UNIVERSITY OF SOUTHAMPTON

EXPLORATION INTO THE BEHAVIOUR OF CARDIAC WAITING LISTS

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A thesis submitted in accordance with the requirements for the degree of Doctor of Philosophy

Faculty of Social Sciences
Department of Management

March 2001

UNIVERSITY OF SOUTHAMPTON

ABSTRACT

Faculty of Social Sciences

Department of Management

Doctor of Philosophy

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By Nicola Anne Hilton

This study explores the behaviour of cardiac waiting lists as they are of political and public concern. It investigates what dynamics are present between the different waiting lists run within a cardiac department. It also looks at how waiting lists interact across the medical/surgical boundary. In addition the thesis examines whether doctors are in control of waiting lists and what factors might affect any decisions they make regarding their waiting lists.

A System Dynamics model is presented focusing on the effect of resource provision on waiting list length in a Cardiac Surgery department. Qualitative data are then collected through the use of open ended questionnaires and interviews of relevant hospital personnel. The information gathered relates to doctors attitudes to and opinions on waiting lists. It is incorporated into a second System Dynamics model which spans both the Cardiology department and the Surgery department.

The findings reveal that decisions made in one department, designed to improve a waiting list, can have an adverse effect on another. It is also shown that doctors do control the dynamics of waiting lists though this is due to their clinical decision making being compromised through the insufficient provision of resources. Many factors are identified which affect waiting lists and clinical decision making.

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Acknowledgements

I would like to thank my patient and calm supervisor, Dr Ruth Davies, whose support throughout this project has been unwavering.

My thanks also go to all the doctors who kindly gave up their time to fill in questionnaires and undergo my interviewing.

I am most grateful to all my PhD colleagues and other friends, in particular Tim, who has kept me amused through the completion of my work.

And last, but by no means least, I would like to thank my parents and my dog for all their encouragement, advice, love and tail wagging.

1 Introduction

The National Health Service (NHS) was set up by the Labour Government of 1946 in an effort to bring health care within the reach of the whole population irrespective of class, gender, colour, domicile, race or membership of insurance schemes. Despite these good intentions, from the beginning the service has been plagued by long waiting lists which do not seem to be equally divided through the population waiting for care. Waiting lists are a complex and undesirable element of the NHS, delaying treatment at present to over one million people (Department of Health 2000).

Waiting lists are created when patients are considered by doctors to require treatment and that treatment cannot be provided straight away. In general terms, a patient presents to a General Practitioner who assesses the condition of the patient and, if appropriate, refers them for further consultation or treatment by a specialist. There may be an outpatient waiting list on which the patient must wait to receive the consultation and a further inpatient waiting list for any treatment. In some cases, following treatment, another referral is necessary to another specialist for instance in the case of surgery. Again, an outpatient waiting list may be present for the consultation and an inpatient waiting list for the treatment.

In terms of the Government, 'the waiting list' is used to mean the total number of patients waiting for inpatient treatment.

1.1 Provision of care

It was initially assumed when the NHS was introduced that the amount of illness in the community was finite; that, in addressing the illness present at that moment in the population, the population would become healthier. With the provision of health care being free at the point of consumption there was concern at the cost of the service but, in applying the assumption of finite illness, it was believed that less health care would be required by the population as time progressed and so expenditure would gradually level off and even decline as less and less health care was used (Beveridge 1948, Ham 1992).

This assumption has been shown to be misplaced with just the reverse happening. Since its inception all aspects of the National Health Service have grown significantly. The number of patients receiving in-patient treatment, the number receiving out-patient treatment and the variety of treatments available have all steadily increased over the past half century and it follows that expenditure has also risen. In the immediate years following the start of the NHS concern was expressed at the cost of the Service with spending already being much greater than had been allowed for in parliamentary estimates. A committee was set up to investigate this in 1953 and it was concluded that even more funds should be made available for the provision of health care.

Despite such increases in funding and despite the provision of health care increasing for the population, the number of people waiting for that health care has also increased creating what is recognised as 'one of the largest queues in the Western world; that is the waiting list for admission to British National Health Service hospitals' (Lindsay and Feigenbaum 1984).

1.1.1 Present levels of care

The NHS still aims to operate in accordance with its initial aim of providing a comprehensive range of services 'covering every branch of medical and allied activity from the care of minor ailments to major medicine and surgery; to include the care of mental as well as physical health, and all specialist and general services' (Min 1944).

There were 11,983,893 funded Consultant episodes in the first quarter of 1998 as compared with 3,821,200 patients in the whole of 1949. Despite this increase in throughput, there is a waiting list with 1.2 million patients waiting to receive treatment as of the end of January 1999 (Department of Health 2000).

In theory it does not matter how many people are on the waiting list, what really matters is how long each person has to wait. Five million people on the waiting list would be no problem if they could be treated in three weeks, but there is sufficient evidence to show that the longer the waiting list, the higher the proportion of patients who will have to wait a long period for admission (Yates 1987).

1.1.2 The History of the Waiting List

It is a common belief that waiting lists are a phenomenon of the present, however they have existed since the inception of the NHS in 1948. It has been shown that not only have waiting lists been increasing in recent times, but they have been increasing since 1949 when the NHS inherited a ready made waiting list, in particular for surgery and gynaecological treatment, of 498,000 (Doran 1990).

1.2 Directives to improve waiting list situation

The number of patients waiting for treatment and the length of time they must wait is of constant concern, in particular to the Government for whom waiting lists are regularly used as a measure of success. A defining moment in the first year of the Labour Government was seen to be the point at which the dole queue was overtaken by the sick queue, and with unemployment receding as a political issue the NHS waiting list replaced it as a 'Government virility symbol' (Warden 1998). However, already by 1990 concern was being expressed over the use of the waiting list time as a performance indicator. With waiting time being defined as the time from being entered on the waiting list by the consultant to being admitted to hospital, in order for people to have an early outpatient appointment longer waits for surgery would be experienced. Williams (1990) suggested that, as waiting times were being used a performance indicator, administrators were loathe to address this situation.

1.2.1 NHS Internal Market

One of the explanations for the presence of waiting lists in the NHS is that the service is inefficient in the way it is run (Yates 1987). In 1991 the Conservative Government created the Internal Market which was designed to create greater competition amongst medical care providers and to improve efficiency (Holliday 1992). It was set up in response to acute funding problems that developed in the 1980s and whilst it did not tackle the long term under funding problems of the NHS, it sought a way to ensure that existing resources were used as efficiently as possible (Ham 1996).

The main changes concerned the delivery of health services. They were intended to create the conditions for competition between hospitals and other providers and to allow the money to follow the patients overcoming the 'efficiency trap', (the use of global budgets for hospitals that provided a fixed income regardless of the number of patients treated). This was to be implemented by splitting the roles of purchasers and providers:

1) the creation of self-governing NHS trusts to run hospitals and other services
2) the transformation of district health authorities into purchasers of services for local people
3) the opportunity for larger General Practitioner practices to become purchasers of some hospital services for their patients as General Practitioner fundholders
4) the use of contracts or service agreements to provide links between purchasers and providers

Despite these changes the Government announced that the basic principles on which the NHS was founded would be preserved.

A further change to the NHS was announced in the November 1998 Queen's Speech when the Labour Government confirmed its intention to replace fundholding with commissioning and to revise the role of health authorities/boards. Authorities and boards now have a duty to improve the health of their population, to encourage co-operation between the various sections of the health service and to oversee the development and implementation of local health targets (RCGP 1999).

1.2.2 Waiting List Fund

With the presence of waiting lists comes public demand for more funds to be made available in order to combat the problem and a belief that the provision of such funds will combat the problem. In 1991 William Waldegrave (1991), the then Secretary of State for Health, announced that £35 million would be allocated to the Waiting List Fund to tackle long waiting lists, with £9 million of that total earmarked specifically for the country's longest lists. In 1993 another £2 million was made available to fund '30 innovative 'pacesetter' projects to help cut down waiting times' (Bottomley 1993).

Despite these consistent injections of cash, waiting lists have not reduced and have recently been seen to increase by over 100,000 patients, bringing the total waiting list across the country to 1,297,700 as of June 1998 (Liberal Democrats 1998). This situation suggests that an increase in funding is not the answer and this has been reiterated by Street and Duckett (1996) who argue that 'traditional suggestions such as spending more money ... are unlikely to result in resolution of waiting list problems'.

1.3 What are Waiting Lists?

Other than a 'virility symbol of the Government' as mentioned above, waiting lists denote people waiting, *in absentia,* for treatment promised by a physician. The waiting list is often referred to, particularly in politics, as a total number of people waiting and this figure is taken as a yardstick for the success of an administration. However, this is a rather simplistic view of the situation.

It has also been described as an inaccurate situation. Following a basic statistical analysis of the number of patients admitted under the care of one General Surgeon over a three month period it was concluded that the waiting list is a poor indication of the number of patients awaiting hospital admission, with the true number being nearly 80% greater (Sykes 1986). Governments and parties in opposition regularly argue over waiting list figures with accusations put forward of 'rigging' and 'fiddling' data to get an 'acceptable' answer. In November 1998 it was reported by doctors and Trust hospitals that NHS waiting lists were being manipulated to back Government claims that the numbers of patients waiting to be treated were falling (Macdonald and Wilson 1998). In March 1999 the Conservative Party accused Frank Dobson, Labour's Health Secretary, of 'fiddling' by not including certain groups of patients waiting for treatment' (Hall 1999). They claimed that the actual figure stood 'some 229,698 higher than Labour claim'.

1.3.1 When does the waiting begin?

Waiting has been defined as the point at which a patient was placed on a waiting list but waiting could also be thought to begin when advice from a GP is first sought, or on referral to a consultant for further treatment. Whilst a patient cannot be placed on a waiting list until they have presented with symptoms, in the patient's mind the wait begins even earlier at the onset of symptoms, not a figure that can be easily assessed (Homa 1998). Such differences in defining the start of the wait could explain allegations of 'fiddling' but are evidence more of confusion.

The number of people waiting for treatment is, therefore, not necessarily the best way to monitor a service. In addition to inaccuracy, there could be reasons that are not immediately obvious, for the figure being as it is. For instance, Frankel (1993) explains that the waiting list length could remain static, but that this could hide an increase in treatments carried out, alongside an increase in demand and referrals. The static nature of the waiting list in this case belies the increase in health care provided and so cannot stand as a measure in itself.

The term 'waiting list' also implies a level of simplicity. When a patient has seen a doctor and the decision has been made that the patient requires treatment, that patient is placed on a waiting list until the treatment becomes available. Hospital waiting lists differ in several respects from, for instance, a bus queue where people are served on a first come first served basis. Health care is often provided on a 'worst come first served' basis. It is rare that there is only one waiting list for a treatment adding to the complexity of the situation (Pope 1991).

1.3.2 Who is treated first?

In 1993 the Department of Health released a statement connecting waiting lists and clinical priority (Department of Health 1993). It stated that 'The Government has always made it clear that clinical priority should determine when a patient is treated'.

Clinical priority is not however the sole influence on the decision taken as to when a patient should be treated, in particular with the introduction of the Governments 'Long Wait Policy' as part of the Patients Charter. This states a limit within which patients should be treated and penalties are imposed on institutions who do not reach the targets set (Patients Charter 1991). This policy works to 'upgrade' the priority of a less urgent clinical patient, by stressing the length of time that they have been expected to wait and not on their clinical need.

1.4 Is the Waiting List a Queue (Who is Waiting?)

With patients being 'chosen' for treatment it has been questioned as to whether the waiting list can be considered a queue in the traditional sense. Prior to the Patients Charter, Frankel (1991) proposed the notion of viewing the waiting list not as a queue but as a mortlake, in which 'the meandering flow succeeds in taking a short cut, and so leaves an isolated lake'. This is a metaphor of the health service in which patients waiting for certain procedures are bypassed or set aside.

Frankel has shown in this study that waiting lists are not universal within the health service, with quite specific groups of patients waiting. He identified two specific areas of responsibility for these patients waiting. 'Public opinion' he claims 'does not seem to have a general interest in problems like piles, hernias and varicose veins'. These conditions are associated with poverty and stereotypes of failure. Alongside these conditions others associated with ageing, for instance hip replacements and cataracts, are also prone to long waiting lists. The Patient's Charter was set up to address such long waiting lists.

Public opinion is not the only influence as it is the medical profession that selects patients and sets priorities both within and between procedures. The interest of the medical profession in waiting list conditions has been shown by Frankel in a study described by Pope (1991) as illuminating. A ratio was calculated of the number of papers published on a topic to the quantity of clinical activity that it represents and it was shown that many waiting list conditions are at the bottom of this list, e.g. cataracts. Frankel believes that this lack of interest in waiting conditions is reflected in medical practice. However this does not explain the presence of long waiting lists in the cardiac sector where patients are waiting for procedures to correct life-threatening conditions.

1.5 Where are Waiting Lists found?

Taking the example of the cardiac department, which will be central to this thesis, there are many stages in the clinical process at which patients may be expected to wait. On referral from a General Practitioner a patient must wait to receive an appointment to be seen as an outpatient. This wait is limited by the Patients Charter, stipulating that once referred to hospital, nine out of ten people can expect to be seen within 13 weeks; everyone can expect to be seen within 26 weeks (Department of Health 1991). Once seen in Outpatients, if the condition presented is considered to require further treatment a patient is placed on a waiting list for inpatient treatment and must wait until a date becomes available. The length of this wait depends on the priority given to the patient by the Cardiologist according to the severity of their condition.

