor of ambulance service costs at differing levels of rurality. Sparsity was chosen and simple regression analysis was used to explore its ability to predict costs at differing levels of rurality. Overall it was concluded that this variable could explain over 55 percent of cost variations in the county. At the same time however, it was recognised that the sparsity model provided an incomplete explanation of geographical variations in costs. It was therefore emphasised that there is a need for further research to identify other variables which might be significant. The results also revealed the additional cost of the AA service per capita. It was noted that costs are very similar around a sparsity value of 20, but the AA costs rises to plus 42 percent as the sparsity value falls to five. The results suggest that, in the Bodmin area, where the population sparsity problem is least, the use of the AA adds approximately two pounds per capita costs each year. This is an increase of 21 percent. In the very sparsely populated area of Camelford, meanwhile, the premium rises to almost five pounds per head, an increase of over thirty one percent.

The third study aimed to determine whether the use of AAs in sparsely populated areas can be justified in terms of social efficiency. This work identifies the sectors of the community in which the costs and benefits of AA use accrue. The structure outlined public sector costs, and costs to families and society. While certain elements of the costings were provided from survey and research work within the Cornwall healthcare system, other elements were based on firm evidence from previous studies. The particular work based on other studies employed morbidity data relating to reduced length of stay in hospital for trauma patients transported by AAs. This approach had to be used as it was not possible to undertake an outcome study as neither the ambulance service nor the health authority released personal data. For the same reasons the estimates of costs for post-hospital treatment had to be conducted by requesting a consensus of GP views rather than obtaining hard data from an outcome study. The overall approach to this study fits in with the 'cost of illness' approach which regards benefits as avoided costs.

The increased cost of operating the AA is £415,610 per annum, all of which is met by fund raising. It appears that the hospital sector overall make a gain of £88,200 on improved morbidity alone. Among the other benefits recognised which accrue to relatives and friends is reduced travelling the reduced anxiety. Similarly the relief of pain and discomfort achieved by the AA because of the quicker response to emergencies, faster journeys to hospital and a smoother ride cannot be ignored. If at least one life per year was saved on the lowest value of life alone credence was given to funding the AA.

A wide range of the specific objectives of the thesis were met. It was shown that there has been very little literature relating the British systems, and it was therefore important to explore the literature of other countries. The review of the literature explored AA systems in countries that might be relevant to Britain. It was seen that this research, based predominately on American literature, but also acknowledging Swedish, German and French contributions, demonstrated that major differences in the organisation of the services meant that there was little which proved applicable to the British situation. This highlighted the need for more evaluative work in this country.

In America the health care system is very different: the AAs are part of private trauma hospitals and are thus financed from cross subsidisation resulting from 'patient capture' for the trauma centres. With the European services AAs were used as part of a graded system of response, being dispatched only to specific types of case or location, a system not used in Britain. A common link with all the systems investigated did provide the first concept for the evaluation of AAs in Britain. This was that, regardless of the systems employed, the most effective use of AAs were in rural areas. Whatever other criteria were investigated, the results were best when applied in rural situations. It was demonstrated that, as population density increased, AA use increased to a certain level and then fell off. Principally, this is because as population density increased hospitals became closer, therefore reducing the potential for time saving which AAs can make. However, in a private healthcare market, when population density fell to very low levels demand fell off and the utilisation was not sufficient to cover the extra cost.

The British ambulance system and its recent history were reviewed to discover why there is a need for AA services in Britain, and to see what current role they perform. It was discovered that, prior to the internal market for health, increasing centralisation of hospital facilities and the increasing severity of RTAs led the ambulance service to adopt paramedic training. If teams could get to the scene fast enough they had been shown to save lives. The creation of the internal market and the adoption of trust status by ambulance services allowed them to set up charitable trusts to help fund rapid response vehicles such as motorbikes and helicopters. They received no central funding for this as the Department of Health remained sceptical about such innovation. It was concluded that the perceptions of ambulance service managers in the early days of the internal market were that the use of AAs funded from sources other than block contracts would boost flagging standards. In Britain between 1989 and 1992 nine ambulance services incorporated AAs into their service, believing that the funding could be achieved from a mixture of income generation schemes and charitable trusts. This policy has largely failed as income generation schemes have not raised the money that was expected. This subject is commented upon further in the discussion relating to policy.

Concepts of effectiveness, efficiency and equity were reviewed in order to find robust definitions that would be useful in assessing the contribution of an AA within the structure of the internal market for health. These definitions were achieved. In addition, the new internal market for healthcare was investigated. This section was crucial in identifying the developing structure of the ambulance service and its ability to adopt the use of helicopters. The conclusions from this contribute to the policy discussion.

<u>Implications For Policy</u>

As the purchaser/provider model became established and competition was introduced, it was expected that the following would happen within the ambulance service:-

1. The number of ambulance services would be reduced as competition increased.
2. In order to compete, new technology would be introduced to improve the efficiency of competing ambulance services.
3. Diversification and income generation schemes would help to fund the adopted new technologies.
4. Factors one to three above would all encourage the greater use of AAs.

Although amalgamations of services have taken place the expected economies of scale and the adoption of new technologies have not materialised. As a case in point the Cornwall, Devon and Somerset Ambulance Services are now the South West Ambulance Service Trust. However, the one central control station for the South West Ambulance Trust, which was to replace a number of smaller control centres within the three counties, has not materialised. Computerised control systems that can manage populations of over two million have not proved the expected panacea. The problems of the computer software introduced by the London Ambulance Service have been the most widely publicised, but there have been other such cases.

Diversification from the core business was envisaged and it was expected that income generation schemes would fund the adoption of new core schemes such as AAs. While the income generation schemes started by many ambulance services have produced income, it has not been on the scale anticipated at the start of the contracting process. Competition within the ambulance service, to date, has not realised the benefits expected, neither has a seamless friction free market been established. The mutual help that ambulance services used to provide to neighbouring services has disappeared and now any work done by a neighbouring service has a cost, thus adding to the contracting costs. The Health Authorities have repeatedly bid down the value of block A&E contracts. The revenue that the ambulance services have received from small economies of scale and from diversification have not compensated for the loss of revenue on the block contracts. The effect of this is that over 40 percent of ambulance services are now not only in financial trouble but also are failing to meet ORCON standards (Butler 1993).

One important consequence of AA services is that only the Cornwall and Scotland services are financially secure. The Cornish service while run as a charitable trust has funds for several years, while the Scottish service is now funded by the Common Services Agency for Scotland. All the other AAs run by ambulance services are facing crisis due to the poor financial shape of the ambulance service, or the charitable trusts which, in the face of recession are unable to procure the funds needed for a continuous unbroken service. In the present economic climate the Department of Health is even less likely to fund these services.

While the adoption of more AAs in Britain looks remote at the moment, the evaluation of the contribution that AAs can offer is encouraging. In the effectiveness study it was demonstrated that in very rural areas AAs can cover greater tracts of land than a land ambulance, carrying the same number of crew. Similarly response and journey times to hospital can be greatly improved. In terms of equity it was demonstrated that the AA aided the equalisation of access to the A&E system. However, it would appear that equity in the competitive healthcare market is the concept least followed. The interpretation of equity in NHS policy has not always been easy, as policy attempting to achieve equal access in reality becomes a policy of equal inputs, and ignores accessibility. The policy now would appear to be more concerned with the maximum health gain for a given budget which indicates that differential costs of access will be ignored. If this is the case the ability of the AA to equalise access will not be valued.

While it was not possible to identify how many lives, if any, the use of the AA saved each year, it was however revealing to note that a cost benefit analysis of the Cornwall AA viewed it as socially efficient. This opens debate in several areas. The first is that the use of the AA could be seen to demonstrate savings in other areas of the health care market such as the hospital system, while imposing costs on the ambulance service. This demonstrates a major weakness in the system of the internal market. If vertical integration occurred between the hospital system and the ambulance service, the hospital system could control the ambulance service and thus balance the costs of the service with the savings in hospital costs. In a market system this could be viewed as cross-subsidisation similar to the American model. Prior to the current market model of the NHS, the advantages of vertical integration were present, and without the very expensive costs of contracting.

The Cornwall model of AA use is interesting in that the local population are willing to pay for a service that the Health Authority is not willing to provide. The land ambulance service is provided out of taxation, but the AA is in effect a local voluntary tax as a large number of the community are willing to contribute to the charity that funds the service. As funds given to charity are finite, the money raised for the AA in Cornwall is at the expense of other charities. This has meant that the Royal National Lifeboat Institution has been replaced by the AA as Cornwall's favourite charity. The greatest gain would seem to be to the Health Service, which does not pay for the AA but reaps the benefits of reduced hospital stays and thus reduced treatment costs.

The ORCON standard fails to differentiate between medical, surgical and trauma cases. It is generally agreed that a twenty minute response time for medical emergencies is too great, and is even more doubtful in the outcome of trauma cases where rapid delivery to a major A&E department is all important. If the ambulance services adopted a graded response system, such as is used in most other European countries, the costs of AA provision might become more acceptable to the Department of Health. However, as has been noted, the department has shown little enthusiasm for funding AAs. This, in conjunction with the problems being faced by the relatively new ambulance service trusts, would indicate an uncertain future for AAs in Britain.

Contribution to Knowledge

The first contribution to knowledge of this thesis was the recognition that an evaluation system for AAs was needed in Britain that is pertinent to the British circumstances. This conclusion recognised the limitations of drawing comparisons from systems abroad. As an example, a large part of the justification for the rapid expansion of AAs in America was the competition for patient 'capture' at trauma centres. In Germany too many doctors have been trained which has led to a tradition of doctors attending the scene of accidents. The civil defence force also pays for many of the AAs which has created a situation that is not analogous to Britain.