If the patient then receives treatment from a Cardiologist and shows a need for surgical intervention he is referred by the Cardiologist for an outpatient appointment to see a Surgeon. He joins yet another waiting list and eventually is seen by the Consultant Surgeon who places him on another waiting list, according to the severity of his condition, where he waits for an admission date. This shows that if a patient presents requiring cardiac surgery there are at least four waiting lists through which a patient must progress prior to surgery.

1.6 Perspectives of Waiting Lists

The many explanations put forward to explain the existence of waiting lists often stem from the perspective from which the waiting list is viewed. The health service has many 'stakeholders' each with their own objectives alongside the goal of the NHS to provide quality and length of life and these can often be conflicting in their aims.

1.6.1 Hospital Clinicians and Management

On an individual level, long waiting lists for a Surgeon can imply prestige, proof of the respect held for him/her in the medical community and a demonstration of their ability as a doctor. This can counteract the pressure from the public and Government to reduce waiting lists. On a more generic level, waiting lists can serve to bring more finances into a department and can be used as a political tool by both physicians and management in order to enhance the provision of such funds.

1.6.2 The Private Health Care Sector

Private health companies use the public awareness of long waits for consultations and treatment as a strong selling point for their policies. They emphasise that the growing demand placed on the NHS 'inevitably leads to operation waiting lists', and they state that, 'should you need to see a Specialist, you know you will get an early appointment', if health insurance is purchased (WPA 1997).

Waiting lists are of benefit therefore to the Private Health Care industry and also to the physicians and Surgeons who work within it. Those conditions that are treated most in the private sector have been shown to be those with the longest waiting lists in the NHS (Yates 1987). This provides another incentive to maintain waiting lists rather than to work to reduce them.

1.7 Patients

It is the patient requiring treatment who is most affected by the waiting list and its length. This wait can however be good for the patient.

1.7.1 'Time heals all ills'

On occasion, patients are added to a waiting list of some length and, during their wait find that their condition has improved and that the planned treatment is no longer required. Le Fanu (1996) has reported in the Sunday Telegraph how a businessman, having been advised to undergo immediate surgery by an American Physician for the treatment of piles, was told by his English Doctor, 'Very nasty .... Come back in seven days'. The businessman, though concerned at the lack of action, accepted this advice and returned a week later walking briskly and having avoided painful surgery. In the same article, a Brighton journalist, having had a similar experience with a lump on his thumb, believes the moral to the stories is that 'NHS waiting lists and time can be great healers'.

1.7.2 Distress / Anxiety

There are many aspects of waiting for treatment which can cause anxiety on behalf of the patient and it has been recognised that long waits can cause great distress (Bottomley 1993, Propper 1994). Anxiety is considered to be an almost inevitable component of many surgical and medical conditions. It is a universal human emotion closely allied to fear, which has many physical manifestations including loss of sleep, raised blood pressure, irritability and eczema (Goodman & Gilman 1991). Such distress can increase the progression of disease and a long wait for treatment adds to this.

1.7.3 Disease Progression

Many diseases are not static in nature, but will, given time, get worse. The patient afflicted with the condition must live with a greater degree of incapacitation due to this progression, e.g. cataracts. Yates introduces readers to his neighbour Mrs G who was diagnosed with a back condition which required an operation and was placed on a waiting list.

> 'There she stays and her condition slowly deteriorates. During these five years my children have grown up watching the lady next door becoming more and more stooped as she moves around her kitchen or walks in her garden. She is in constant pain but puts a brave face on it.' (Yates 1987)

Whilst this is an emotive description it illustrates the undesirable reality of waiting lists.

1.8 Conclusion

Waiting lists hold a significant influence over the National Health Service and its management. With guidelines set out specifically to target waiting lists and significant funding provided to target waiting lists, the waiting list tail seems to be wagging the NHS dog (Frankel 1991).

Waiting lists are highly complex problems. For an improvement to be made in the length of waiting lists, a greater understanding of the behaviour and interaction of those lists needs to be achieved. It is not sufficient to focus on one explanation for the presence of waiting. For example one explanation, that the waiting list pre-dates the inception of the NHS and as such is just a backlog of work 'does little to help us understand their true dynamics' (Pope 1991).

1.9 How waiting lists can be better understood

The content of this chapter describes the waiting list and shows the complexities associated with it. The influences affecting the waiting list are many and to improve understanding of waiting lists the effects of these influences on the waiting list should be investigated.

Independently some influences have been studied (Street and Duckett 1996, Pope 1991, Propper 1994, Gudex 1990), but to provide further insight into waiting lists the influences should be drawn together and the overall effect on waiting lists investigated.

This thesis aims to improve the understanding of waiting lists with the objective of answering the following questions:

1) What dynamics are present between different waiting lists? Although the Government states a single figure for the number of patients waiting for inpatient treatment there are, in fact, waiting lists for nearly every procedure. These dynamics will be explored taking cardiac waiting lists as an example

2) Do doctors control the waiting lists? It has been stated that doctors control the waiting lists (Light 1997) but doctors deny this (Aiono 2000). The factors involved are investigated.

3) Do waiting list policies in one department affect waiting lists in another department? Decisions made in one department may have an effect on how another department runs.

4) What factors affect waiting lists? There are believed to be many factors which may affect the length of a waiting list and these are investigated.

5) What factors do waiting lists affect? There are also many factors upon which waiting list length acts and these are explored.

2 Literature Review

2.1 Introduction

This chapter aims to draw together the research that has been conducted in the waiting list field highlighting the many aspects that can be investigated. It aims to show that there is no right or wrong way of investigating waiting lists, each approach providing further insight. The approaches cover costs of waiting lists in terms of funding and allocation of funding, and costs to the patients, the role of rationing in health care and the role of the waiting list in rationing. It will also be shown that there is still an element of confusion about the dynamics of waiting lists and that there is more that can be studied in terms of the sensitivity of waiting lists to doctors' decisions about referral and acceptance for treatment.

2.2 Economic explanations for waiting lists

Economics in this context is concerned with the costs of the provision of health care, the benefits attained from the provision of that health care and the supply of, and the demand for, that health care.

2.2.1 Supply and Demand

Waiting lists are a manifestation of the imbalance between the supply of health care and the demand for that health care (Frankel 1993). The supply of health care is the number of patients who can be treated according to contract and resource constraints. The demand for health care is the number of patients who have been deemed in need of clinical treatment by a doctor.

2.2.2 Zero-pricing policy

The presence of the imbalance between the supply and demand for health care has often been attributed to the lack of a pricing mechanism for seeking and obtaining treatment. From an economist's point of view, if there is no cost to the consumer to obtain a commodity then demand for that commodity is not controlled. With a zero price allocation, consumers are not deterred from the market and it is characterised by excess demand. Economists recognising that the resources available for medical care are scarce frequently promote the idea of a pricing system as an equilibrating mechanism (Frost 1980). Whilst this idea would work in the commercial sector in order to 'control' demand for a product, health care is not controlled in such a manner. Health provision prior to the setting up of the NHS was based on an ability to pay and the aim of the NHS after 1948 was to provide health care irrespective of wealth.

Globerman (1991) shows a simple diagram to demonstrate a model of excess demand. Assuming the given demand curve D_h determines the demand for the whole range of health care, at price P_h the quantity of demand would be shown by Q_h, as illustrated by point A. As such, a supply of health care, quantity Q_h, would satisfy the demand.

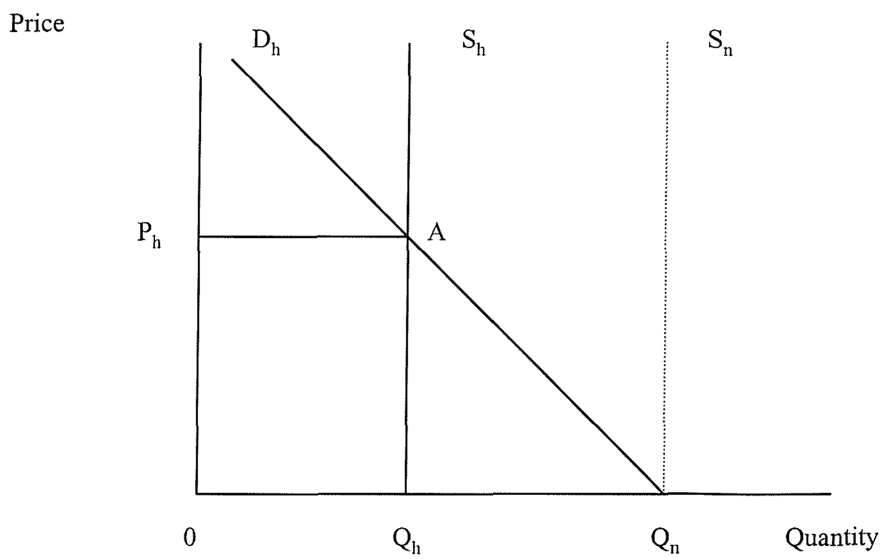


Figure 2-1 Excess demand for medical service Globerman 1991

As can be seen from the figure however, as the price for seeking and receiving treatment reduces, so the demand for treatment increases due to the cost of the treatment to the consumer becoming more acceptable. As the price for health care approaches zero, that is health care becomes free to the consumer, an increase in the quantity demanded from Q_h to Q_n is seen.

In the above figure the supply curve is shown by S_h, a finite amount of health care. It is shown by the graph that if the demand curve crosses the x axis to the right of this supply curve, the demand for health care has exceeded the supply available. A supply of S_n would be required to meet the demand. A characteristic of this inequality between supply and demand when applied to the health service is the presence of waiting lists.

2.2.3 Supply-induced demand

In theory this diagram shows that a demand for health care can be met by supplying the quantity Qn. However the effect of supply-induced demand makes this difficult to achieve in practice (Frost and Francis 1979, Wennberg et al 1982). The provision of increased resources has been shown to lead to an increase in demand creating a vicious circle and a rather pessimistic outlook for the future of reducing waiting lists. This relationship can be shown using simple influence arrows as shown in Figure 2-2 below. Following the hypothesis of supply-induced demand, as supply increases, demand increases, causing a further increase in supply.

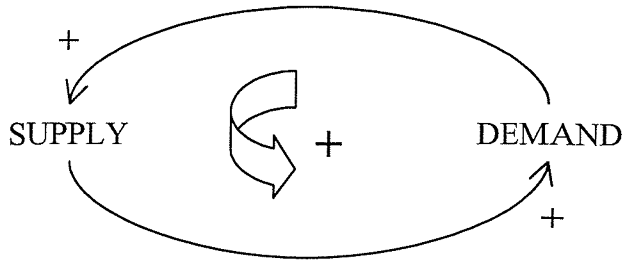


Figure 2-2 Diagram to show the relationship between supply and demand

Frost and Francis (1979), carrying out a study in order to explore the permanency of waiting looked at the hypothesis that a 1% increase in consultant numbers would lead to a 1% increase in the waiting list. This study was in a general surgical department within Trent Regional Health Authority.

One of the main conclusions following the investigation was that the dynamic effect of an increase in consultant numbers would still be detectable some years after the initial increase and the hypothesis of consultant-induced demand seemed encouraging. The study concluded also that the consultants are acting as the agents for the patients and it is therefore up to them how much surgery is ordered. The more consultants there are, the more surgery can be ordered and the greater the demand.

There are many advocates of this principle. Cullis and Jones (1985) suggest that increases in direct public expenditure or inpatient provision may cause consultants to stress the importance of inpatient care. Street and Duckett (1996) suggest that reductions in waiting lists are not likely to be achieved using the traditional method of increasing funding. Frost and Francis (1979) propose that if resources were directed to increasing the availability of beds, the policy might be ineffective or even counterproductive in reducing waiting list length.

The increase in 'resources' can relate to a myriad of aspects of health care including the provision of more beds for inpatient treatment or the opening of theatres at evenings and weekends as well as an increase in the number of clinicians or actual funding. In looking at figures relating to outpatients seen in Great Britain, Roland and Morris (1988) concluded that the number of outpatients seen was strongly associated with the number of consultants and only weakly associated with actual need for outpatient services. They suggested that interpretations of the variations in the supply of specialists should be considered as a factor that may influence the referral behaviour of general practitioners; the presence of more surgeons causing more surgery to be ordered and so a greater demand for treatment.

2.2.4 Infinite Demand or Unmet Need

The presence of this variability of demand has been described as 'an iceberg of unmet need' (Yates 1987) that need at times being considered infinite. The conventional view of the infinity of demand is sustained by the persistence of waiting lists which, in the absence of adequate empirical population data, are taken as an indicator of overwhelming demand. West (1993) does suggest though that the reality of 'infinite' demand, as opposed to excessive demand, can be discounted by *'reductio in absurdum'*.

Goldacre et al (1987) looked at the relationship between admissions from the waiting list and the length of the list, the hypothesis being that when admissions from the waiting list increased the length of the waiting list would decrease, and vice versa. However they found that no such simple relationship existed and they considered it likely that the ability of the system to meet expressed need by admitting patients to hospital influences patients and their doctors to translate previously unmet need into demand.

Yates (1987), however, states that we should not blame surgeons for creating waiting lists, that they are just taking on more of the 'iceberg of unmet need'. The role of physician decision thresholds has been mentioned by some researchers (Frankel 1993, Yates 1987, Houghton and Brodribb 1989) but little has been written about the influence it has over demand levels and therefore waiting list levels.

2.2.5 Non-monetary factors affecting demand

Acton (1975) investigated the role of non-monetary factors in the demand for medical care. He states that to reduce waiting lists, supply could be increased to a sufficient level to meet demand (assuming that infinite demand is not a reality), or demand could be decreased to the level of supply possible. The decrease in demand, from an economic point of view, comes from the controlling element of a price for a commodity. As health care is free at the point of delivery Acton suggests that it is reasonable to expect an alternative mechanism to control demand, that is non-monetary factors functioning as prices in discouraging demand.