The identification of specific roles for AAs in Britain has been a major contribution to knowledge in this area. It has been shown that the most valuable role played by the AA is to add to the sum of the parts within a system. This has not been previously understood or appreciated. It was further shown that the AA has a valuable contribution to make to the overall service when it is not flying, but providing cover in rural areas. This enables the land ambulances to respond to calls without reducing the overall cover. This is perhaps surprising as the usual belief is that the main role of an AA is saving lives due to the speed of its response. Similarly, evaluation work, as discussed in Chapter Two, has tended to identify the contribution which AAs may make by trying to assess the improvement in mortality or morbidity of patients carried by the AA versus those carried by a land ambulance. There has been a failure to recognise the improved mortality and morbidity that can be attributed to patients carried in land ambulances that are assisted by an AA compared to systems that are not. Again this demonstrates the holistic nature of the contribution of the AA in terms of not just morbidity and mortality, but also vehicle utilisation and the less tangible aspects of paramedic training and service morale.

A further contribution to knowledge is that the thesis has drawn together the evaluation literature on ambulances to describe the impact of change in terms of the internal market. This will illuminate judgement on AAs, providing a model for general evaluation and therefore a role in the decision making process. This will put issues regarding the adoption of AAs and their contribution to the ambulance service in the context of change in the NHS. The identification of the opportunities and conflicts posed for a seamless market are common to many industries, but the ambulance service is a special case in which a public good can be traded. As such it has considerable relevance for other models within the Health Service.

The use of definitions from evaluative economics to describe the work done has proved extremely helpful. This had not been undertaken previously and it demonstrates an important step forward and uses a cross fertilisation of disciplines. The model developed in this thesis for assessing service provision by defining separately how the service is deemed to be effective, efficient and equitable and how these concepts can be quantified, has offered a model for the analysis of any mobile community health services, such as midwives, health visitors, and community nurses.

Each of the three sub studies has made a contribution to knowledge. The first study looked at the processes of the Cornwall ambulance service in terms of demand, standards and resources through the analysis of over 11,000 separate land ambulance responses in the county and over 800 AA responses. This in itself is an important study revealing how an ambulance service operates, and identifying the current role of the AA which could be measured. However, modelling the vastly different speeds and capabilities of the two modes needs further work, possibly within the realm of simulation. This would show the overall improvement in the system in meeting ORCON standards.

The second study established a basic model in order to identify the costs of ambulance service provision at differing levels of rurality. In the context of this thesis the model was used to identify the additional cost of AA use in areas of increasing rurality in order to comment on equity. The model is now being used to investigate how to reward the workloads of GPs in rural areas.

The third sub study, a cost benefit analysis of AA use, provided useful knowledge on the distribution of costs and benefits. Its primary conclusion was that, while the Cornish public at large contributed the funds to their AA, the NHS, and particularly the hospital system, received substantial cost savings.

Further Research

As with much research, in answering certain questions others are raised. Further research opportunities have therefore been identified in several areas of this thesis. The sparsity model showed that over 55 percent of the cost of ambulance provision at differing levels of rurality were explained by sparsity. However, there was one, or a range, of confounding variables in the model that were not identified. Multiple regression could well be useful in further developing the model to explain a larger percentage of the costs. The equity model measured by sparsity was a crude first step which has scope for refinement and application in a number of areas. This research has started with a collaboration between Exeter University and Devon Family Health Services Authority. They are jointly exploring methods of assessing remuneration for GPs working in rural practices. This research is based on the model and concept of sparsity. There is also a potential application for funding all the care in the community and general service provision within rural areas.

In order to provide accurate answers to the contribution that AAs can make to any particular area, there is a need for a simulation package to be developed. Basic trip information and demand information could be used to show the operational advantages which might be achieved using an AA. While such software would be expensive to develop, it would be cost effective when taking into account the half a million pounds it costs each year to run one AA.

There is also a need to model the results of two AAs working together. It was indicated in this thesis how a valuable aspect of AA work was providing cover over a large area. One problem with this is that when all land ambulances are on missions and a 999 call is received, the AA has to respond. This leaves a vulnerable period while the controller moves land ambulances to provide the basic cover. Two AAs could provide cover over a much larger area and would act to back each other up when one is actively deployed on a mission. However, this is a very expensive option and would need very careful work to identify whether or not it would be cost effective. As there are now AAs in Devon and Cornwall there could be possibilities to assist in defining the role for two AAs.

Further research is also needed into establishing why the public give the funding they do to support the AA in Cornwall. Cornwall has among the lowest wages in the country and among the highest unemployment but still raises the funds for the AA. This is now in preference to the Royal National Lifeboat Institution which was the county's favourite charity before the AA service started. Similarly, a more extensive economic appraisal of the benefits of AA use could adopt the 'willingness to pay' approach for the benefits of the AA rather than the cost of illness method adopted in this thesis. This would have to tease out whether the willingness to pay was based on an accurate perception of benefit or not. This approach would, like the current research, have numerous logistic and philosophical problems to address.

In conclusion, this thesis has explored the ambulance service in a way that has never before been attempted. While essentially an economic evaluation in healthcare the traditional outcome study has been limited. However, this has more than been made up by perspectives, methods and concepts that have been taken from a number of other disciplines such as epidemiology, geography, systems analysis, statistics and health service research to illuminate aspects of the service which have previously been neglected. It has also demonstrated that there are numerous areas in which this research could be continued in the future.

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Appendices.

Appendix A1.

ORCON STANDARDS FOR MEASUREMENT OF PERFORMANCE IN EMERGENCY & URGENT CASES.

Patients Categories.

Patients are divided into two priority categories:

1. Emergencies
2. Urgent

1. Emergency

These are:

a. All accident and sudden illness patients.

b. Maternity patients, except where a clear indication to the contrary is given, for example, that an ambulance is not required until a specified later time.

c. Any other type of patient for whom emergency procedure is necessary. Calls with this priority must be dealt with immediately, even if other work is delayed.

2. Urgent.

These are for patients when a definite time limit is imposed:

a. Maternity cases not given emergency priority.

b. Hospital admissions for which the doctor has given a specified time, e.g. within one hour. The word urgent must always be followed by a time limit, e.g, 'Urgent at a hospital before 11.00 hours'.

Measures of Service.

The measures of service to patients and the priority category to which they apply are as follows:

a. Activation time - emergency cases

b. Response time - emergency case

c. Arrival time in relation to scheduled arrival time - urgent cases

Definitions.

The definitions of each of these measures is given below together with some comments on the definitions.

Emergency cases.

a. Activation time - the interval in minutes between receipt of the request and the time at which a fully equipped, fully manned vehicle starts moving to the incident.

b. Response time - the interval in minutes between the receipt of the request and the arrival of the first fully equipped, fully manned vehicle at the scene of the incident.

Activation time is thus a measure of the effectiveness of the service in mobilising an appropriate vehicle.

Response time, which is actually the sum of activation time and travel time, is a measure of the speed with which an ambulance service can provide assistance at an emergency incident. The shorter this time, the better is this particular aspect of the service given to the patient.

For both measures, the time of receipt of the request is the time at which the first contact is made; for example, it is the time when the telephone rings, not the time when the message is complete.

Urgent cases.

c. Arrival time in relation to scheduled arrival time is the number of minutes by which an 'urgent' case is late at the hospital. The scheduled arrival time is the latest time specified as acceptable by the caller at the time the call is received.

ORCON Recommendations.Achievable Standards of Service.

Measure of Service	percentile	Standard Values	
		Metropolitan	Non-Met
Emergencies			
activation time	95	3 mins	3 mins
response time	50	7 mins	8 mins
	95	14 mins	20 mins
Urgent cases			
Arrival time in			
relation to scheduled arrival time	95	5 mins late	5 mins late

Appendix B1. Equity and Justice

Equity implies fairness in distribution. It follows that issues of fairness would be addressed by theories of justice. Veatch, (1981) discusses theories of justice. They are:

1. Entitlement theory. If people have acquired what they possess in a just fashion, then they are entitled to those possessions, and are entitled to use those endowments in what ever way they can.

This theory is difficult to apply in health, but can be applied to health care.

2. Theory of justice. Pursuit of the greatest happiness for the greatest number.

Williams (1987), suggests that this is not so much a theory of justice as a criterion for economic efficiency, in the maximisation of social benefit, subject to resource availability often, or normally, irrespective of resource availability). In this narrow sense utilitarianism is not a theory of justice at all, in that it counts each person for one and none for more than one.

3. Maximin theory, commonly associated with Rawle's theory of justice (Rawle 1972). Rational individuals, without perfect knowledge would choose to arrange social and economic inequalities in such a way that they are to the greatest benefit of the least advantaged. (Maximising the minimum position).

However, this would probably lead to the impoverishment of society by pouring scarce health resources into what might in practice be 'hopeless' cases.

4. Egalitarian theory, equality of welfare among individuals.

Even if the above were to be interpreted as equal health for all, and standardised for age and sex, it would not be a practical goal:

a. It would mean a low level of health as it would be very expensive to raise the level of health of some even by a small amount.

b. The resources to be deployed to achieve this end would require much better knowledge than presently exists of the effectiveness of different forms of health cure.

Appendix C1

Variables in Cornwall Ambulance Data.

Data includes all land and air ambulance missions in Cornwall for one week per month for two years. The data has been accessed through an SPSSX command file reproduced below.

```
TITLE 'COMFILE4.SPSSX'
FILE HANDLE PAGE/NAME='CRUX'
FILE HANDLE SYS/NAME='CRUCIAL4.SYS'
DATA LIST FILE=PAGE   RECORDS =2
            /1 V1 1-3 V2 5 V30 7-8 V31 9-10 V32 11-12 V4 14-16(A)
   V5 17-20 V33 9-12
   V6 22-23 V60 24-25 V7 26-27 V70 28-29 V8 30-31 V80 32-33 V9 34-35 V10
37
   V11 38-39 V101 40-41 V12 42-45 V15 55-56 V150 57-58
   V13 46-47(A) V14 50-51(A) V140 52-53(A) V16 60-62(A) V17 64 V130
48-49(A)
            /2  V18 5-12(A)
```

The original variables used for analysis are shown below. Other variables have been created.

```
VAR LABELS V1 'MISSION NO IN MONTH'
      V2 'DAY OF WEEK'
      V30 'DAY'
      V31 'MTH'
      V32 'YEAR'
      V4 'AMBULANCE STATION'
      V5 'AMBULANCE CALL SIGN'
      V6 'TOO HR' [Time of origin]
      V60 'TOO MIN'
      V7 'TP HR'  [Time passed from control to an ambulance]
      V70 'TP MIN'
      V8 'TM HR'
      V80 'TM MIN'
      V9 'ACTIVATION TIME'
      V10 'EMERGENCY OR URGENT'
      V11 'AAI HR'
      V101 'AAI MIN'
      V12 'RESPONSE TIME'
      V13 'DEPART INCIDENT HR'
      V130 'DEPART INC MIN'
      V14 'ARRIVE HOSPITAL HR'
      V140 'ARRIVE HOSPITAL MIN'
      V15 'CLEAR HR'
```

```
        V150 'CLEAR MIN'
        V16 'RECEIVING HOSPITAL'
        V17 'WEATHER'
        V18 'LOCATION OF INCIDENT'
        V33 'MTHYR'
VALUE LABELS V2 1 'SUNDAY'
            2 'MONDAY'
            3 'TUESDAY'
            4 'WEDNESDAY'
            5 'THURSDAY'
            6 'FRIDAY'
            7 'SATURDAY'/
         V17 1 'FINE'
            2 'RAIN'
            3 'SNOW'
            4 'ICE'
            5 'SHOWERS'
            6 'HAIL'
            7 'WET&WINDY'
            8 'DRY&WINDY'
            9 'HORSSHOWS'
RECODE V4 ('ABO'=1) ('ABU'=2) ('ACB'=3) ('ACF'=4) ('AFL'=5) ('AHE'=6)
   ('AIR'=7) ('ALA'=9) ('ALK'=10) ('ALO'=11) ('ANQ'=12) ('APZ'=13)
   ('ARR'=14) ('ASA'=15) ('ASH'=16) ('ASI'=17) ('ATP'=18) ('ATR'=19)
   ('AWB'=20) INTO CALLSIGN
SELECT IF ( CALLSIGN NE 7)
MISSING VALUES V16 ('000','   ')
RECODE V16 ('RCT' 'RCC' = 'TRU')
RECODE V16 ('DER' 'GBH' 'MGH' 'REI' 'RNH' 'FFH' = 'PLY')
MISSING VALUES V8 (0)
RECODE V6 (0100 THRU 0159 =1)
        (0200 THRU 0259 =2)
        (0300 THRU 0359 =3)
        (0400 THRU 0459 =4)
        (0500 THRU 0559 =5)
        (0600 THRU 0659 =6)
        (0700 THRU 0759 =7)
        (0800 THRU 0859 =8)
        (0900 THRU 0959 =9)
        (1000 THRU 1059 =10)
        (1100 THRU 1159 =11)
        (1200 THRU 1259 =12)
        (1300 THRU 1359 =13)
        (1400 THRU 1459 =14)
        (1500 THRU 1559 =15)
        (1600 THRU 1659 = 16)
        (1700 THRU 1759 =17)
        (1800 THRU 1859 =18)
```

```
(1900 THRU 1959 =19)
(2000 THRU 2059 =20)
(2100 THRU 2159 =21)
(2200 THRU 2259 =22)
(2300 THRU 2359 =23)
(0000 thru 0059 =24)
INTO V20
RECODE V18 ('FCAA '='FCAC ')
STRING WARDNAME (A8)
RECODE V18 ('EXAA '='LISKEARD')('EXAB '='SALTASH ')
('EXAC '='LOOE ') ('EXAD '='TORPOINT') ('EXAE '='STCLEER ')
('EXAF '='STIVE ') ('EXAG '='MENHENIO') ('EXAH '='LANSALLO')
('EXAJ '='STNEOT ') ('EXAK '='LINKINHO') ('EXAL '='DOBWALLS')
('EXAM '='DULOE ') ('EXAN '='LANREATH') ('EXAP
'='LANTEGLO')
('EXAQ '='BOCONNOC') ('EXAR '='CALLINGT') ('EXAS
'='MILLBROO')
('EXAT '='MAKERWIT') ('EXAU '='PILLATON') ('EXAW '='ANTONY
')
('EXAX '='BOTUSFLE') ('EXAY '='CALSTOCK') ('EXBB
'='QUETHIOC')
('EXBC '='CALSTOCK') ('EYAA '='FALMOUTH') ('EYAB '='CARRICK
')
('EYAC '='CHASEWAT') ('EYAD '='FEOCK ') ('EYAE '='KEA ')
('EYAF '='KENWIN ') ('EYAH '='MYLOR ') ('EYAJ '='NEWLYN ')
('EYAK '='PENRYN ') ('EYAM '='PERRANZA') ('EYAN '='PROBUS
')
('EYAP '='STJUST ') ('EYAQ '='STAGNESS') ('EYAR '='STCLEMEN')
('EZAA '='BREAGE ') ('EZAB '='CAMBORNE') ('EZAE
'='CONSTANT')
('EZAF '='CROWAN ') ('EZAG '='GRADERUA') ('EZAH '='HELSTON
')
('EZAK '='ILLOGAN ') ('EZAM '='MABE ') ('EZAN '='BUDOCK ')
('EZAP '='MAWGANIN') ('EZAQ '='MULLION ') ('EZAR
'='PORTHLEV')
('EZAS '='REDRUTH ') ('EZAU '='STDAY ') ('EZAW '='STKEVERN')
('EZAX '='STITHIAN') ('EZAY '='WENDRON ') ('FAAA '='ALLAN
')
('FAAB '='ALTERNUN') ('FAAC '='BODMIN ') ('FAAE '='BUDE ')
('FAAF '='CAMELFOR') ('FAAG '='GRENVILL') ('FAAH '='LANIVET
')
('FAAJ '='LAUNCEST') ('FAAL '='LESNEWET') ('FAAM
'='NPETHERI')
('FAAN '='OTTERY ') ('FAAP '='PADSTOW ') ('FAAQ
'='PENFOUND')
('FAAR '='RUMFORD ') ('FAAS '='STBREWAR') ('FAAT
'='STENDELL')
('FAAU '='STMINVER') ('FAAW '='STTEATH ') ('FAAX
```

```
'='SPETHERW')
 ('FAAY   '='STOKECLI') ('FABA   '='TINTAGEL') ('FABB   '='TRIGG   ')
 ('FABC   '='WADEBRID') ('FABD   '='WEEKSTMA') ('FBAA   '='GWINEAR
')
 ('FBAC      '='LELANTAN')  ('FBAD      '='LUDGVAN  ')  ('FBAE
'='MARAZION')
 ('FBAF   '='PENZANCE') ('FBAM   '='STBURYAN') ('FBAN   '='STERTH
')
 ('FBAR   '='STJUST  ') ('FCAC   '='STAUSTEL') ('FCAD   '='MEVAGGIS')
 ('FCAE   '='STBLAZEY') ('FCAF   '='STENODER') ('FCAG   '='CREED   ')
 ('FCAH   '='LUXULYAN') ('FCAJ   '='COLAN   ') ('FCAK   '='LANLIVER')
 ('FCAL   '='FOWEY   ') ('FCAM   '='NEWQUAY ') ('NDEV   '='NDEVON
')
 ('PLYM   '='PLYMOUTH') ('FDAA   '='SCILLY  ') INTO WARDNAME
RECODE V14 V140 V13 V130 (CONVERT) INTO V200 V201 V202 V203
RECODE V4 ('ASI'='ACB')
IF (V202 GE 22 AND V200 LT 22) V200 = V200+24
SAVE OUTFILE=SYS
FINISH
```

The command file below relates to 12 months aa only data.

```
TITLE 'AACOM'
FILE HANDLE PAGE/NAME = 'R91386>AA>TRIP1'
FILE HANDLE SYS/NAME='TRIP1.SYS'
DATA LIST FILE = PAGE RECORDS=2
   /1 V1 1-4 V2 6-9 V3 11 V4 13 V5 15-22 V6 24 V7 26-27
   V8 29 V9 31 V10 33-35 V11 37-38 V12 40-41 V13 45-48 V14 50-53
   V15 55-57 V16 59-62 V17 64-66 V18 68-71 V19 73-75 V20 77-80
   V120 42-43
   /2 V21 1-2
   V22 4-6   V23 8  V24 10-12 V25 14-15 V26 19-20   V27 22-25
   V28 27-29   V29 31  V30 33-34   V31 36-37 V250 15-16
VAR LABELS V1 'LINE NUMBER'
         V2 'MISSION NUMBER'
         V3 'YEAR OF OPERATION'
         V4 'OPERATIONAL DAYS PER WEEK'
         V5 'DATE OF MISSION'
         V6 'DAY OF WEEK'
         V7 'MONTH OF YEAR'
         V8 'PRIMARY SECONDARY OR TERTIARY MISSION'
         V9 'EMERGENCY URGENT OR PLANNED MISSION'
         V10 'LOCATION OF INCIDENT'
         V11 'LOCATION OF AA'
         V12 'HOUR OF ORIGIN'
         V120 'MIN OF ORIGIN'
         V13 'TIME CALL PASSED TO AA'
```

V14 'TIME AA MOBILE'
V15 'ACTIVATION TIME'
V16 'TIME AA ARRIVED AT SCENE'
V17 'RESPONSE TIME OF AA TO SCENE'
V18 'TIME AA LEFT SCENE'
V19 'TIME AA ON SCENE'
V20 'TIME AA ARRIVED AT DESTINATION'
V21 'DESTINATION OF AA'
V22 'TIME FROM SCENE TO DESTINATION'
V23 'NUMBER OF PATIENTS CARRIED IN AA'
V24 'PATIENT INJURY OR ILLNESS'
V25 'HOUR AA CLEAR'
V250 'MIN AA CLEAR'
V26 'AA RELOCATE TO'
V27 'TIME RELOCATED'
V28 'TOTAL FLYING TIME'
V29 'MISSION ABORTED'
V30 'REASON FOR ABORTED MISSION'
V31 'NON-MISSION FLIGHT'
VALUE LABELS
V3 1 '01.04.87 TO 31.03.88'
2 '01.04.88 TO 31.03.89'
3 '01.04.88 TO 31.03.90'/
V4 1 'OPERATIONAL 5DYS WK'
2 'OPERATIONAL 7DYS WK'/
V6 1 'SUN'
2 'MON'
3 'TUE'
4 'WED'
5 'THUR'
6 'FRI'
7 'SAT'/
V7 1 'JAN'
2 'FEB'
3 'MAR'
4 'APRIL'
5 'MAY'
6 'JUNE'
7 'JULY'
8 'AUG'
9 'SEPT'
10 'OCT'
11 'NOV'
12 'DEC'/
V8 1 'PRIMARY'
2 'SECONDARY'
3 'TERTIARY'
0 'NO DATA'/