2.3 Non-monetary explanations for waiting list lengths

The increased availability of specialists enables an increased level of research, investigating disease and discovering new forms of treatment. Such 'advances in medical science enable surgeons to intervene earlier, more speedily and more effectively and in pushing back the barriers they create a demand which is soon translated into a waiting list' (Yates 1987). An example of this can be seen in cardiac surgery and cardiology.

Cardiac surgery and surgeons are still the choice targets for the news media and the public because heart surgery is glamorous, the operations are expensive and post-operative death is a highly visible end point (Parsonnet 1995). This public awareness has resulted in a large amount of research into heart disease, its prevention and its treatments. This in turn has led to previously accepted risk factors becoming less of a concern. Katz and Chase (1997) investigated the risks of elderly patients associated with undergoing cardiac operations - elderly being defined as over the age of 70 - and they concluded that 'modern surgical techniques and clinical practices have reduced the importance of the age factor'. This immediately enables a greater percentage of the population requiring cardiac surgery to be suitable for such treatment.

Recent research and the implementation of new techniques may serve to reduce lengths of stay following treatment, costs may be reduced or medical alternatives may be found to previously time-consuming and expensive surgical interventions. Again within the field of cardiac surgery and cardiology, studies have been carried out investigating the cost-effectiveness of alternative methods of treatment and clinical practice. In 1989 Haywood et al (1989) looked at the insertion of pacemakers as day cases, as opposed to the procedure requiring the patient to remain in hospital overnight. It was concluded that patients found day case treatment as acceptable as conventional admissions and there was no evidence that there was a higher rate of complications or that it imposed a greater burden on GPs in the ensuing month. They suggested that pacing centres with a similar proportion of suitable patients to the cohort studied could hope to double throughput.

The use of rapid recovery techniques following coronary artery bypass grafting has also been investigated (Ott 1997). The procedure had been applied successfully to young patients with normal ventricular function but had not been investigated with regard to the elderly patient regarding whom early discharge from some hospitals was resisted. They found that application of the rapid recovery protocol helped expedite recovery for all patients regardless of age, acuity of illness, or associated conditions. The subsequent lengths of stay following the surgery were reduced significantly and considered appropriate for the elderly.

Such developments can help to increase throughput without a concurrent increase in the availability of facilities but also increase demand through improved treatment methods.

2.4 Resources

The use of resources in an efficient way aids the minimisation of waiting lists as throughput is enhanced. There is an argument to encourage waiting lists to be maintained at a certain level in order to ensure that expensive resources are not left lying idle for want of suitable patients to use them. Waiting lists are however, usually much bigger than are required for this purpose (Worthington 1987).

2.4.1 Theatres

A report in 1989 by the National Audit Office suggested that NHS operating theatres were used for only 50-60% of the time for which they were available. One of the reasons for this was the non-attendance of patients selected from the waiting list. Houghton and Brodribb (1989) investigated the booking mechanisms of two surgeons to determine the reason for this under-utilisation; one used a waiting list system and one kept a diary giving all patients in clinic requiring an operation a date for admission. It was found that 15% of those called from the waiting list and 6% of patients with booked admissions failed to attend for operations after arrangements for their admission had been made. This finding suggests that both prospective patients and the waiting list system itself should shoulder some of the responsibility for inefficient use of theatre slots which directly affects the length of the waiting lists. This was corroborated by Frankel et al (1989), who noted the importance of efficient administrative arrangements in order to facilitate attendance.

2.4.2 Staff & Beds

To have either beds or surgeons idle suggests inefficiency somewhere in the system, but there are many reasons that could explain this apparent waste of resources (Yates 1987). For instance financial constraints may prevent there being sufficient people to properly staff the beds, or that the variation in admission patterns requires a large number of empty beds in order to cope. However, Yates concluded that there did not seem to be a simple relationship between districts that were regarded waiting list 'black spots' and those with beds, theatres or personnel idle. He suggested that significant improvement in the provision of health care and the length of waiting lists could be achieved if inefficiency in the NHS was eradicated.

The longer waiting lists are, the more resources must be directed to any administration system employed, and any resources used on administration are resources that are not being directly used for the provision of health care (Street and Duckett 1996).

2.5 Resource allocation

As there is a finite supply of financial backing the many treatments available on the NHS must 'compete' for the funding available. The Royal Commission on the NHS in 1979 (1979), noted the 'capacity of health services to absorb resources is almost unlimited' and 'choices have therefore to be made about the use of available funds and priorities have to be set'.

More recently Ham (1992) suggests that there are four perspectives from which the subject of resource allocation can be approached.

1) Geographical areas - The consideration of resource allocation by this means was suggested by RAWP (Resource Allocation Working Party) in 1976. The report showed that there are favoured regions within the NHS. In looking at the resource allocation for regions budgetary policy it was hoped that equity would be achieved over the passage of a few years. RAWP recognised that any change in budget allocation must be implemented slowly due to resistance from regions who already receive a generous share of the funds and who do not want to have to give up any of their funding.

2) NHS Services – There is distribution of funding across the services offered by the National Health Service with hospital, community, drugs and other general medical services e.g. dental and ophthalmic services, all requiring financial input.

3) Age - Resource allocation can be analysed by looking at the different age groups that use the service and the proportion of the budget that they receive. Analysis from this angle shows that the largest expenditure is for the very young and the very old, leading to concerns that with the increase in births and a greater percentage of the population surviving to old age, pressure will be put on the health service.

4) Patient groups – Allocation of resources on different patient groups can be analysed, which shows that acute hospitals take the largest division of the budget, followed by services for elderly people. The smallest proportion of the budget is spent on services for mentally handicapped people and children.

2.6 Measurement of Health

In order to determine a fair allocation of resources between different treatments and conditions there must be a common measure of health or disability. Without such a measure who is to say which condition requires more funding, whether hip pain and physical immobility in an elderly woman is more severe or less severe than heart pain and psychological incapacity in a young man, and who is to say how much of one balances how much of the other? (West 1991).

The QALY (Quality Adjusted Life Year) was developed to aid in determining priority amongst procedures. It is a measure which seeks to summarise the benefits of medical intervention in terms of the number of years of life it saves and the quality of life saved. It is possible to draw up a league table for different procedures, and if costs are available, to determine the cost benefits of the different procedures (Ham 1992).

It was introduced by Williams (1985) who first used the approach to decide whether or not the number of coronary artery bypass graft (CABG) operations should alter. He determined the cost-effectiveness of the procedure, relative to other claimants on the resources of the National Health Service. Williams, in studying CABG, took effectiveness to be the effect on life expectancy adjusted for quality of life. He determined that the cost-effectiveness for CABG operations rates well for severe cases of angina and extensive coronary artery disease, but less so for the less severe cases. It compared favourably with procedures such as transplantation but was probably less cost-effective than hip replacements.

Dixon and Welch took this further in the state of Oregon developing a unique method to aid in the setting of priorities in their health system which combines a cost-utility formula with the attitudes and values of the general public (Dixon and Welch 1991). The cost-utility method took into account three considerations:

i) how much a treatment costs
ii) what improvement the procedure is likely to produce on a person's life
iii) how many years that improvement will last.

The use of public opinion was considered to be of benefit but it was recognised that it was not easy to get an unbiased population at public meetings, attendees being more likely to be from a health background. The development and use of the QALY has not moved into general use and is not used in the allocation of waiting list places.

2.6.1 Social Worth

Though the problem of equitable and efficient allocation of resources has yet to be solved, Furnham (1996) investigated the factors that can influence non-medical decision-makers according to the notion of 'social worth'. He concluded that, in particular, whether a person smoked or not was an influential factor. Others were that females were more likely to receive a scarce resource than males and poor people favoured over rich. Political bias was also found to be influential with left wing patients preferred to right wing. It was recognised in the study that those questioned may have been encouraged to focus on variables which would otherwise have had little influence.

The idea of social worth was also expressed by professionals in a study by Varekamp (1998) who felt that it was not morally justifiable to other patients to give a non-compliant patient priority. This has been recently demonstrated (The Times 1999) when a doctor refused treatment to a man in need of a triple by-pass operation on the grounds that he had not given up smoking. The view of the Health Authority involved was that the 'risks of operating while he continued to smoke were considered too high by the doctors'. It was suggested in the article however that the patient had been denied treatment due to the fact that he still smoked and that there was an element of social worth applied; that it was not the operative risk that was the deciding factor, but that resources would be better to go to patients willing to help themselves.

The notion of a person's worth has also been manifested in the positioning of liver transplantation in the Oregon priority setting results (Dixon and Welch 1991). Two scenarios put forward for a patient requiring a liver transplant were 'cirrhosis of liver without mention of alcohol', and 'alcoholic liver cirrhosis'. Both scenarios were placed in category 5 which denoted a 'chronic fatal condition with treatment improving lifespan and well-being, but cirrhosis without mention of alcohol was ranked at 364 as compared with alcoholic cirrhosis at 695 (the higher the value the lower the priority). The idea that a person is directly responsible for their condition seems to have a bearing on whether they should be considered 'worthy' of funding.

2.7 Rationing & Priority setting

There are many definitions that have been used in research into rationing and they cover a broad spectrum from the alarmist to the benign as outlined by Mullen (1996). One such definition suggests, 'rationing means that government will deny one of its citizens life-sustaining medical care on the basis of an arbitrary budgetary limit'. At the other extreme it has been proposed that 'the elimination of care that provides no benefits at all' could be rationing, though this seems to be an attempt at efficiency rather than rationing.

Whilst the initial version proposed as a definition seems severe, publicity was given to Steven Thornton, the chief executive of the NHS Confederation, and his decision in refusing expensive treatment for Child B (Jamie Bowen) for cancer. Subsequently referred to as 'Mr. Rationing', Thornton was known as the 'man who would not sign the cheque' (Waters 1998) though Waters claimed that the case which has brought attention to the problem of priority setting in the NHS was not about rationing for financial reasons but about the appropriateness and effectiveness of the treatment available. Mullen suggests that there would have been considerable public sympathy for the victim if the argument had stated that even if the possible treatment had been cheap it still would not have been used. However, in a letter written to the family of

Jamie Bowen, the Chief Executive of the Health Authority supposedly wrote ' I considered that the substantial expenditure on treatment with such small prospect of success would not be an effective use of resources. The amounts available for health care are not limitless'.

This approach, though a logical one, goes against the basic philanthropic view of human nature where there is a voluntary promotion of human welfare. The general public, a recognised force in health care decisions, seems to hold the view that saving a life, in particular a child's life, is of such concern that it cannot be ignored irrespective of the many who could benefit from the same money but who are not in such dire need or who have less 'heroic' complaints such as piles or hernias (Frankel 1993). Such patients do not receive the same emotive response seen with, for instance, Child B.

This sentiment is challenged by West et al (1981), asking 'is there not, in fact, far more scope for achieving this by diverting attention and resources away from the life-threatening, but irremediable, towards the merely disabling, but curable?'. Mullen (1996) also expresses concern at reducing the value of human life to health care costs believing that the answers to such difficult questions must lie within the subject of medical ethics and not in economics.

The definition of rationing most suitable to the understanding of this thesis is written by Dougherty (1991) suggesting that rationing is 'a denial of services that are potentially beneficial to some people because of limitations on the resources available for health care. This means putting the common good ahead of the interests of individuals in some cases'. This definition seems to encompass the unwillingness to deny treatment to any person in need, but incorporates the requirement for cost-effectiveness in a market exhibiting excess demand.

The waiting list present in the National Health Service has for many years been seen as the only rationing device there is in a system where treatment is free at the point of delivery. It was explained by Lindsay and Feigenbaum (1984) that, in economic theory, 'if prices are below the market-clearing level, queues of demanders will form to ration the available supply'. They developed a theory that implied that the rate of joining will be negatively related to expected delay in supply and to the rate at which demand diminishes over time.

The use of waiting lists as a rationing mechanism is one explanation for their existence and Lindsay and Feigenbaum propose that as membership in such a queue itself imposes no cost, waiting lists may ration only through the influence of delay on the value of the good sought. Propper (1995) however counteracts this argument stating that waiting lists do have a cost to the consumer in terms of the restriction of a patient's daily activities. The cost to the consumer however is no greater than that consumer not being on a list, as rate of disease progression etc. will not be altered. It is possible that Lindsay and Feigenbaum consider there to be no cost to the patient whilst waiting as, the simple act of putting a name on a list itself incurs no cost. Lindsay and Feigenbaum are right to consider that a person having their name added to a waiting list will incur no specific cost, though the delay of treatment and the act of waiting will create a cost as argued by Propper.

Other costs considered to be incurred are anxiety to the patient due to lack of information and uncertainty regarding outcome, in addition to uncertainty as regards time or date of treatment. The cost to the patient in terms of anxiety is specifically investigated by Fitzsimons (2000). In this paper she determined that patients who are waiting for coronary artery bypass surgery require more information regarding their operation and the wait for their operation, in order to combat the fear associated with angina and the anxiety levels of the patient.