V9 1 'EMERGENCY'
2 'URGENT'
3 'PLANNED'
0 'NO DATA'/
V10 1 'BODMIN'
2 'BODMIN ECH'
3 'BODMIN ST LAWRENCES'
4 'BOSCASTLE'
5 'SPARE'
6 'BUDE'
7 'CAMELFORD'
8 'DELABOLE'
9 'FALMOUTH'
10 'FREEDOM FIELDS'
11 'HAYLE'
12 'HAYLE TOWANS'
13 'HELSTON'
14 'ISLES OF SCILLY'
15 'LANDS END'
16 'LAUNCESTON'
17 'LAUNCESTON HOSPITAL'
18 'LIZARD'
19 'MULLION'
20 'NEWQUAY'
21 'PADSTOW'
22 'SPARE2'
23 'PENZANCE'
24 'CITY HOS TRURO'
25 'TRELISKE HOS TRURO'
26 'ST AUSTELL'
27 'STRATTON'
28 'STRATTON HOSPITAL'
29 'TINTAGEL'
30 'WADEBRIDGE'
100 'BLISLAND'
101 'BOLVENTOR'
102 'BUDOCK WATER'
103 'BUGLE'
104 'BURLAWN'
105 'CALLINGTON'
106 'CAMBORNE'
107 'CARBIS BAY'
108 'CARDINHAM'
109 'CARNM ELLIS'
110 'CARTHEW'
111 'CASTLE AN DINAS'
112 'CAWSANDS BEACH'
113 'CONSTANTINE'

114 'COTEHELE'
115 'CRACKINGTON HAVEN'
116 'CULDROSE HELSTON'
117 'DAVIDSTOWE'
118 'DAYMER BAY'
119 'DULOE'
120 'SPARE'
121 'FEOCK'
122 'FOWEY'
123 'FROGPOOL'
124 'GILLAN BEACH'
125 'GOLANT'
126 'GOONHAVEN'
127 'GORRAN'
128 'GORRAN HAVEN'
129 'GOSS MOOR'
130 'GURNARDS HEAD'
131 'GWEEK'
132 'GWITHIAN'
134 'HARLYN BAY'
135 'HENWOOD'
136 'HIGHLAND TURN A38'
137 'HOLLYWELL BAY'
138 'HOLSWORTHY'
139 'INNIS DOWN'
140 'JACOBSTOWE'
141 'KELLY BRAY'
142 'KENARDS HOUSE'
143 'KESTLE MILL'
144 'KILKHAMPTON'
145 'KILKINGTON'
146 'LADOCK'
147 'LANIVET'
148 'LANTEGLOS CAMELFORD'
149 'LEEDSDOWN'
150 'LELANT'
151 'LERYN'
152 'LEWARNICK'
153 'LIFTON'
155 'LNC HOSP'
156 'LOCKINGATE'
157 'LOOE'
158 'LOSTWITHIEL'
169 'LUXULYAN'
170 'MABE'
171 'MADRON'
172 'MARHAM CHURCH'
173 'MAWGAN PORTH'

174 'MAWNIN SMITH'
175 'MELBOR ECC PIT'
176 'MEVAGISSEY'
177 'MILLBROOK'
178 'MILLENDREATH'
179 'MYLOR'
180 'MYLOR BRIDGE'
181 'NORTH TAMERTON'
182 'OLD POLZEATH'
183 'PAR'
184 'PELYNT'
185 'PENRICE'
186 'PENROSE'
187 'PENRYN'
188 'PENSILVA'
189 'PENTIRE'
190 'PERRAN SANDS'
191 'PERRANPORTH'
192 'PIPERS POOL'
193 'POLBATHIC'
194 'POLGOOTH'
195 'POLKERRIS'
196 'POLPERRO'
197 'POLRUAN'
198 'POLZEATH'
199 'POOL'
200 'PORT ISSAC'
201 'PORTH NQ'
202 'PORTHCURNO'
203 'PORTHLEVAN'
204 'PORTHSCATHO'
205 'PORTHTOWAN'
206 'PORTREATH'
207 'PRAZE'
209 'RAF ST MAWGAN'
210 'REJJARAH'
211 'ROCHE'
212 'ROCK'
213 'RUAN HIGH LANES'
214 'RUAN MINOR'
215 'SCH'
216 'SENNEN'
217 'ST AGNESS'
218 'ST ANTHONY MANACCAN'
219 'ST AUSTELL HOS'
220 'ST BLAZEY'
221 'ST BREWARD'
222 'ST BURYAN'

223 'ST DAY'
224 'ST DENNIS'
225 'ST HILLARY'
226 'ST IVES'
227 'ST JUST'
228 'ST KEW'
229 'ST MAYBYN'
230 'ST MAWES'
231 'ST MAWGAN'
232 'ST MAWGAN AIRFIELD'
233 'ST MAYBYN'
234 'ST MELLION'
235 'ST MERYN'
236 'ST MINVER'
237 'ST TEATH'
239 'ST WENN'
240 ' STOKE CLIMSLAND'
241 'TAPHOUSE'
242 'TEHIDDY'
243 'TOLCARNR BEACH NQ'
244 'TOLLGATE WADEBRIDGE'
245 'TOLPETHEMIN'
246 'TOLVERNE'
247 'TREBARWITH'
248 'TREBETHERICK'
249 'TREBURDOCK NR ST EVAL'
250 'TREGADILLET'
251 'TREGAROCK PORT ISSAC'
252 'TREGONY'
254 'TREKENING'
255 'TRENDEAL'
256 'TREVONE BAY'
257 'TREWINT'
258 'TROON PZ'
259 'TYWARDREATH'
260 'VERYAN'
261 'VICTORIA ROCHE'
262 'WATERGATE BAY'
263 'WEEK ST MARY'
264 'WELCOME'
265 'WHITECROSS NQ'
266 'WHITSAND BAY'
267 'WINNARDS PERCH'
268 'ZELAH'
269 'ZENNOR HEAD'
270 'LISKEARD'
271 'CASTLE AIR'
272 'ND&E WANFORD'