Street and Duckett (1996) believe that the inability of Governments to reduce waiting lists has been due to what they describe as a system of 'perverse incentives'. These are of two sorts, the capping of a department's budget with the consequence of ward closures and subsequent waiting list increases and the alternative which is the rewarding of 'hospitals with long waiting lists through the provision of additional resources'. It has long been recognised that, although the waiting list is generally considered to be a bad phenomenon and one that goes against the 'motto' of the National Health Service, there are health service personnel who regard the waiting list as a political tool of some value. With the introduction of the market state, purchasers are required to negotiate contracts determining the number of cases that will be provided over the year. If the waiting list for that procedure is considered to be too long, management then has bargaining power in order to procure more funds to increase throughput of patients through the department directly if facilities are already available, or indirectly by the improvement of facilities for the department. This approach to the use of waiting lists can also be applied to the Consultant who may wish to attract more resources to his/her specialty.

In Victoria, Australia, it was attempted to remove the ability to use the waiting lists as such a tool and, whilst ensuring that hospitals had sufficient resources to tackle any waiting list problem, financial rewards were available according to throughput, with 50% of a hospital's revenue being related to the number of cases and type (mix) of patients treated. This alternative incentive structure was seen to work immediately with overall waiting list numbers falling dramatically (Street and Duckett 1996). The change in the incentives for the Victorian hospitals provided evidence that with the right management approach, waiting lists do not have to be inevitable and can be reduced without necessarily investing additional resources targeted specifically at their reduction.

Amongst those who accept the existence of rationing there is debate as to whether it should be explicit or implicit. There is the argument that 'there is rationing going on out there - let's open our eyes to it, let's be honest about it, let's admit it and do something about it', (Waters 1998). This belief is also suggested by Mullen (1996), that hard decisions are what rationing is all about and that to let it carry on 'unchecked' is tantamount to cowardice.

The question of who should decide how rationing should be approached and the priorities in health care is addressed by Stronks (1997) in a study looking at the decisions that would be made by different panels of people regarding what should be included in a health care package. The panels included patients, the public (comprising university students and civil servants), health care professionals and health insurers. The panels were asked to economise nearly one third of the total budget for health care and, in addition, they had to decide whether a certain service should be included in the basic package (that is, provided with public funds) or should be removed from the package, either totally or partially. All choices had to be fully explained.

The study highlighted several differences in the approach to allocating the resources available across a health care package, with the main difference being the extent to which they took the principle of equal access into consideration. The main conclusion from the study was that to include all the involved parties in the decision making process in an attempt to achieve more equitable or broadly supported outcomes would not work. This suggests that, though to ration is a 'threatening' prospect and too much for one group, too many cooks may spoil the broth!

2.7.1 Rationing within a specialty

The rationing discussed so far has looked at the allocation of resources of a macro nature. It has been concerned with the distribution of the overall health care budget across every facet of medicine offered by the National Health Service. However, resource allocation and rationing is not only relevant at this level of health care provision. It is also necessary at a more micro level and is responsible for determining how resources should be distributed within a specialty once a budget has been allocated. In a study carried out by Naylor (1990) the panellists involved were specifically asked to approach the study into consensus principles for coronary revascularisation with an appreciation that resources for the revascularisation programme were in competition with other worthy programmes. It was found that there were three key determinants of urgency ranking:

i) symptom status
ii) coronary anatomy
iii) results of non-invasive tests for ischaemic risk.

The study was designed to show how a formal consensus process can help set guidelines for identifying patients who deserve priority for revascularisation. The priorities involved within a specialty are determined by two 'priority' approaches; clinical and political.

While the distribution of the health care budget can be considered political, the Government can and does suggest which patients should receive attention within an allocated service according to their clinical need as defined by a physician. A prime example of the Government suggesting a priority for treatment is the 'Long Wait' policy explained in the Patient's Charter (Patients Charter 1991). In the Charter it is specified that patients should not be expected to wait more than 12 months for treatment and their priority for treatment increases as they approach and pass this length of wait. There is often a financial penalty for the institution that is unable to adhere to these guidelines.

Such financial penalties are, as mentioned above in the words of Street and Duckett, 'perverse'. A vicious circle is created if those hospitals that are not able to provide treatment within a time limit are subject to a reduction in their funding. This reduces the facilities that can be provided and can create further waits.

Government guidelines such as this cause patients who have been waiting for twelve months to be treated with greater priority, at times, than a patient with a greater clinical need and questions have been raised as to whether the Governments drive to reduce long waiting times should be able to override clinical need (Appleby 1993).

2.7.2 Priority setting on a clinical level

Despite the globally known ability of the British to queue in an orderly fashion, in the National Health Service the usual 'first come first served' of a queue becomes 'worst come, first served'. This is without the intervention of Government as discussed above, with those who are considered to have less immediate 'need' of treatment being expected to wait.

Clearly, from an ethical point of view, it is not appropriate to keep a person waiting who is in immediate need of treatment, however the criteria used to determine who is 'worst' are varied and numerous.

Varekamp (1998) studied the allocation of urgency within two sections of health care; renal transplantation and psychogeriatric nursing home care. This comparison was designed to explore the ethical consideration on patient selection for scarce resources choosing two quite different specialties, one a 'care' service, and the other a 'cure' service. Following qualitative data collection in the two services, the processes involved in the allocation of urgency were analysed.

For patients requiring renal transplantation the Eurotransplant waiting list distinguishes the following categories: highly urgent, highly immunised, immunised and transplantable. It is stated that patients with a high antibody level often have to wait a long time for treatment and that by placing these patients in a higher 'urgency' category waiting times may be reduced. Whilst the influence of waiting lists and waiting times on the allocation of an urgency status is often denied in the NHS, here we see that it is a factor in the decision making process.

Consensus amongst clinicians was hard to find with doctors differing in their attitudes and approaches to urgency codes. Factors such as the mental well-being of a patient was of considerable importance to some physicians, whereas this problem was not considered a good enough reason for a high urgency status by others. Highlighting this, one doctor was quoted as saying, 'It is better to jump off the roof without a new kidney than with one'.

In comparison, such socio-economic factors hold greater importance in the urgency allocation in the psychogeriatric service. Criteria for urgency include the overburdening of 'informal carers', the development of behavioural disturbances in the patient like aggression or wandering, inadequate formal care or the loss of informal care perhaps due to failing health of the carer. Interpretation of these criteria is, as with renal transplantation, 'somewhat arbitrary' with nursing staff having 'their own strategy' to influence urgency admissions, and it is noted that 'very long waiting times, actual or expected, may be an additional reason for giving a highly urgent code'.

With renal transplantation the allocation of urgency is based on criteria that are patient-centred whereas with the nursing home care, more emphasis may be put on the informal carer. The concept of urgency in these two health services appears to be equivocal with inter-professional variation preventing the equality of allocation. In order to provide treatment in an 'equal' fashion it is concluded by Varekamp that criteria for the allocation of an urgency category should be defined more precisely and the goals of the urgency category should be further discussed. Expanding this thought, it follows that whilst goals should be more specifically defined, the manner in which they are applied should be more rigorously monitored in order to try and gain some equality in the distribution of treatments.

Work has been carried out by Naylor (1991) in an attempt to reduce the inequality seen to be present in the assignment of priority to patients requiring coronary revascularisation. In light of the long waiting lists in Canada, the approach brought together 16 specialists in the cardiac sector who were asked to rank how urgently 438 fictitious cases were in need of revascularisation and how long each 'rating' should be expected to wait for treatment.

In the absence of formal schema for assigning priorities variations in practice were inevitable and for only 1% of cases was there agreement on a single rating by at least 12 out of the 16 panellists. Whilst it was mainly clinical factors that were considered in rating urgency the relevance of the waiting list was not ignored. Each category of urgency was accompanied by a maximum acceptable waiting period which patients assigned that urgency could be expected to wait for treatment. The panel specifically stated that in adopting the recommendations the panel itself were not countenancing the delays in treatment that were outlined as a maximum wait, but that the protocol should help to form more rational queues for coronary revascularisation. In this study there was no consideration to the possibility that a wait for a patient may prove beneficial to the patient as is suggested by Dr James Le Fanu (1996). Angina, for instance, a symptom relieved by coronary revascularisation, can get better over time.

Brook (1988) studied the differences in diagnosis and treatment of coronary artery disease between doctors in the USA and the UK. Two panels of experts were asked to consider the 'appropriateness' of angiography and bypass grafting according to the possible benefits to the patients, excluding any cost considerations. The study was undertaken because there was a large difference in the number of operations carried out per million population; in 1985 the rate of coronary artery bypass graft operations was 1000 per million population in the USA compared with 210 per million population in the UK. The difference could not be explained by disease prevalence, teaching methods or access to scientific information. It was concluded that the diversity came about due to differences in the methods of practising medicine, and the cultural and economic attitudes of the patients. Although all members of the panels were asked to disregard cost as a factor it was recognised in the analysis that such considerations could have had a subconscious effect on the decisions made, hence on the results. The study was described in the concluding remarks as being 'crude', because, for instance the use of percutaneous transluminal coronary angioplasty (PTCA) was not considered. It did however demonstrate well the influence of the doctors on the decision making.

It is the behaviour and attitudes of physicians that determine which patients are considered appropriate for treatment and, once placed on a waiting list, it is the decision of the physician which patient is chosen for treatment. There is also pressure from other doctors persuading physicians to accept their patients. Several researchers mention the role of doctors in waiting lists but few focus on the importance of this.

2.8 Summary of issues

The review has provided a summary of the issues associated with waiting lists and health care provision. It has demonstrated the variety of aspects that are relevant to the problem and the diversity of issues considered important. It has set the scene for a study to draw together those issues in an attempt to understand what creates the waiting list.

Waiting lists are an issue of importance due to the recognised effect that the delay of treatment has on patients and their families. In drawing together both qualitative and quantitative issues discussed it will be argued that the influences considered to act upon waiting lists, are in fact acting upon the decision makers, the doctors. It is the response of doctors to these identified stimuli that control the dynamics of the waiting lists. It is not the intention of this thesis to blame or accuse doctors for the presence of waiting lists, but to draw attention to the fact that they have the responsibility for the dynamics of waiting lists and are allowed little or no authority to prevent them.

2.9 Waiting lists for patients with Coronary Artery Disease

The waiting lists investigated in this thesis are cardiac waiting lists which hold patients who are suffering with Coronary Artery Disease. The details of the condition and the treatments provided are explained in Appendix 1. Many reasons have been put forward as to why general waiting lists exist, lack of interest in the disease from the point of view of the profession and the public and lack of urgency in terms of non-fatal diseases. However, neither of these conclusions explain the presence of cardiac waiting lists, making the waiting lists of significant interest.

Within the cardiac specialty there are waiting lists run for each procedure offered and different waiting lists run within each procedural waiting list according to the degree of patient need. The dynamics of these cardiac waiting lists and their interactions are complex. Also, patients with cardiac problems may require the services of more than one department allowing investigation of how departments interact and how waiting lists are affected across a departmental boundary.

Cardiac waiting lists are complex, prevalent and life-threatening, making them an ideal example to study with the aim of further understanding waiting list dynamics.

3 Methodology

The waiting lists present in the cardiac sector that patients must join in order to receive treatment are seen as a problem by patients, doctors, managers, politicians and the general 'healthy' public. The delay in treatment has been shown to be bad for patients' health due to the anxiety of the wait and disease progression (section 1.7.2). The effects of such delays on staff are severe as patients call to try to find out more about or improve their position on a list, or require more nursing due to the increased severity of their status when finally admitted, increasing workload.

As waiting lists are used as a universal measurement for determining how well Governments are governing, there is great interest politically in keeping them low. Much money has been allocated to their control, special initiatives have been set up to 'conquer' waiting lists, (section 1.2), and yet, they are still present and still are considered to be too long.

Logic suggests that if the funding and the throughput were increased, more patients would be treated, fewer would then be waiting for treatment, and waiting lists would reduce, but this appears not to be the case, (section 2.2.3). If waiting lists do not respond to changes in throughput in this way, another element or elements must be influencing the list length. The interactions between influential elements and the waiting list need to be investigated to determine how they work and why the allocation of money has not worked. The investigation focuses on the waiting list problem experienced in the cardiac sector where patients encounter long waits for treatment, whilst suffering from a progressive disease.

To answer the questions posed in section 1.9, both qualitative and quantitative techniques were required. Numerical information would be needed to investigate the dynamics of waiting lists both inter and intra department. Influences and opinions would need to be included in any analysis to determine where control of the waiting lists lies and the factors that affect any dynamics.

This chapter first explores different research approaches available and then looks in detail at the methodologies chosen for the study.

3.1 Characteristics of the Waiting List problem

Waiting lists are highly complex, partly due to their far-reaching nature and the subsequent number of influences that act on waiting lists, and partly due to more detailed interactions between waiting lists within one department, and also between the waiting lists of different departments. Complexity comes when decisions made in one department not only affect the waiting lists within it, but have knock on effects causing change in other departmental lists. This will be demonstrated in Chapter 7.

Focussing on the influence these decisions have, the effects they produce, and including the influence the waiting lists have on these elements, is an important feature of the problem. It is not sufficient to observe an influence in only one direction, but it is necessary to see if the consequence of this influence has any further effects. This is known as feedback and is vital to understanding how waiting lists interact and why they are resistant to efforts to reduce them.

3.1.1 Quantitative element

Reports on waiting lists all focus on the quantitative element of the subject as a means of providing a picture of the situation. Government waiting list information states the number of people waiting for treatment and the number of weeks they must wait for that treatment. It is these numbers which are brought to the attention of the public and on which hospitals are judged.

At a more detailed level, rates that patients arrive for treatment, the number of patients who can be treated with available resources, the number of beds which are open or closed, or the number of staff able to work, combine to make the quantitative element of waiting lists very important.

However, whilst such numbers are important, there are other characteristics of the problem to be included in order to give a more realistic picture of the situation.

3.1.2 Qualitative element

There are many aspects of the waiting list problem which are qualitative or 'soft' and it is crucial to include these when exploring or investigating a human based system. Waiting lists, while reported numerically, have many qualitative influences acting upon them. The patients that make up the list exhibit behaviour influencing doctors in an attempt to be treated sooner. The doctors can react to patients requests, to the waiting list lengths and to pressure on them from Governments, all in addition to clinical variables. In turn Government (which is allegedly human) reacts to public opinion, media influence and waiting list statistics, making decisions which feed back to a clinical level.

With all these behavioural interactions, and more, the qualitative element of the waiting list problem is as important as the quantitative one and a combination of the two is required to investigate the problem.

3.2 Techniques employed in waiting list research

With such varied issues being associated with the phenomenon of waiting lists it follows that the approaches used to investigate those issues are themselves varied.

3.2.1 Queuing Theory

A branch of mathematics, queuing theory was specifically designed to analyse problems such as what resources are required in order to keep waiting times within acceptable limits. It requires information concerning the rate at which customers arrive, and the pattern of that arrival, the distribution of service times and the number of servers e.g. beds. With these data, various characteristics of the queue can be determined such as the average waiting time, the average length of the queue and the probability that a customer will need to wait before being served.

Waiting lists are often seen as queues of people waiting for treatment and although this is rather a simplistic view, queuing theory has been used in an effort to highlight the implications of attempting to reduce waiting lists. Worthington (1987) describes how a consultant's waiting list can be considered as a queuing system. The service is considered to be hospital inpatient treatment, with the number of beds considered to be the servers as he assumed that it is the number of beds that imposes a limit on the number of people in the service. The time that it takes to treat a patient, that is the patient's length of stay in hospital together with a short turnover time in which the bed for the next patient can be prepared, is the service time.

Arrivals in to the system come from General Practitioner referrals, via a waiting list, or as an emergency case. Worthington notes that feedback due to the lengths of the waiting list affects the decision of physicians to refer and the decision of the patient to accept referral. He concludes that it is rare that conventional 'solutions' solve the problem; that increasing bed numbers or decreasing service time, whilst improving the service provided, has little effect on the waiting time for patients.

The mathematics of queuing theory is currently being applied to the modelling of waiting lists for outpatient clinics and inpatient admissions, (Goodyear 1997), showing that it 'courts disaster' to design a system so that its capacity can cope only with average demand.

3.2.2 Discrete Event Simulation

Simulation has become well established as an aid to decision-making in both business and industry. It has provided a means of altering real-life values without having to intrude on the real world that could prove costly and disruptive.

When formulating a simulation the boundaries of the system to be simulated must be identified. The smaller the system, the easier it is to model but this will be of little use if those elements left out of the system are likely to have a considerable influence on the pertinent results (Davies 1985).

In the health services simulation and modelling have been used by Davies (1994) to provide a management aid in planning services for patients with coronary artery disease. The simulation was formulated using Pascal and was used to predict the resource use and cost arising from the treatment of patients with coronary artery disease. The results were able to identify a bottleneck associated with the number of cardiology beds available, and though the aim of this study was not to investigate waiting lists, it follows that unless more beds were provided waiting lists and times would build up. A similar study was carried out using simulation which showed that the provision of laboratories offering angioplasties (a treatment for coronary artery disease) was a significant bottleneck (Hilton 1995).

While DES models allow patients to have individual attributes and to interact with resource provision they are can be time consuming to test, run, and to formulate as they require a large amount of quantitative data. They also use little qualitative information to influence the dynamics.

3.2.3 System Dynamics

System Dynamics, as an analytical modelling methodology, can be attributed to Jay Forrester, whose work at the Massachusets Institute of Technology led to the development of the process (Forrester 1969a). It is an off-shoot of Industrial Dynamics which involves the study of the fundamental aspects of manufacturing systems and their interactions.

Using Industrial Dynamics as a stepping stone, the role of System Dynamics (SD) was originally as a computer simulation method to aid the analysis of complex socio-economic systems (Wolstenholme 1999). Initially the diagram from which the model was created was dominated by mathematical equations, as may be implied by the term computer modelling, however it is now not just quantitative information which is utilised by SD.

Forrester put forward the idea that any situation can be considered as complex in terms of stocks and flows, where the flows are defined as the way in which the elements of the model are connected. These connections define the structure of the system and may form loops hence feedback can be demonstrated. The analysis of this feedback and the effects of the interactions are considered a fundamental aspect of SD as it is a view which places emphasis on such structure and the processes within that structure.

Influence diagrams became important in their own right displaying the model, moving away from the numbers and providing a high level means of conceptualising models in terms of the feedback properties. The idea of using such models was to increase the insight into managerial issues by determining, rather than calculating, the behaviour, over time, of the system represented.

While System Dynamics has been used in health research its role in the studying of waiting lists and their interactions is not extensive. Wolstenholme (1993) applied the method to a community care system aiming to further understanding of the system and to clarify the role of System Dynamics as a framework for strategic debate. It is highlighted using a System Dynamics model that in the past for instance, GPs have rarely had to think about the 'downstream' consequences of their referrals. Such feedback loops are an important element of the System Dynamics approach and of the way in which complex systems are controlled.

Lane (2000a) has used System Dynamics to explore factors that contribute to the long delays experienced by patients waiting for admission to an Accident and Emergency ward. The approach allows understanding both of how social systems change over time and how these changes are best influenced. One of the most important factors it allows is the element of feedback and influence from factors both internal and external. It is these feedback loops which control the flow of patients in a hospital system and in modelling them insight is gained as to how they are linked together. Information at this level provides a basis for policy decisions and longer-term strategy.

As Lane describes, though System Dynamics is the result of forty years sustained development, it could have been tailor-made for the intricacies of a hospital environment. This thesis uses the approach of System Dynamics to investigate further the interactions of waiting lists and the factors that are considered to affect them. This approach is not designed to provide accurate predictions, the emphasis of the modelling being to improve understanding and clarification of a complex environment.

3.2.4 Questionnaires and Interviews

System Dynamics has been criticised in the past for jumping straight to a quantitative model, bypassing the use of qualitative data in the form of causal loop / influence diagrams (Wolstenholme 1993). To glean qualitative information it is recognised that models should be built interactively with the system participants.

Such qualitative based studies have provided insight into day to day organisation and management in a department. Pope (1991) specifically studies surgical waiting lists by drawing upon the sociology of work, highlighting the conflicts between different management and physicians, using qualitative case study data. The results from such studies create a useful 'stepping stone' to the modelling stage providing information on many social interactions present.

3.3 Choice of methodology

To explore the interaction of waiting lists, an approach was required that would allow a combination of the quantitative and qualitative characteristics discussed in section 3.1, with specific focus on the feedback elements believed to be present. It needed to be able to cope with numerical data in integer, distribution or graphical form, and support the inclusion of the 'soft' variables which can be quantified but not measured.

Two modelling methodologies were possible and choosing between them depended on the aims of the project, the nature of the conclusions to be drawn and the information considered necessary to be included. The two approaches were System Dynamics (SD) and Discrete Event Simulation (DES).

The overall aim was to observe the general flow of patients on to and off the waiting lists, looking at their interactions. It was not to try to recreate every individual patient making up a population, each with specific characteristics. In particular, an output of the study was to be an understanding of the behaviour of the waiting lists, as determined by the structure of the environment in which they exist. Specifically the initial phase of the construction of a qualitative map of causal structure was seen to be particularly informative and relevant. Because of the many qualitative inputs and influences present in the hospital system, the 'harder' more detailed models of DES seemed less appropriate.

The aim was not to try to recreate each individual entity as it joined or left a waiting list within the system, but to observe the general flow of patients onto and off the lists. This would allow the effects from decisions, and the knock-on consequences of any changes that had occurred to be seen. Any conclusions drawn were to be based on trends detected over time and not on absolute values. The overall goal of the investigation was to improve understanding of the internal interactions of waiting lists.

Given these criteria for choosing a methodology, System Dynamics was considered to be the most appropriate providing a proven medium for the inclusion of both 'soft' and 'hard' variables. It could be used to model the environment in which the waiting lists were present and to simulate how the waiting lists behaved following changes in the qualitative variables, and in quantitative information such as the number of treatments available.

As has been discussed in section 3.1.2 there is a need for qualitative information to enrich any model. The methodology used for the collection of this data was a combination of questionnaires and follow-up informal interviews.

The questionnaires allowed general information covering a broad range of topics to be gathered, with participants being chosen from each stage in the cardiac pathway; that is general practitioners, cardiologists and surgeons. For more detailed information and to clarify some of the comments, informal interviews were carried out, all of which were taped. Further details of this information collection are discussed in Chapter 5.

3.4 System Dynamics (SD)

3.4.1 System Dynamics software

In the 1970s and 1980s use of SD was limited to largely industrial application, partly because, at this stage SD had its own computer language. There were, therefore, limits for users due to the specialist skill this programming required. However, the mid 80's saw the advent of specialist software which managed to bring SD to a much broader audience. Such software allowed the creation of models electronically by creating stock flow diagrams directly on the computer screens as icons. These could be opened and data inserted in order to construct the mathematical simulation.

Software such as IThink and STELLA (both products of High Performance Systems, Inc.), has made SD more accessible. SD as an analytical process is now one of the tools of many consultancy firms, (Richardson 1999). It should be noted that the software does not provide support for influence diagrams as yet, focussing on the representation of the SD flow diagram.

3.4.2 Influence Diagrams

The initial discussion of the problem works to identify the elements considered fundamental to the system as a whole and those that are likely to generate an influence in the problem situation. Whilst determining these elements it should be remembered that the emphasis with SD is on structure.

The identified elements are placed within a boundary and a causal loop diagram which conveys the direction of feedback and influence is created. The terms influence diagram and causal loop diagram are considered to be synonymous by the majority of practitioners, (Lane 2000b). The notation associated with a causal loop diagram is described fully in Appendix 2 and an example is shown in Figure 3-1.

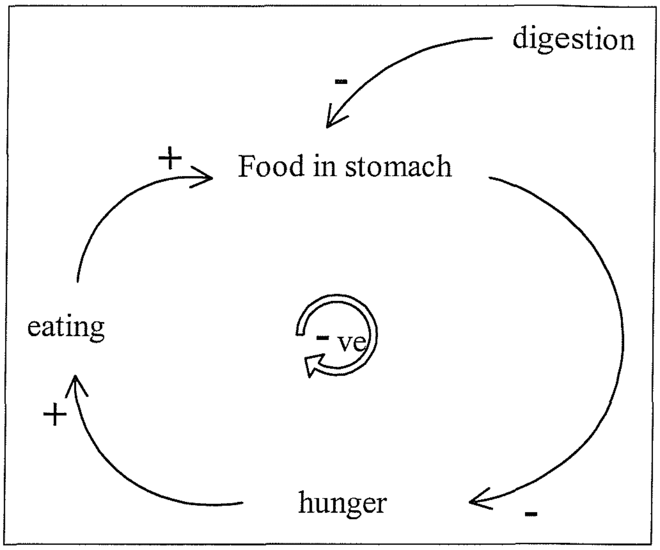


Figure 3-1 Causal Loop diagram to demonstrate notation

On completion of a causal loop diagram (CLD), behavioural relationships can be investigated and determined, though the dominance of the loops is difficult to allocate due to the lack of quantification.

3.4.3 System Dynamics Flow Diagrams

Once a causal loop, or influence diagram, has been constructed, if the quantitative stage of SD is to be used, the approach requires it to be converted to a SD flow diagram, (SDFD). In order to proceed with this conversion the relationships are considered to represent the flows and are described as the rate at which the flow contributes to a change over time. The specified elements are called levels which are quantities that dynamically change over time in response to rates in and out. The key to basic SD notation is shown in Appendix 3. Using this notation a SDFD can be built, depicting the same relationships as would be shown in a causal loop diagram, an example of which is shown in Figure 3-2. This is based on the CLD in Figure 3-1. The creation of the SDFD is the last step prior to mathematisation.

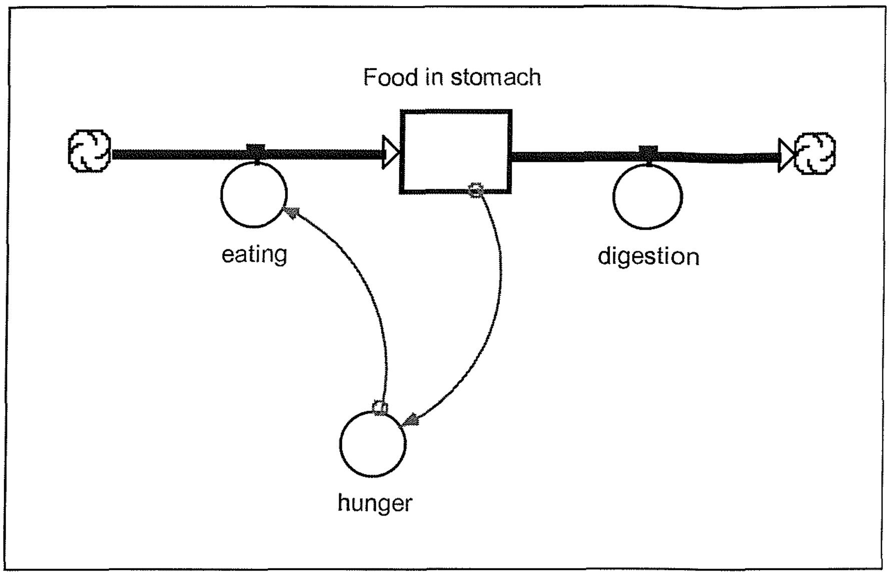


Figure 3-2 Example of a Flow Diagram using SD notation

The SDFD can be used instead of a CLD. The diagrams do not depict exactly the same information and both are appropriate under slightly different circumstances, depending, for instance, on the skill of the technicians and the audience for whom the diagram is intended, whether there is a qualitative, or quantitative bias (Wolstenholme 1999).