273 'TORPOINT'
274 'ND&D BARNSTABLE'
999 'MISSING DATA'/
V11 11 'GLOWETH'
12 'PLYMOUTH AIRPORT'
13 'TRURO CITY'
14 'ND & EXETER'
15 'FREEDOM PARK'
16 'BODMIN ST LAWRENCES'
17 'GLOWETH REFUELLING'
18 'CASTLE MOTORS'
19 'DAVIDSTOW'
21 'FROM PREVIOUS MISSION'
22 'RETURNING TO BASE'
23 'NOT ACTIVATED BAD WEATHER'
24 'BAD WEATHER'
30 'TO NEXT MISSION'
31 'LISTENING WATCH CARDINHAM'
32 'FROM PUBLIC RELATIONS VISIT'
99 'NOT KNOWN'/
V21 10 'RN HOS LANDING ROB'
11 'TRELISKE LANDING TRELISKE'
12 'CITY LANDING TRELISKE'
13 'FREEDOM FIELDS LANDING FREEDOM PARK'
14 'DERRIFORD LANDING ROB'
15 'PENRICE'
16 'TEHIDDY'
17 'ST. MAWGAN'
18 'GREENBANK PLYMOUTH'
19 'NORTH DEVON DISTRICT HOS'
22 'CITY LANDING CITY'
33 'WCH'
44 'DERRIFORD LANDING DERRIFORD'
55 'RD&E HOS'
56 'ODDSTOCK'
57 'BOVISAND'
66 'MOUNT GOULD PLY'
77 'STRATTON N CORNWALL'
88 'FF LANDING AT ROB'
97 'ST MARY IOS'
98 'ROYAL EYE INFIRMARY'/
V23 0 'ONE PATIENT CARRIED'
2 'TWO PATIENTS CARRIED'
3 'SPECIAL EQUIPMENT CARRIED'
9 'MISSING INFORMATION'/
V29 0 'SUCCESSFUL MISSION'
1 'MISSION ABORTED'
2 'NON-MISSION'/

```
    V30 11 'LANDED AT SCENE BUT NOT REQD'
        12 'CANCELLED IN FLIGHT'
        13 'ASSISTED AT SCENE, DID NOT TRANSPORT PATIENT'
        14 'DIVERTED TO NEXT CALL'
        15 'TO REFUEL'
        16 'AT SCENE DIVERTED TO NEXT CALL'
        17 'PATIENT DEAD AT SCENE'
        18 'REQUEST CANCELLED BEFORE ARRIVING AT SCENE'
        19 'PUBLIC RELATIONS MISSION'
        20 'TRAINING MISSION'
        21 'MISSION CANCELLED BEFORE TAKEOFF'
        22 'BAD WEATHER, COULD NOT LEAVE SCENE'
        23 'AA MECHANICAL FAILURE'
        24 'PATIENT NOT SUITABLE FOR AA'
        25 'PATIENT REFUSED TO TRAVEL BY AA'
        26 'PATIENT TOO DRUNK TO TRAVEL BY AA'/
    V31 16 'PUBLIC RELATIONS FLIGHT'
        17 'TRAINING MISSION'
        18 'LISTENING WATCH CADINHAM'
        19 'OVERNIGHT STAY PLYMOUTH'/
STRING LOCATION(A4)
RECODE V10 (1 2 3='FAAC') (4='FAAL') (6='FAAE') (7='FAAF') (8='FAAW')
   (9='EYAM') (10='PLYM') (11 12='FBAA') (13='EZAH') (14='FDAA')
   (15='FBAM') (16 17='FAAJ') (18='EZAG') (20='FCAM') (21='FAAP')
   (23='FBAF') (24 25='EYAB') (26='FCAC') (27 28='FAAZ') (29='FABA')
   (30='FABC') (100 101='FABB') (103='FCAC') (105='EXAR') (106='EZAB')
   (107='FBAP') (108='FABB') (110='FCAC') (111='FCAJ') (112='EXAT')
   (113='FCAM') (114='EXAY') (115='FAAQ') (116='EZAH') (117='FAAC')
   (118='FCAM') (119='EXAM') (121='EYAD') (122='FCAL') (123='EYAH')
   (124='EZAP') (125='FCAL') (127 128='FCAG') (129='FCAJ') (130='FBAD')
   (131='EZAE') (132='EZAB') (134='FAAE') (135='EXAK') (137='FCAM')
   (138='NDEV') (139='FAAH') (140='FAAQ') (141='EXAU') (143='FCAJ')
   (144 145='FAAG') (146='EYAN') (147='FAAH') (148='FAAF') (149='EZAS')
   (150='FBAA') (151='EXAP') (152='FAAB') (153='NDEV') (155='FAAJ')
   (156='FCAJ') (157='EXAC') (158='FCAK') (169='FCAH') (170='EZAM')
   (171='FBAD') (172='FABD') (173='FCAJ') (174='EZAN') (175='FCAH')
   (176='FCAD') (177='EXAS') (178='EXAC') (179 180='EYAH') (181='PLYM')
   (182='FAAU') (183='FCAE') (184='EXAN') (185='FCAC') (187='EYAK')
   (188='EXAE') (190 191='EYAM') (192='FAAB') (193='EXBC') (194='FCAG')
   (195='FCAL') (196='EXAH') (197='EXAP') (198='FAAU') (199='EZAS')
   (200='FAAT') (201='FCAM') (202='FBAM') (203='EZAR') (204='EYAP')
   (205='EZAK') (206='EZAS') (207='EZAF') (209='FCAJ') (210='EYAM')
   (211='FCAH') (212='FAAU') (213 214='EZAG') (215='FAAZ') (216='FBAM')
   (217='EYAR') (218='EZAP') (219='FCAC') (220='FAAE') (221='FAAS')
   (222='EZAW') (223='EZAS') (224='FCAH') (225='FBAN') (226='FBAF')
   (227='EZAG') (228='FAAA') (229='FAAA') (230='EYAP') (231 232='FCAJ')
   (233='FAAA') (234='EXAB') (235='FAAP') (236='FAAU') (237='FAAW')
   (239='FCAT') (240='FAAX') (241='EXAR') (242='EZAB') (243='FCAM')
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    (244='FABC') (247='FABA') (248='FAAU') (249='FAAR') (250='FAAX')
    (251='FAAT') (252='EYAN') (255='EYAN') (256='FCAM') (257='FAAF')
    (258='EZAB') (259='FCAE') (260='EYAP') (261='FCAH') (262='FCAM')
    (263='NDEV') (264='FAAG') (265='FCAJ') (266='EXAW') (267='FCAJ')
    (268='FBAR') (269='FBAD') (270='EXAA') (271='EXAG') (272='NDEV')
    (273='EXAD') (274='NDEV') INTO LOCATION/
STRING HOS (A2)
RECODE V21 (13 18 44 88 66 98='PL') (11 12 22='TR') (55='EX') (15='SA')
  (19='ND') (33='PZ') (57='BV') (77='SR') INTO HOS
SAVE OUTFILE=SYS
FINISH
```

Explanation of variables.

a. The mission number in the month, and the date.

The mission number is just a chronological identifier given to each mission that occurs in the month. The date is self explanatory.

b. Time of origin. This is the time a call for an ambulance is received at ambulance control. With manual systems this is logged by a card punched by a time clock. On more modern systems the time is automatically recorded by the switchboard.

c. Time passed. This is the time that the information regarding the call is passed onto the nearest available ambulance. The difference between time of origin and time passed gives an indication of whether suffcient resources are available. For example, a long delay suggests that the controller is finding difficulty contacting a free ambulance, or that the controller has too many calls to deal with. Another reason for a delay here could be that the controller is having difficulty obtaining accurate information about the location of an incident from a distressed caller who might have just witnessed a serious accident, and may be unfamiliar with the local geography. Again in more modern systems the switchboard identifies immediately the address of a telephone call, highlights it on a digital map, alerts the nearest ambulance on call, and switches on that ambulances' radio to receive while giving the address of the telephone call. This high technology approach has greatly reduced the number of controllers needed. The control panel can be operated by relatively inexperienced personnel, thus leaving the controller to deal with the less straight forward cases. The high cost of such systems is recouped by the need for less staff, and using spare capacity in the system for income generation, as described in chap six.

d. Time mobile is the time that the receiving ambulance starts to act on the call. If the ambulance is standing on call it is almost instant. However the ambulance may be in the process of dropping the last patient at a hospital.

e. Activation time is the difference between time of origin and time mobile. This gives an indication of how well resourced the service is. A long activation time suggests that the controller is having difficulty in finding free ambulances to respond to an emergency.

f. Ambulance station call sign is a three digit code which identifies which ambulance station a particular ambulance belongs to. Ambulances can often be found working outside their own 'patch'. For instance a Liskeard ambulance returning from taking a casualty to Truro hospital can be diverted to an emergency anywhere along its return route.

g. Ambulance code sign is a code belonging to each individual ambulance, which can identify the utilisation of each vehicle in terms of hours of actual wheelturn and time spent standing on call. Unfortunately this variable is more complex than it first seems as vehicles loaned to other stations take on new numbers, and crews have favourite vehicles which they will always use in preference to others. A research study is now in process to identify why crews choose particular types of vehicles in preference to others.

h. Arrive incident is the time the ambulance arrives at the scene of an accident or incidence of illness.

i. Response time is the time taken for the ambulance to reach the scene of an accident from the time the call was passed. The Orcon standards for emergencies, already discussed, indicate that an ambulance should reach the scene within 19 minutes in rural areas in 95 per cent of cases. This is historically the main yardstick of efficiency in the service as previously discussed. For urgent cases the patient should reach hospital within five minutes of the time specified by a doctor. This does give scope for a stretched service to schedule its resources. If a doctor indicates that a patient should reach hospital within four hours, the controller has a degree of flexibility in making an ambulance available for that mission.

j. Time left incident is self explanatory.

k. On scene time gives an indication of seriousness of the case. Superficial injuries can be taken quickly to a local casualty department to free the ambulance for its next mission. However a coronary arrest may need defibrillation on the spot. A patient involved in a serious accident suffering a large blood loss or severe shock will need replacement fluids via a drip. Setting up a drip in less than ideal circumstances can take some time. A victim may still be trapped in a vehicle, in which case the ambulance crew must stand by while the fire service free the victim. The time spent on scene is a bone of contention within the medical service at present. Increasing paramedic skills encourages the crews to stabilise the patient before transport to stop deterioration of the patient during transport. However there is still a body of medical opinion that suggest that the ambulance men should 'scoop and run', rather than 'stay and play'. A problem in assessing this area is that little work has been done on the quality of paramedic intervention at the scene, particularly in the use of certain analgesics.

l. Time arrived at hospital is self explanatory.

m. Time to hospital from the scene gives an indication of the remoteness from hospital of certain areas. While most locations have a GP or cottage hospital locally, all patients except the most superficially injured must go to one of the main A&E departments at the district general hospitals. It is this figure that starts to give an indication of geographic inequity for the services provided for patients as a result of historic policy to adopt the policy of a few centres of excellence. It is the peripheral services such as the ambulance service that has had to react to those policies in trying to keep patients alive over long distances.

n. Time clear gives the time that the ambulance is available for its next job after having dropped its patient to the hospital. From an equity point of view it can be seen that living close to a large hospital, which by definition will be in an urban area gives you a much better chance of fast response to hospital, as all ambulances from the regions dropping patients at the hospital are available as they leave the honeypot. Meanwhile cover at the periphery is reduced, or to maintain it works out much more expensive per head of population.

o. The receiving hospital has been logged to identify patient flows across the county.

p. The weather has been logged to give an idea of how bad weather affects accident rates. However the ambulance crews used such vague codings, and often did not bother to fill the section in that it is not possible to use in analysis. It would also be difficult to assess what degree of multi-collinearity exists between the seasons and the weather.

q. Location of incident has been written in as a place name. For analysis this has been re-coded into electoral wards. This has taken many hours of work and consultation as many Cornish names are similar and need careful differentiation. For example, St Columb, St Columb Major, St. Columb Minor, St. Columb Road. Newlyn in one part of the county and Newlyn East in another. There are many hundreds more similar examples. The process was not helped by ambulance crews writing in place names in a fast moving vehicle with their patients to consider. This has resulted in a number of place names being missed.

Appendix C2.

Emergency & urgent calls in the sample week each month.

Month	Emergencies	Urgents	Total
Mar 88	260	297	557
Apr 88	310	250	568
May 88	280	285	565
Jun 88	303	255	638
Jul 88	356	247	603
Aug 88	349	302	651
Sep 88	367	224	591
Oct 88	296	218	514
Nov 88	241	226	467
Dec 88	278	231	509
Jan 89	265	226	491
Feb 89	224	216	440
Mar 89	286	213	499
Apr 89	254	267	521
May 89	255	241	496
Jun 89	314	251	565
Jul 89	368	255	623
Aug 89	363	272	635
Sep 89	311	223	534
Oct 89	254	241	495
Nov 89	300	214	514
Dec 89	303	253	556
Jan 90	285	307	592
Feb 90	289	213	502
TOTALS	6954	5694	12648

Appendix C3
Wards Attached to Ambulance Stations: Size and Population.

Ward	Ambulance Station	Hectares	Population
faad	Bodmin	887	5202
FAAC	Bodmin	442	6790
FAAH	Bodmin	4197	1647
FABB	Bodmin	8865	1260
FCAK	Bodmin	3304	2353
		17695	17252
FAAE	Bude	1142	5325
FAAG	Bude	9165	1898
FAAQ	Bude	6203	1651
faaz	Bude	575	1485
FABD	Bude	7288	1552
		24373	11911
FAAF	Camelford	3037	1835
FAAL	Camelford	9258	1872
FAAS	Camelford	5778	1353
FAAW	Camelford	2381	1716
FABA	Camelford	1987	1485
		22441	8261
eyal	Falmouth	118	5728
eyas	Falmouth	151	3954
eyaw	Falmouth	172	5299
EYAA	Falmouth	337	2832
EYAK	Falmouth	338	5049
EZAE	Falmouth	3237	2003
EZAM	Falmouth	1906	1967
EZAN	Falmouth	1846	2284
		8105	29116
ezaj	Helston	862	4011
EZAA	Helston	3423	3009
EZAG	Helston	2950	1619
EZAH	Helston	185	3618
EZAP	Helston	4435	2167
EZAQ	Helston	3728	2566
EZAR	Helston	570	3097
EZAW	Helston	4189	1814
EZAY	Helston	6273	3514
		26615	25415

faak	Launceston	532	2346
FAAB	Launceston	10527	2129
FAAJ	Launceston	350	3671
FAAM	Launceston	7945	1501
FAAN	Launceston	6473	1173
FAAX	Launceston	3763	1645
FAAY	Launceston	5400	1801
		34990	14266
EXAA	Liskeard	1098	6213
EXAE	Liskeard	4401	2531
EXAF	Liskeard	2395	2013
EXAG	Liskeard	2839	1280
EXAJ	Liskeard	6590	993
EXAK	Liskeard	4494	1694
EXAL	Liskeard	2765	2005
EXAM	Liskeard	4818	1733
EXAN	Liskeard	3920	1493
EXAP	Liskeard	2660	1302
EXAQ	Liskeard	5709	960
EXBB	Liskeard	4302	1007
		45991	23224
EXAC	Looe	686	4279
EXAH	Looe	1946	1538
		2632	5817
fcan	Newquay	333	7218
fcap	Newquay	672	3067
EYAJ	Newquay	4872	2068
FCAJ	Newquay	11236	6679
FCAM	Newquay	882	4429
		17995	23461
fbag	Penzance	87	4858
fbah	Penzance	245	2661
fbaj	Penzance	545	4323
fbak	Penzance	311	3459
fbap	Penzance	607	3750
fbaq	Penzance	383	3286
FBAD	Penzance	9142	4511
FBAE	Penzance	297	1392
FBAF	Penzance	110	3481
FBAL	Penzance	444	1528
FBAM	Penzance	7464	2954
FBAN	Penzance	2708	1637
FBAR	Penzance	3094	3960
		25437	41800

fbap	Carbis Bay	1957	4801
FBAC	Carbis Bay	768	3072
FBAA	Carbis Bay	2239	3498
		4964	11371
ezac	Redruth	1011	6239
ezad	Redruth	1534	5697
ezal	Redruth	1173	5734
ezat	Redruth	541	5263
EYAH	Redruth	3687	5180
EZAB	Redruth	241	6403
EZAF	Redruth	3045	1930
EZAK	Redruth	2091	5725
EZAS	Redruth	1093	5653
EZAU	Redruth	1217	5270
EZAX	Redruth	1788	2119
		17421	55213
fcaa	St. Austell	1651	3366
fcab	St. Austell	1222	9115
FCAC	St. Austell	414	6606
FCAD	St. Austell	2533	6753
FCAE	St. Austell	1662	8255
FCAF	St. Austell	6642	6373
FCAG	St. Austell	6780	5105
FCAH	St. Austell	6060	5102
FCAL	St. Austell	1904	2357
		28868	53032
exaz	Saltash	696	1485
exba	Saltash	263	1350
EXAB	Saltash	2224	12772
EXAR	Saltash	1129	2919
EXAU	Saltash	3723	1396
EXAX	Saltash	2835	1854
EXAY	Saltash	1411	2049
EXBC	Saltash	1697	1627
		13978	25452
EXAD	Torpoint	388	8367
EXAS	Torpoint	428	1773
EXAT	Torpoint	1045	1074
EXAW	Torpoint	2260	1331
		4121	12545
eyag	Truro	126	2894
eyat	Truro	293	3154
eyau	Truro	327	4662

EYAB	Truro	338	4963
EYAC	Truro	961	1391
EYAD	Truro	1211	3143
EYAE	Truro	2433	1578
EYAF	Truro	2850	3659
EYAM	Truro	4422	4579
EYAN	Truro	8109	3457
EYAP	Truro	5753	2903
EYAQ	Truro	3566	5519
EYAR	Truro	6071	1970
		36460	43872

FAAP	Wadebridge	2953	3660
FAAT	Wadebridge	1532	998
FAAU	Wadebridge	3069	2033
FABC	Wadebridge	5510	4879
FAAA	Wadebridge	4704	1301
FAAR	Wadebridge	4735	2131
		22503	15002

Appendix D1 Receiving hospitals for survey period

Hospital	Frequency	Percent
Barncoose, Redruth.	145	1.1
East Cornwall Hospital, Bodmin.	140	1.1
Edward Haine Hospital, St Ives.	28	0.2
Elizabeth Barclay, nr Bodmin.	12	0.1
Falmouth Hospital.	35	0.3
Fowey Cottage Hospital.	59	0.5
Helston Cottage Hospital.	35	0.3
Lamellion, Liskeard.	5	0
Launceston General	182	1.4
Meneage, nr Helston	29	0.2
North Devon District, Barnstable.	58	0.5
Newquay Hospital.	223	1.8
Passmore Edwards Hospital, Liskeard.	199	1.6
Penrice Maternity Hospital, St Austell		
Plymouth	1527	13.9
Redruth.	227	2.1
St. Lawrences Hospital, Bodmin.	74	0.6
St. Michaels Hospital, Hayle.	43	0.3
St. Austell Hospital.	152	1.2
St. Barnabus Hospital, Saltash.	50	0.4
Stratton Hospital.	126	1.0
Tavistock Hospital.	4	0
Tehiddy, Redruth.	31	0.2
Truro	6,383	53.1
West Cornwall Hospital, Penzance.	1,166	10.6
Aborted missions	1382	10.9
Missing	292	2.3
TOTAL	12,653	

Appendix D2 Mean calls per shift for emergency and urgent calls by ambulance station, for the 'all survey' period.

	Day shift		Night shift	
	Emergency calls	Urgent calls	Emergency calls	Urgent calls
Bodmin	1.42	0.95	1.25	0.58
Bude	0.4	0.2	0.43	0.13
Carbis Bay	0.66	0.86	0.76	0.65
Camelford	0.86	0.73	0.78	0.36
Falmouth	1.83	1.37	1.77	0.46
Helston	1.23	0.86	0.98	0.37
Launceston	0.46	0.34	0.74	0.27
Liskeard	1.54	0.91	1.52	0.41
Looe	0.35	0.29	0.27	0.11
Newquay	1.75	1.38	1.26	0.73
Penzance	2.4	1.49	2	0.75
Redruth	3.6	2.9	4.01	1.95
St. Austell	2.35	1.95	2.03	0.92
Saltash	1.03	0.72	0.88	0.32
Torpoint	0.4	0.26	0.47	0.14
Truro	2.38	3.35	1.67	1.88
Wadebridge	1	0.79	0.91	0.45

Appendix D3 Staff allocation to each ambulance station.

Station	Paramedics	Qualified ambulance persons	Total
Carbis Bay	2	18	20
Penzance			
Helston	5	4	9
Redruth	11	17	28
Falmouth	7	4	11
Truro	6	7	13
Newquay	4	8	12
Wadebridge	3	5	8
Bodmin	5	4	9
Camelford	1	8	9
Bude	1	4	5
Launceston	1	7	8
Saltash	2	8	10
Torpoint	1	2	3
Looe	2	0	2
Liskeard	4	8	12
St. Austell	3	12	15

Appendix D4 Vehicle Allocation to Each Shift and Ambulance Station.

Station	Vehicles on day shift	Vehicles on night shift	Vehicles on station
Carbis Bay	2	1.5	2
Penzance			3
Helston	1	1	2
Redruth	2.5	1.5	7
Falmouth	1	1	3
Truro	1	1	3
Newquay	1	1	3
Wadebridge	1	3	2
Bodmin	3		2
Camelford			2
Bude			4
Launceston			2
Saltash	2	1	2
Torpoint			1
Looe			1
Liskeard	1	1	4
St. Austell	1.5	1.5	4
TOTALS	17	13.5	47

Appendix D5 Time Involved in Responding to Calls During the Day Shift

	Emergency time	Urgent time	Total time	Percentage of shift
Bodmin	96.56	102.6	199	27.64
Bude	34	22.6	57	7.92
Carbis Bay	40.26	77.4	118	16.39
Camelford	84.28	94.17	178	24.72
Falmouth	113.46	120.56	234	32.5
Helston	87.33	81.7	169	23.48
Launceston	34.5	32.64	67	9.33
Liskeard	107.8	80.99	189	26.22
Looe	30.1	32.77	63	8.73
Newquay	98	113.16	211	29.33
Penzance	110.4	129.63	240	33.33
Redruth	194.4	223.3	418	58
St. Austell	152.75	191.1	344	47.76
Saltash	64.89	68.4	133	18.51
Torpoint	26.8	24.96	52	7.18
Truro	104.72	227.8	333	30.32
Wadebridge	92	85.32	177	24.63

Appendix D6 Time Spent Responding to Calls During the Night Shift.