Because each have some advantages over the other, the processes could be used together, or in series. Initially a CLD could be constructed, concentrating on clarification of the problem area, guaranteeing a wider audience and increased understanding due to the simplicity of the notation. Having constructed a CLD the acceptability and understanding of a SDFD would be enhanced, providing more information about the model and allowing the difference between conservative flows and information links to be observed. The order of this process is discussed in section 3.4.7. This would allow advantage to be taken of both methods of representation, as 'the point where CLD disadvantages begin to dominate is strongly related to the point where SFD advantages emerge, and vice versa', (Lane 2000b).

For instance, the specific notation provided in SDFD's to distinguish between conserved flows and information links may prevent any misinterpretation based on a CLD. Referring back to Figure 3-1, whilst it is clear that an increase in digestion reduces the amount of food in the stomach, it could also be surmised that if digestion decreases, the amount of food in the stomach increases, which is not so. Once an influence diagram has been developed therefore, care must be taken in interpreting the relationships and the behaviour represented by the structure.

With SD models, the aim is not to produce an absolute value or result, but to understand the structure of the model, the relationships, and to observe model stability and long term changes. The introduction of hunger increases the complexity of the model as hunger is a 'soft' variable. Such soft variables could be omitted, but this runs the risk of leaving something essential out of the model. Soft variables can be woven into a model. Even variables that are not easily measured can be quantified. In this way it is possible to create models which include recognised 'soft' elements, such as hunger, self-esteem, knowledge, and to observe how they affect the behaviour observed.

3.4.4 Qualitative aspects of System Dynamics

Initially the qualitative element of SD was not considered to be an important part of the approach, with the equations derived dominating the model development process and the diagram of the system (Wolstenholme 1999). However recently the benefits of the qualitative aspect have been appreciated, with Wolstenholme and Lane being particular advocates.

Whilst the magnitude of the behavioural relationships defined is not shown at the qualitative stage, the direction of the relationships can be clearly demonstrated. They combine to create a view of the problem which is easily explicable to others. This aids discussion and hence clarification of the system.

Diagrammatic representation assists the sharing and expanding of ideas and can aid the mental models held by people. SD models are presented as abstract representations of the actual physical and information flows in a system stating a mental model in a precise way, (Lane 1999). This leads to improved understanding of the problem and enhanced dialogue regarding the problem. Overall, this supports the notion that the 'primary function of model building should be educational rather than predictive ...' (Sherman 1988), with a specific predictive role requiring the use of the quantitative stage, if not an even more numerical and specific process, such as Discrete Event Simulation.

The following paragraph from Richardson (1999) demonstrates the level of understanding that can be attained using simple CLD principles. It shows that very straightforward ideas and relationships can be used and even very young minds can grasp the behaviour represented and apply it to business philosophy.

> *'The teacher drew a causal-loop diagram with pictures instead of words, showing a pair of rabbits at the top, a lot of little rabbits at the bottom, and two arrows linking the two groups in the self-reinforcing loop that underlies rabbit population growth. She then asked the children for similar self-reinforcing processes. Many children drew the expected sort of pictures with a pair of horses and a lot of foals, a pair of people and a lot of babies, and so on, but one child drew a running shoe at the top and a dollar bill at the bottom, linked with arrows. He explained that "the more shoes Nike makes, the more money they make, so the more shoes they can make".*

3.4.5 Quantitative aspects of System Dynamics

Data are needed for initialisation of all levels and to determine the rates and model branching. Also, formulae are needed to define the feedback loops to be included in the model. It can be time consuming to collect such data. The issue of time becomes particularly relevant when data are difficult to access, or in an incompatible format. Another problem with data dependency is that the data itself may be dynamic so becoming 'out of date' quickly. It is therefore important to ensure that the data used in such models are as accurate as possible so that confidence can be placed in the results.

The use of data should also be balanced with an awareness not to over complicate the model. Having use of high-powered computers can encourage complexity unnecessarily, and even encourage the use of quantitative system dynamics inappropriately. There is a skill not only in using equations but in limiting their use (Wolstenholme 1999).

Despite the limitations to quantitative SD, its use brings many advantages to analytical modelling. Most importantly it allows the consideration of the magnitude of the relationships present, as defined by the model structure. The aim of SD is to investigate relationships and the behaviour those relationships demonstrate, but without a numerical base such behaviour is merely defined in terms of direction rather than magnitude.

3.4.6 Difference equations

On formulating the model and connecting stocks and flows together, the STELLA software generates equations which are known as 'finite difference equations'. These are based on DT, or 'Delta Time', which is the interval of time between calculations. It is expressed in the time unit defined in the model. Each stock equation in a model is a finite difference equation and solving these involves a two step initialisation process and a three step iterative evaluation phase. These processes are outlined in Appendix 2.

3.4.7 Combining Qualitative and Quantitative stages of System Dynamics

The use of both the qualitative and quantitative aspects of SD have been shown to be important and have specific benefits when investigating a problem. The sequential use of the processes has been suggested by Wolstenholme (1999) which is shown, in part, in Figure 3-3.

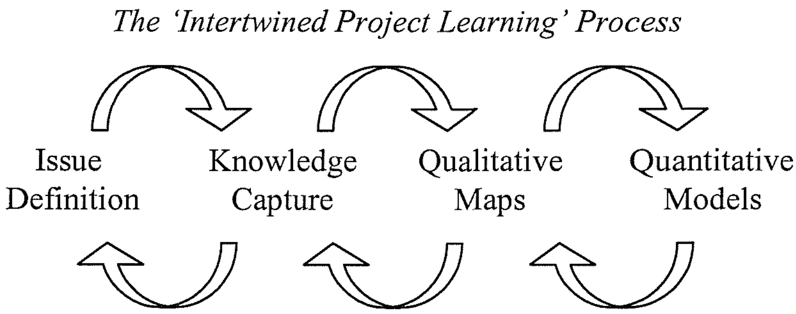


Figure 3-3 Blending Qualitative and Quantitative SD within projects Wolstenholme 1999

Figure 3-3 demonstrates the feedback nature of, not just individual SD models, but the whole process of building a model. It also shows how interdependent the different aspects of SD can be and how the qualitative and quantitative aspects can aid the overall analysis. Despite this, the flexibility of SD allows for any stage to be self contained if that is what is required.

3.4.8 Inputs of System Dynamics

The inputs to the different stages of SD can take many forms due to the different stages which require data. Inputs can be numerical in the form of numbers or graphs in order to provide data for the quantitative modelling. For the qualitative structuring and diagrammatic representation data can be in the form of discussion groups identifying the fundamental elements of a system likely to generate an influence.

3.4.9 Outputs of System Dynamics

Whilst the formulation of the problem provides increased understanding and this can be considered to be an output, more tangible output forms are available.

Outputs from SD simulations take two main forms; tables and graphs. These can be attributed to any elements which are specified in the model structure and each have their own uses. Tables provide more specific information, showing the numerical values calculated in each time unit. They can be used to identify if a variable is behaving unexpectedly, e.g. producing a negative value when a positive one had been predicted, and they can be used to isolate variables to allow focus on specific results.

Graphical display has advantages in that it allows the dynamics of the system to be more clearly represented, showing trends over time. In particular, comparisons can be made by plotting specific variables together, demonstrating the behavioural trends of elements and how they interact and respond to each other.

3.4.10 Applications of System Dynamics

Because of the flexibility of the process, along with its ability to combine both qualitative and quantitative information, SD has been applied in many different fields of study. The special issue in April 1999 of the Journal of the Operational Research Society (JORS 1999) demonstrates the breadth of relevance of the technique, focussing on System Dynamics and its influence on people, policy and management education. Just in this one issue the fields of application include defence analysis, project management, corporate diversification, electricity deregulation, petroleum exploration, and most relevantly to this thesis, health care. This list does not include the many references to other significant works such as Forrester's study into the counterintuitive behaviour of social systems (Forrester 1969b).

3.5 Quantitative data collection techniques

The acquisition of quantitative data relies heavily on the co-operation of third parties who have access to what is needed. It is known to be a time-consuming task and requires a clear understanding of the information sought. Examples of the formats of a theatre timetable and a catheter laboratory timetable, from which some data were gained, are shown in Appendix 5.

3.6 Qualitative data collection techniques

As discussed above, the role of qualitative information in SD is important, and it is no longer sufficient to collect solely numerical data. When modelling dynamic systems there are often 'soft' variables which are recognised as influential in the system, and which need to be included. Such variables are more likely to be appreciated by people who work within the system, highlighting the need for models to be built interactively with the system participants. This involvement ensures that those who know and work within the system are able to emphasise the important elements, with a system dynamicist able to facilitate discussion, or question aspects of it which may be taken for granted.

The method by which such information is obtained from participants depends on constraints which may be present e.g. time available, determination to see the problem solved, interest in the defined problem, understanding of the process being used, belief or trust in the process, impact of improved understanding on the stakeholder. It is not always possible to gather all participants together so other means must be employed.

Less involved information gathering can provide sufficient understanding to build a model, which can then be validated. Surveys and questionnaires can allow specific information to be sought without pressurising respondents and enabling them to answer questions in their own time. This process can also be geared to the type of response required, i.e. questions can be designed to require a 'yes' or 'no' answer, or could encourage annotation. Responses can be followed up with interviews to ensure clarity of understanding.

3.7 Role of mixed methodology

As has already been emphasised, System Dynamics requires both quantitative and qualitative information. The numerical data is relatively straightforward to collect and can be put into the model if that is what is required. The qualitative information must be understood and interpreted before it can be included in the model satisfactorily.

The interpretation and analysis of qualitative data is a very large subject area in its own right. The processes which are followed in techniques such as Grounded Theory and Ethnography are rigorous, developing a good understanding of the topics discussed and allowing themes and relationships to be detected.

It was therefore considered that a formalisation of the qualitative data collection and interpretation for System Dynamics would be of benefit, thus ensuring that the feedback relationships included in the model were based on demonstrable interactions present in the text collected.

3.8 Analysis of Text

Open-ended questionnaires were used to obtain information about the cardiac system and follow up interviews were used to gain further insight. The open ended responses need to be analysed in a systematic and structured way. This was initially done using The Ethnograph software.

[The Ethnograph is not to be confused with the qualitative analytical technique Ethnography. Ethnography is a holistic research method and is based on the assumption that something cannot be fully understood unless it has been experienced. It has the capacity to embody a variety of perspectives and settings and is used when there is a particular interest in understanding an organisation or problem (Borodzicz 1997).]

The Ethnograph is a piece of software that allows text to be ordered and drawn together, facilitating analysis. It is designed to facilitate the process of 'noticing interesting things within your data', 'marking those things with code words' and 'retrieving those things for further analysis'. This process of 'noticing' is highly interpretative and is based on reading and re-reading the data to be analysed, (The Ethnograph v4.0 A Users Guide).

The Ethnograph allows for all text to be entered and then coded. The mechanism for coding involves reading and re-reading the text and allocating a word to the sentence or paragraph to represent the issues mentioned. The word allocated is then defined clearly in a codebook to ensure that whenever it is used it is to mean the same thing. The software allows more than one code word to be applied to a section of text. The Ethnograph can then be used to search for specific code words drawing together blocks of related text across all respondents.

However, searching through the text was done using the question numbers from the questionnaires and not specific code words. This worked to draw together responses to the same question which could then be analysed. The most useful part of this whole process was found to be the reading and rereading of the text which ensures a detailed knowledge of the information provided. Access to the text within such software also saved time in searching for specific responses or quotes, acting as an electronic filing system. On many occasions, however, paper and pencil proved more useful in drawing topics together.

Once the topics discussed were drawn together it was necessary to identify how those topics had been linked together by the respondents. Some examples of connections were explicit and some less so.

e.g. '*...as the pressure builds up, the sickness rate goes up*'

pressure $\xrightarrow{+}$ sickness

'*... there is a guy in intensive care who was almost dead and every day he's in ITU it cancels another operation*'

severity $\xrightarrow{+}$ length of stay $\xrightarrow{+}$ cancellations

This output from the questionnaires and interviews provided the elements of the System Dynamics influence diagrams. This initial part of System Dynamics is very similar to the cognitive mapping used in, for instance Strategic Operations Development and Analysis (SODA), as recognised by Eden, (1989).

The connections identified were then joined to develop a full influence diagram, (see Chapter 6).

3.9 Application of the Methodologies

An initial quantitative model was devised using System Dynamics. The model focuses on the waiting lists relating to a specific aspect of the cardiac system, the surgical department, and is discussed in Chapter 4. The model was limited but in order to develop a more extensive one, more qualitative data were needed. This data then had to be gathered using questionnaires, follow-up interviews and informal interviews, and analysed. This is presented in Chapters 5 and 6.

The expanded version of the model, Chapter 6, encompasses the cardiac system from the referral of the patient with initial symptoms, through various pathways, until the patient leaves the system through discharge or death. It incorporates feedback mechanisms so the behaviour of the waiting lists over time, in response to changes within the system, can be monitored and interpreted.

The results from the expanded model are presented and discussed in Chapter 7 with conclusions on the thesis presented in Chapter 8.