	Emergency time	Urgent time	Total time	Percentage of shift
Bodmin	85	62.64	148	20.5
Bude	36.55	14.69	51	7.12
Carbis Bay	46.36	58.5	105	14.56
Camelford	76.44	46.44	123	17.07
Falmouth	109.74	40.48	150	20.86
Helston	69.58	35.15	105	14.55
Launceston	55.5	25.92	81	11.31
Liskeard	106.4	36.49	143	19.84
Looe	23.22	12.43	36	4.95
Newquay	70.56	59.86	130	18.11
Penzance	110.4	65.25	176	24.39
Redruth	216.54	150.15	367	50.93
St. Austell	131.95	90.16	222	30.84
Saltash	55.44	30.4	86	11.92
Torpoint	31.49	13.44	45	6.24
Truro	147.4	127.84	275	38.23
Wadebridge	83.72	48.6	132	18.37

Appendix D7. Day Shift Ambulance Utilisation

Station	Vehicles on day shift	Percentage wheel turn per vehicle	Minutes of wheel turn
Carbis Bay	2	24.86	118
Penzance			240
Helston	1	23.48	169
Redruth	2.5	23.2	418
Falmouth	1	32.5	234
Truro	1	30.32	218
Newquay	1	29.33	211
Wadebridge	1	24.63	177
Bodmin	3	23.19	199
Camelford			178
Bude			57
Launceston			67
Saltash	2	17.22	133
Torpoint			52
Looe			63
Liskeard	1	26.22	189
St. Austell	1.5	31.85	344
TOTALS	17		3064

Appendix D8. Night Shift Ambulance Utilisation.

Station	Vehicles on night	Percentage wheel turn per vehicle	Minutes of wheel turn
Carbis Bay	1.5	26.01	105
Penzance			176
Helston	1	14.55	105
Redruth	1.5	33.98	367
Falmouth	1	20.86	150
Truro	1	38.23	275
Newquay	1	18.11	130
Wadebridge	3	24.77	132
Bodmin			148
Camelford			123
Bude			51
Launceston			81
Saltash	1	23.19	86
Torpoint			45
Looe			36
Liskeard	1	19.84	143
St. Austell	1.5	20.55	222

Appendix E1. Total Fixed Costs P.A.

	Cost of crew (day shift)	Cost of crew (night shift)	Total crew costs	Ambulance depreciation	Total costs
Penzance	136,571	102,428	239,000	10,713	249,713
Carbis Bay	26,014	19,511	45,524	7,142	52,666
Helston	81,293	81,293	162,586	7,142	169,728
Redruth	203,232	121,939	325,171	24,997	350,168
Falmouth	81,239	81,239	162,586	10,713	173,299
Truro	81,239	81,239	162,586	10,713	173,299
Newquay	81,239	81,239	162,586	10,713	173,299
Wadebridge	81,239		81,239	7,142	88,381
Bodmin Camelford Bude Launceston	243,878	243,878	487,756	37,510	525,266
Saltash Torpoint Looe	162,586	81,239	243,825	14,284	258,109
Liskeard	81,239	81,239	162,586	14,284	176,870
St Austell	121,939	121,939	243,878	14,284	258,162
	1,381,708	1,097,183	2479323	162,495	2,640,968

Appendix E2. Annual Variable Costs of Land Ambulance Utilisation.

	hrs year day shift	variable costs	hrs year night shift	variable costs	total variable costs
Penzance	1460	17,520	1071	12,852	30,372
Carbis Bay	718	8,616	639	7,668	16,284
Helston	1028	12,336	639	7,668	20,004
Redruth	2543	30,516	2233	26,796	57,312
Falmouth	1424	17,088	913	10,956	28,044
Truro	2026	24,312	1223	14,676	38,988
Newquay	1284	15,408	791	9,492	24,900
Wadebridge	1077	12,924	803	9,636	22,560
Bodmin	1211	14,532	900	10,800	25,332
Camelford	1083	12,996	748	8,976	21,972
Bude	347	4,164	310	3,720	7,884
Launceston	408	4,896	493	5,916	10,812
Saltash	809	9,708	523	6,276	15,984
Torpoint	316	3,792	274	3,288	7,080
Looe	383	4,596	219	2,628	7,224
Liskeard	1150	13,800	870	10,440	24,240
St Austell	2093	25,116	1350	16,200	41,316
					399,936

Appendix E3. Total Fixed and Variable Costs per Ambulance Station

	Fixed cost	Variable cost	Total cost
Penzance	253,998	38,879	292,877
Carbis Bay	48,381	7,405	55,786
Helston	169,728	20,004	189,732
Redruth	350,168	57,312	407,480
Falmouth	173,299	28,044	201,343
Truro	173,299	38,988	212,287
Newquay	173,299	24,900	198,199
Wadebridge	110,456	22,560	133016
Bodmin	92,047	25,332	117,379
Camelford	110,456	21972	132,428
Bude	122,729	7,884	130,613
Launceston	177,958	10,812	188,770
Saltash	172,933	15,984	188,917
Torpoint	51,622	7,080	58,622
Looe	33,554	7,224	40,778
Liskeard	176,870	24,240	201,110
St Austell	258,162	41,316	299,478

Appendix E4 Land Ambulance Sparsity Regression Model

Land ambulance costs = 11.2 - 0.229 sparsity.

Predictor	Coef	StDev	t-Ratio	P
Constant	11.225	1.051	10.68	0.000
Sparsity	-0.22872	0.05433	-4.21	0.001

S = 2.050   R squared = 54.2%   Adj R squared = 51.1%

Analysis of Variance.

Source	DF	SS	MS	F	P
Regression	1	74.438	74.438	17.72	0.001
Error	15	63.010	4.201		
Total	16	137.448			

Unusual Observations

Obs	sparsity	LA Cost	Fit	StDev Fit	Residual	St. Residual
1	2.0	14.66	10.763	0.956	3.987	2.15R
17	33.9	7.120	3.467	1.043	3.653	2.07R

R denotes an observation with a large standard residual.

Appendix E5 Air Ambulance Sparsity Regression Model.

AA costs = 16.5 - 0.433 sparsity.

Predictor	Coef	StDev	t-Ratio	P
Constant	16.483	1.933	8.53	0.000
Sparsity	-0.43314	0.09994	-4.33	0.001

S = 3.770   R squared = 55.6%   Adj R squared = 52.6%

Analysis of Variance.

Source	DF	SS	MS	F	P
Regression	1	266.95	266.95	18.78	0.001
Error	15	213.17	14.21		
Total	16	480.12			

Unusual Observations

Obs	sparsity	AA Cost	Fit	StDev Fit	Residual	St. Residual
1	2.0	23.02	15.608	1.758	7.412	2.22R

R denotes an observation with a large standard residual.

Appendix E6 Fitted Values for 'Land Ambulance Only'

Sparsity	Cost per head	Standard dev	95% con int
5	10.082	0.822	8.33 - 11.83
10	8.938	0.627	7.60 - 10.28
15	7.794	0.509	6.71 - 8.88
20	6.651	0.522	5.54 - 7.77
25	5.507	0.659	4.10 - 6.91
30	4.364	0.862	2.53 - 6.20
35	3.220	1.095	0.89 - 5.55

Appendix E7 Fitted Values for 'Land Ambulance With AA'

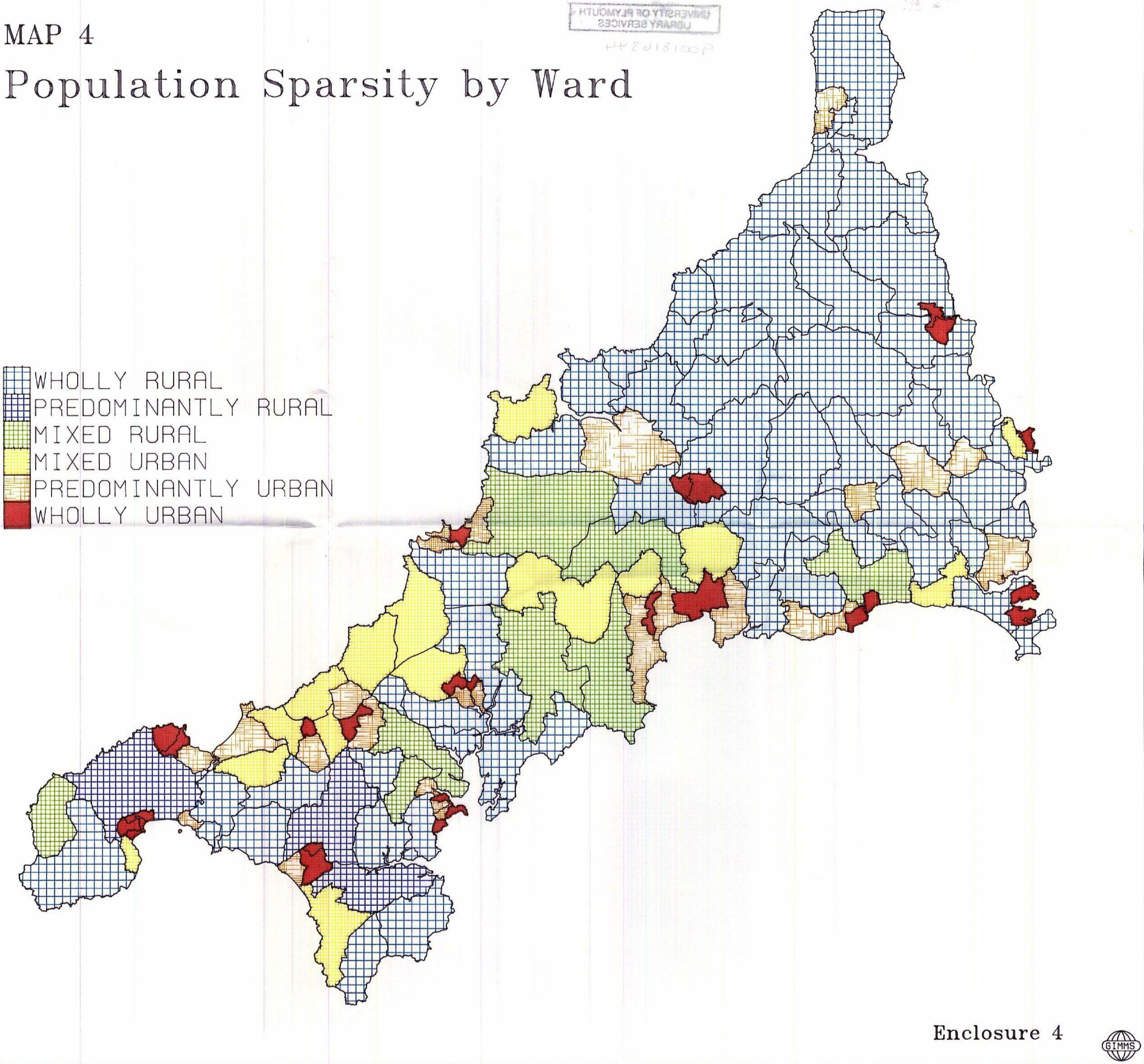
Sparsity	Cost per head	Standard dev	95% con int
5	14.318	1.511	11.11 - 17.54
10	12.152	1.154	9.69 - 14.61
15	9.986	0.937	7.99 - 11.98
20	7.821	0.961	5.78 - 9.87
25	5.655	1.212	3.07 - 8.24
30	3.489	1.585	0.11- 6.87
35	1.324	2.014	-2.97 - 5.66

Appendix E8. Predicted Costs Per Head for Each Ambulance Station For 'Land Ambulance Only' and 'Land Ambulance With AA'

Ambulance station area	Predicted Cost per head (£) land ambulance with AA	Residual	Predicted Cost per head (£) land ambulance only	Residual
Camelford	15.63	2.22	10.76	2.15
Bude	14.67	0.62	10.26	-0.00
Looe	12.82	-1.24	9.28	-0.46
Wadebridge	12.77	-0.13	9.25	-0.74
Liskeard	12.61	-0.58	9.17	0.70
Launceston	11.85	1.06	8.76	0.45
Helston	10.10	-0.67	7.84	0.11
Bodmin	9.67	1.00	7.61	0.44
Truro	9.10	-0.93	7.31	-0.81
St. Austell	8.58	-0.96	7.04	-0.93
Saltash	8.53	-1.06	7.01	-1.26
Redruth	7.9	-0.48	6.68	-0.28
Newquay	6.7	-0.45	6.04	-0.5
Carbis Bay	6.92	-0.76	5.93	-1.13
Falmouth	3.18	1.15	4.19	1.55
Torpoint	2.63	0.01	3.89	-0.68
Penzance	1.81	1.64	3.46	2.07

MAP 4

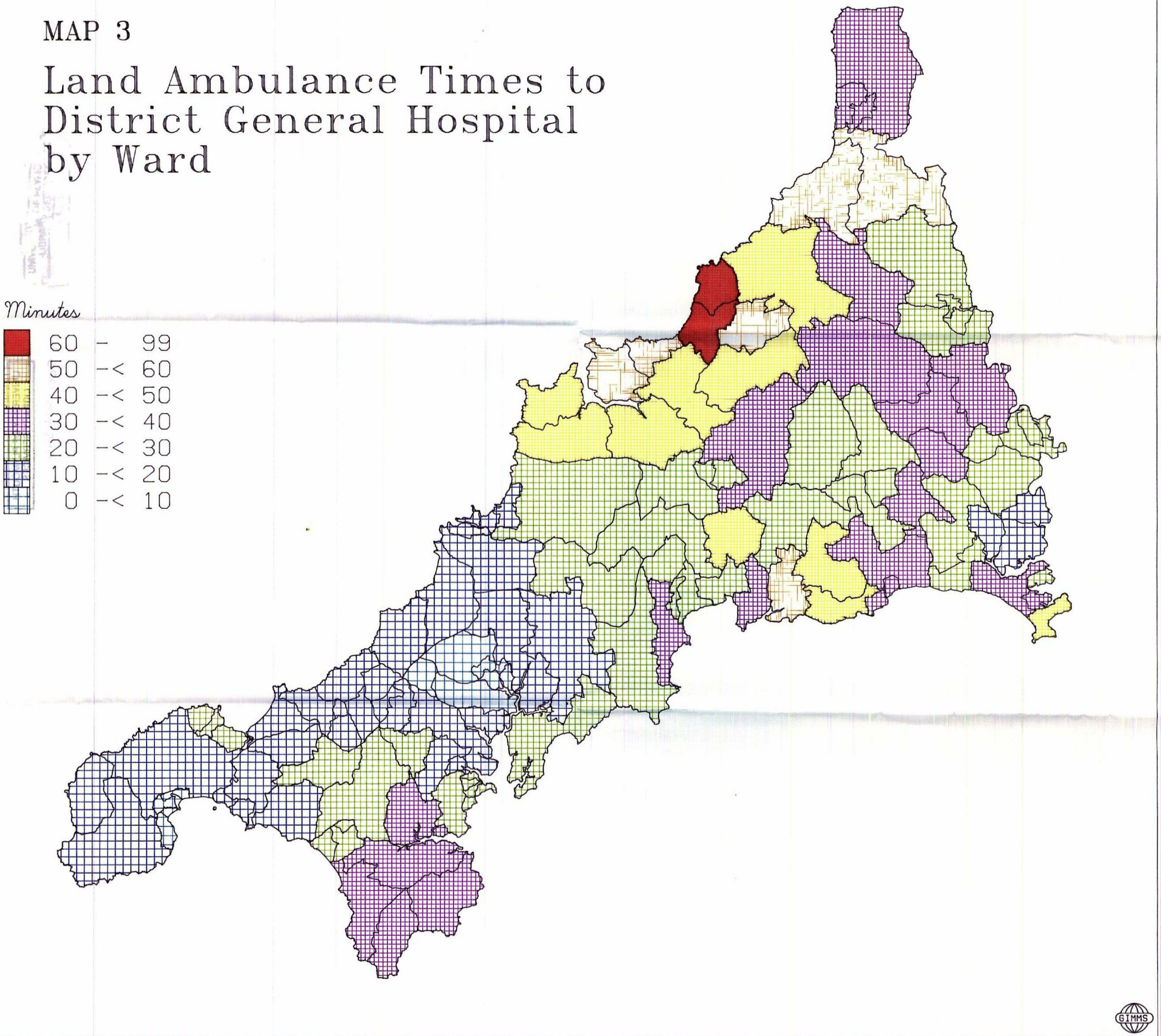
Population Sparsity by Ward



Enclosure 4

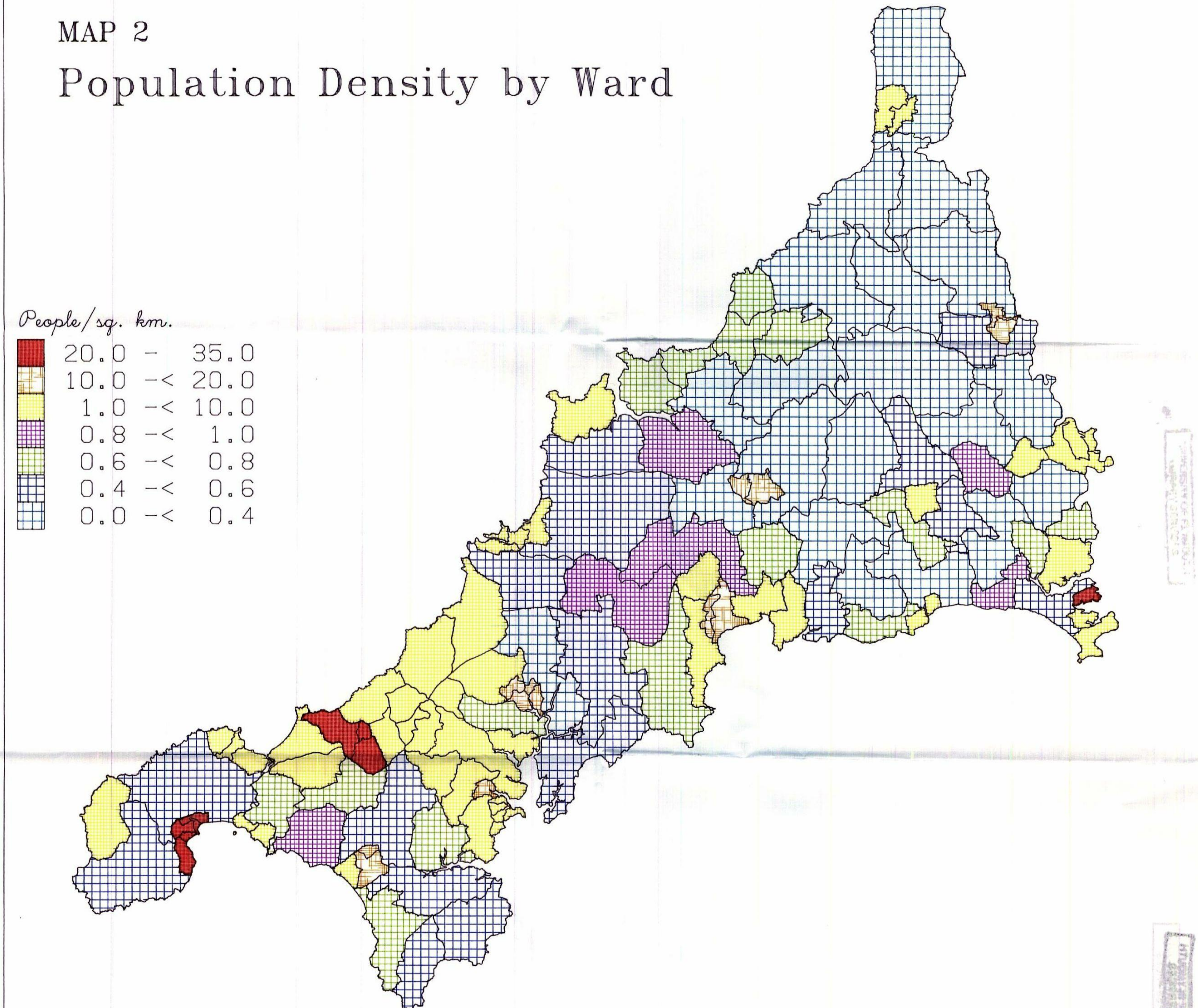
MAP 3

Land Ambulance Times to District General Hospital by Ward



MAP 2

Population Density by Ward



MAP 1

Areas covered by Ambulance Station