3.10 Conclusion

System Dynamics requires the use of both qualitative and quantitative information but is not designed to provide a framework for collecting that information. A mixture of the two methodologies, data collection through questionnaires and interviews and System Dynamics, was suitable for this study.

4 System Dynamics Model

4.1 Introduction

The cardiac waiting lists hold patients diagnosed as having coronary artery disease of varying severity and requiring coronary artery bypass surgery. There are three main waiting lists run and details of these are given in section 4.2. Waiting lists in this area are long but it is not clear whether this length has implications on the different waiting lists present or what the effect of changes in contract levels is on how those waiting lists balance. The model aims to demonstrate the effects seen in waiting lists due to contractual changes. Contracts are between the Regional Health Authority and the hospital and define the number of patients who are to be operated on over the year. They define the number of scheduled patients to be treated. Patients admitted for treatment as emergencies do not count against the contract.

The model developed aims to examine the effect of the contract level on different categories of waiting lists.

4.2 Method

Data required for the development of this model were obtained through informal discussions with surgeons, secretaries and management in the cardiac department. Quantitative data came from databases, maintained voluntarily and independently by surgical staff and theatre timetables, which contained information on procedures and details about from which waiting list a patient had been admitted. An example of the format of the information is shown in Appendix 5.

Following informal discussions with surgeons, Figure 4-1 was developed. The figure schematically represents the passages possible for patients to follow having presented with cardiac symptoms to a Cardiologist and been referred for a surgical consultation. An outline of the symptoms associated with coronary artery disease (CAD) is provided in Appendix 1. At the start of the process the surgeon assesses the clinical status of the patient and determines, assuming the patient to be suitable for surgery, to which waiting list they should be added. The patient is categorised into one of three groups as depicted below; routine, urgent or unstable with increasing clinical urgency respectively. At this stage it is assumed that the patient is allocated to a waiting list based purely on clinical requirements. As coronary disease is progressive in nature it is possible for a patient to pass between waiting lists as their clinical status changes. This leads to an increased likelihood of a patient requiring reassessment and subsequently being allocated to a different list. If the patient is on the routine waiting list and the symptoms they experience worsen, that patient could be admitted to hospital to the unstable system, or as an emergency.

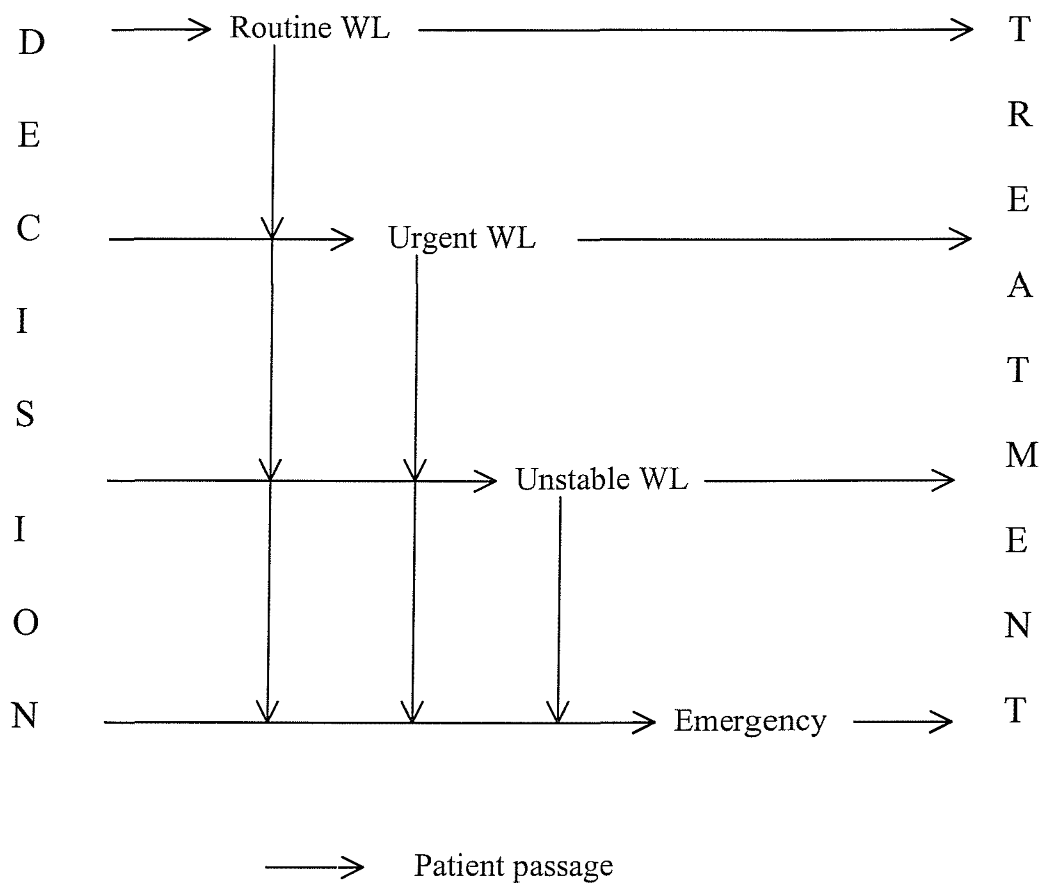


Figure 4-1 Schematic representation of cardiac waiting lists of different priorities

One further category is that of the patient who requires treatment as an 'emergency'. These patients do not get placed on a waiting list for assessment as they require immediate treatment and are considered too sick to wait. The admission of an emergency patient can prevent a patient who is scheduled on the theatre timetable from being admitted from a waiting list for treatment. It is possible that an emergency patient could already be on a waiting list for treatment and, by being admitted as an emergency, jumps the queue. Both of these occurrences will affect the overall dynamics of the waiting list.

4.2.1 Influence Diagram

Whilst it can be argued that a long waiting list does not necessarily mean a long wait, if the different lists are for the same service then it can be assumed that the longer the waiting list the longer a patient should expect to wait (Yates 1987). As waiting lists build therefore, so do waiting times.

Long waiting lists influence many areas and the presence of waiting lists can create costs other than administrative. The following description of the relationship between waiting lists and costs can be aptly demonstrated as an influence diagram, as shown in Figure 4-2.

If a patient with CAD is left without treatment the more time the disease has to progress. As the disease progresses and the clinical status of the patient becomes more severe the chance increases for the patient to require reassessment and to be allocated to a different waiting list.

The amount of care a patient requires is directly related to the clinical status of a patient when they are treated. With increased initial need comes increased length of stay in hospital. The longer a patient is in hospital the more costly the total treatment is as the patient requires more resources.

A further implication of a patient remaining in hospital longer than anticipated is that another patient may already have been scheduled for admission and require that patient's bed. This creates a cost for the cancelled patient in terms of preparation, anxiety and increased time for their condition to worsen.

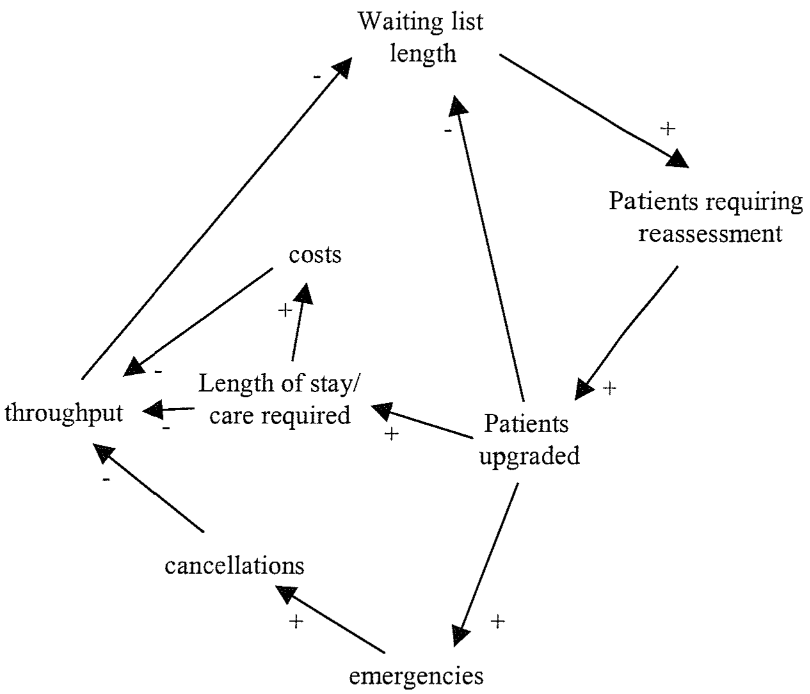


Figure 4-2 Influence diagram demonstrating the relationship between waiting list length and costs

With the length of stay in hospital increased, the overall throughput is limited as fewer patients can be treated. This increases waiting lists, in turn increasing the time for disease progression to occur and completes a vicious circle.

The only controlling element is the reduction of the waiting list length when a patient leaves it, either due to admission as an emergency or due to reassessment and subsequent addition to a more urgent list.

Based on the relationships shown in the influence diagram above a SD model was built.

4.2.2 System Dynamics Model

The System Dynamics model of the waiting lists of different priority was developed and included the following simple flows:

Emergency } patient requires immediate treatment → patient treated

Routine
Urgent } patient referred to waiting list → patient waits → patient treated
Unstable

Translating the flows described above the following System Dynamics model was determined as shown in Figure 4-3.

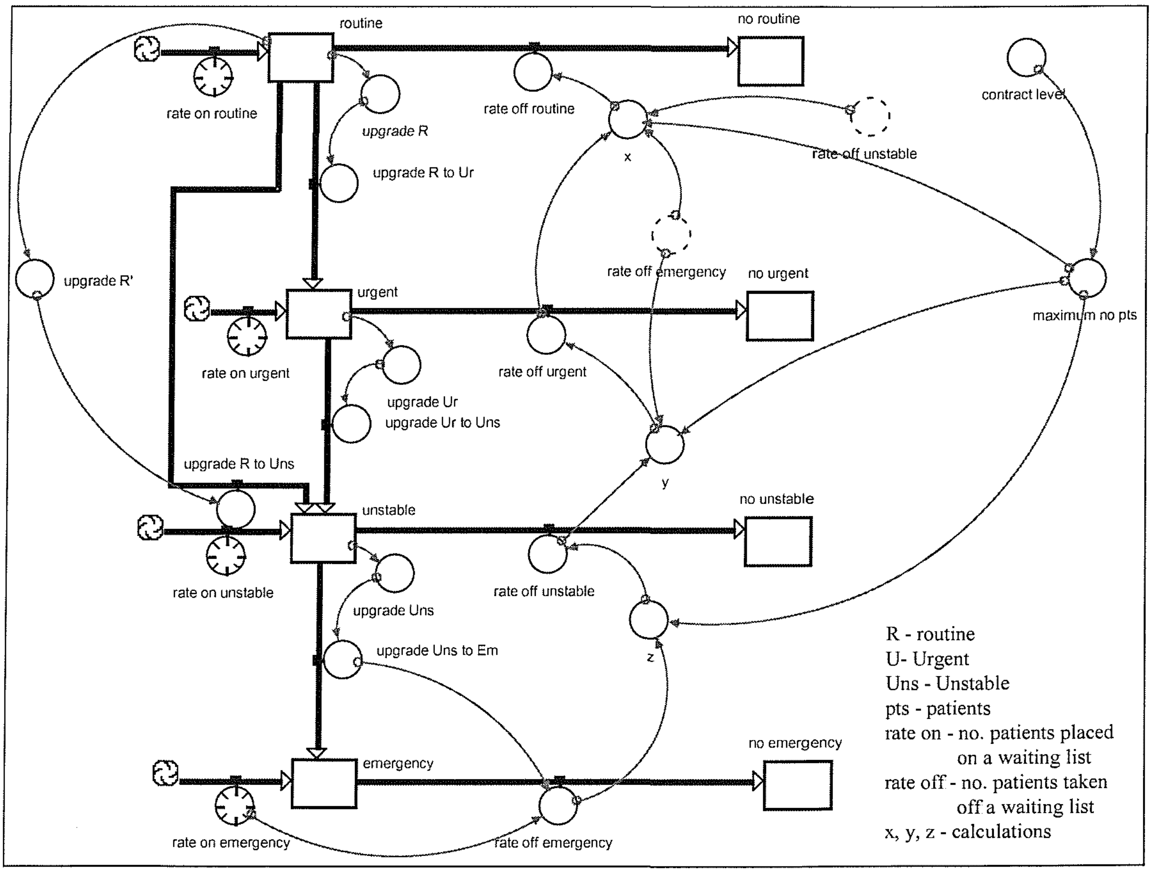


Figure 4-3 System Dynamics model of cardiac surgical waiting lists

This model represents each waiting list as a stock i.e. a pool of people waiting for treatment. (A stock is also allocated to the emergency patients but the associated flows ensure a waiting list can never build up here due to hospital policy, which ensures that emergency patients do not wait for treatment.)

Flows into these waiting list stocks determine the rate at which patients are allocated to a certain list. Data for this were obtained from the Outpatient Department of the Trust.

The other inputs to the waiting list pools come from the rates at which patients are reassessed and subsequently allocated to a different waiting list. Information on these rates was available from a database for unstable patients which described from which waiting list a patient had been admitted. The rate for unstable patients being 'promoted' to emergency was also derived from the unstable database. An unstable patient was defined as an emergency if they had undergone treatment out of hours. No information was available concerning the rate of upgrade from the routine waiting list to the urgent. This was determined by consensus from cardiac surgeons.

The rates at which patients were removed from the waiting list was determined by the following logic. The contract level negotiated for the department determines the number of procedures that can be carried out over the year. This can be translated to a 'per week' value which defines the maximum number of patients who can be treated in the week. All emergencies are always done and the distribution of routine, urgent and unstable patients is based on a 'worst-come-first-served' rationale. This rationale is preferred by doctors as it ensures that patients who are most in need of treatment receive it first. It does not consider the time a patient has already waited for treatment.

The points 'x', 'y' and 'z' are points at which a formula has been defined which allows the software to work out how many patients from each waiting list can be treated. It takes the number of patients who should be treated over the week according to the contract level from the waiting lists in order of severity. Emergencies, always treated, count against the number of patients who can be treated in a week as they will take up a bed that was to be used for a scheduled patient.

Finally, in Figure 4-3, a stock is provided to allow the number of patients treated to be monitored.

The equations which were used to define this basic initial model can be found in Appendix 3. The model was run using a DT of 0.125 and was run over one year for contract levels of 600, 700, 800, ..., 1200, the model time unit being 1week. General guidelines for choosing the value of DT are outlined in Appendix 2.

4.3 Results

4.3.1 Effect of contract changes on routine patients treated

As can be seen in Figure 4-4, as the contract levels increase so does the number of routine patients who are treated.

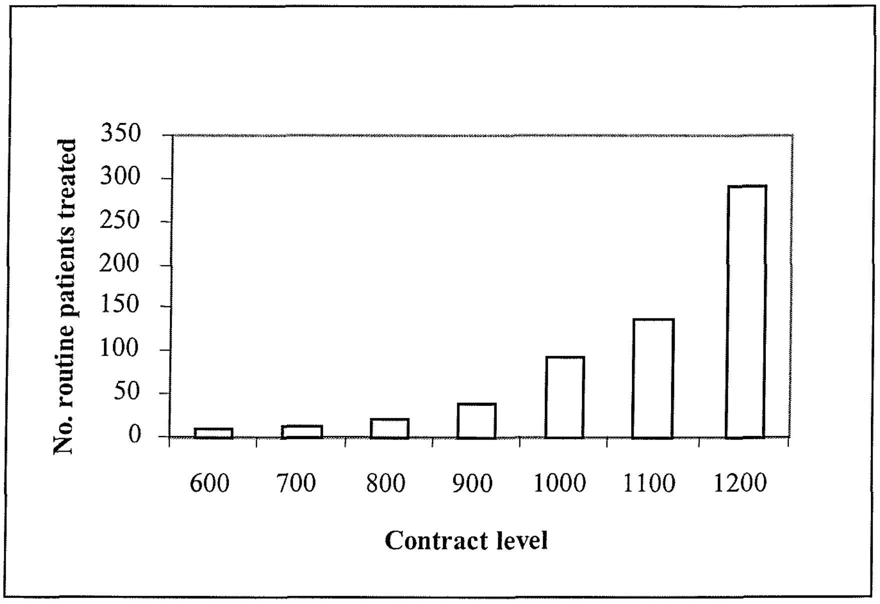


Figure 4-4 The effect of the contract on the number of routine patients treated

With the contracts at 600 or 700 patients per year almost no scheduled routine patients can be treated.

4.3.2 *Effect of contract changes on emergency admissions*

Of more concern is the demonstration of the relationships described previously in the influence diagram. As the number of patients waiting increases so too does the number of patients requiring reassessment, resulting in increased allocations to another waiting list or admissions as emergencies. It would therefore be expected that, if the contracted number of patients who could be treated was reduced, waiting lists and times would increase and more emergency admissions would be encountered.

As shown by Figure 4-5 the effect of the contract level on this value is considerable. The very low contract levels put pressure on the waiting list leading to an increase in the number of patients being admitted as emergencies.

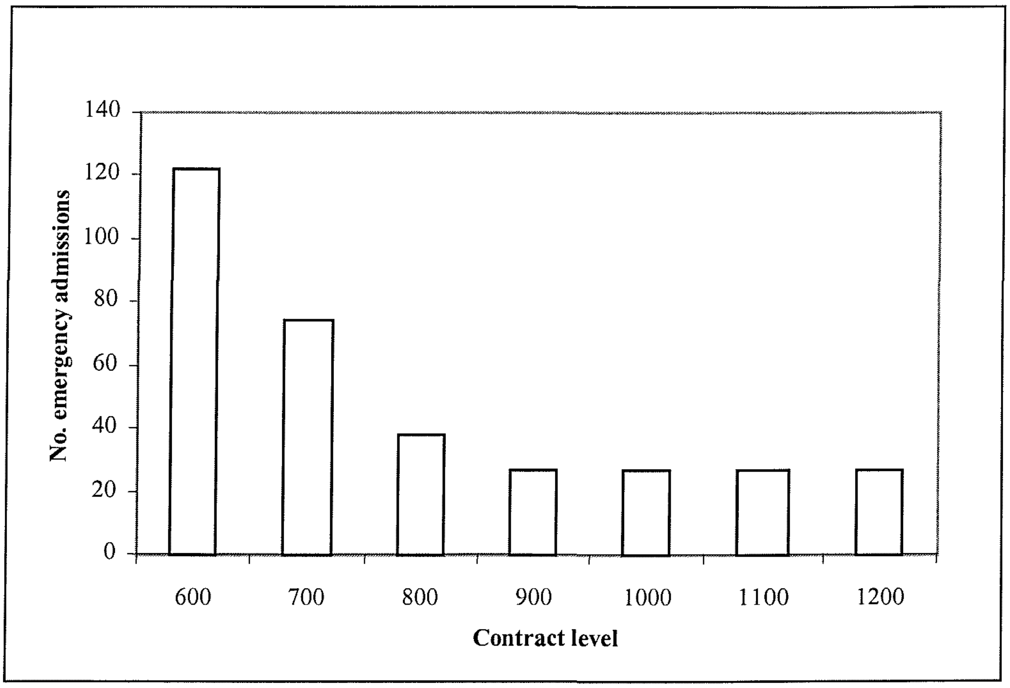


Figure 4-5 Effect of contract level on the number of emergencies

One interesting aspect to note regarding the dynamics of the emergency admissions is that as contract levels increase they can only reduce emergencies to a certain level. The number of emergency admissions does not fall below 26, on average one emergency admission a fortnight.

4.3.3 *Waiting lists at a contract level of 1200*

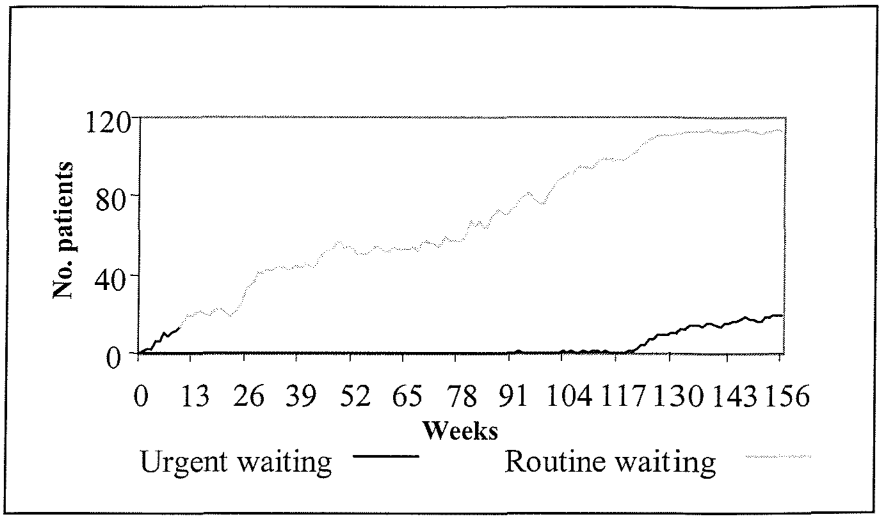


Figure 4-6 Waiting lists with a contract level of 1200

Figure 4-6 shows the dynamics for the routine and urgent waiting lists. The waiting list for the unstable classification is zero as the contract level of 1200 allows sufficient operations to be carried out to clear this waiting list. This simulation has been run over three years to determine whether there was any effect on the urgent waiting list over time. The routine waiting list rises and reaches a steady state of about 120 patients. At this point it can be seen that the urgent waiting list begins to increase.

4.4 Discussion

4.4.1 *Routine patient throughput*

It is intuitive that as the number of treatments allowed by the contract level increases, the number of routine patients who are admitted increases. What is surprising is the extent to which this contract level affects the admissions. It can be seen in Figure 4-4 that when the contract level is low, say 600 or 700 patients per year, very few routine patients are treated. The contract level is only just sufficient to cope with emergency admissions alongside those patients who are unstable or urgent. There is little left, in terms of resources, to treat the patients who are considered able to wait.

4.4.2 Emergency admissions

It has been shown that by increasing the availability of treatment, the number of emergency admissions reduces down to a minimal level.

Coronary artery disease can be detected on many occasions through the manifestation of the symptoms described in Appendix 1. However, all these symptoms may occur, or none of them. In the case of a patient suffering no symptoms it is possible that they will suffer a heart attack and require emergency surgery with no prior physiological or anatomical warning. They would not appear on a waiting list but would be admitted directly from the population. Despite increasing the availability of treatment and being able to address all the patients, of whatever severity, on the waiting lists, it will not be possible to treat those people with unmanifested disease prior to their emergency admission.

Referring back to the influence diagram presented in Figure 4-2, it can be seen that if patients require emergency admission then the costs to them are likely to be greater as they are sicker than the average patient. They are at a greater risk of complications and are likely to require a higher level of nursing after the operation. This shows that the savings made through limiting contract levels and deciding not to pay for more operations actually costs in the long run.

4.4.3 Dynamics of the waiting lists at a contract level of 1200

Figure 4-6 shows that the routine waiting list, with a contract level of 1200, plateaus at about 120 patients. At this point the arrival rate of patients must be equivalent to the rate at which patients are upgraded to another waiting list. Also at this stage Figure 4-6 shows an increase in the urgent waiting list. This is likely to be due to the fact that more patients are being passed on to that list from the routine list as it increases and there is no change in the rate at which patients are removed from the urgent waiting list.

4.5 Conclusion

Although only a couple of scenarios have been presented here, the running of the model has been sufficiently useful to expand upon it. As a methodology, System Dynamics has proved to possess sufficient facilities to investigate waiting list dynamics representing the lists as stocks and the admission and referral rates as flows. The effect of changing the availability of operations in a surgical department has been shown to have a direct effect on the dynamics of the waiting lists.

It was decided to enlarge the model from just the surgical department to include the cardiology department also. This would allow investigation of any effects that decisions made in cardiology had on the surgical department and vice versa as all patients referred for cardiac surgery must have been assessed and referred by a Cardiologist. The running of the departments is closely linked and the interaction of the waiting lists reacting to policy decisions is of interest.

5 Questionnaire Results

5.1 Introduction

The previous chapter demonstrated how general waiting list dynamics can be investigated through the use of System Dynamics. The model developed was limited at this stage to the surgical department and was also limited in its complexity. The next model is expanded to encompass the whole cardiac department.

The way in which patients receive treatment for cardiac problems is as follows. The patient visits a general practitioner (GP) having developed symptoms of coronary artery disease, as described in Appendix 1. The GP considers the severity of the condition and chooses whether or not to refer the patient for a specialist opinion. If a specialist opinion is required the patient will be referred to a cardiologist.

The cardiologist, in turn, assesses the patient and determines whether or not the patient should be passed back to the GP, their condition should be monitored in his/her department, or be given an angiogram investigation, see Appendix 1. If the patient is considered suitable he/she undergoes the investigation and the cardiologist makes the next decision based on the results received.

The patient is then either suitable for further treatment or not. If no further treatment is required the patient is retained for general monitoring or referred back to the GP. If further treatment is required then the patient is put on a waiting list for a PTCA (Percutaneous Transluminal Coronary Angioplasty) or referred to the surgical department for consideration for a CABG (Coronary Artery Bypass Graft).

If a PTCA is required the patient receives the treatment and then is referred back to the GP. If a CABG is to be considered the patient is referred to a surgeon and the surgeon then assesses the patient for his/her suitability. If the patient is not suitable for the procedure then he/she is referred back to the cardiologist and if he/she is suitable for the procedure he/she is operated on and then referred back to the cardiologist. After review, the cardiologist would normally then refer the patient back to the GP. This description of the system has explained the pathway a patient might follow. Prior to any consultation or treatment, the patient is likely to have to wait.

This system is portrayed simply in Figure 5-1.

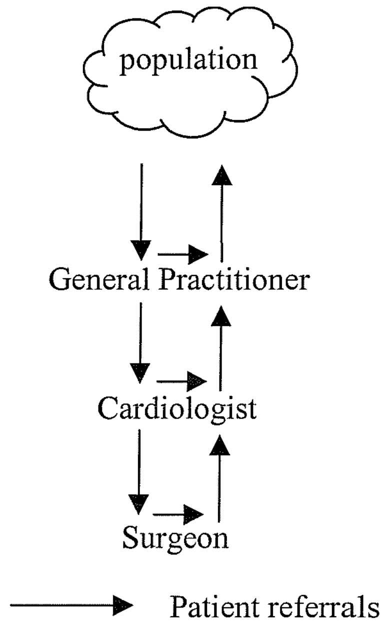


Figure 5-1 The possible passage of a patient through the cardiac system

As shown the arrival of patients for the surgeon and the surgical department is dependent on the decisions made in the cardiology department.

To clarify how these interactions work and their consequences a questionnaire was devised to question the doctors within the cardiac department, that is GPs, cardiologists and surgeons. The aim was to provide information on the relationships between the departments which could then be used to expand and improve the System Dynamics model in Chapter 4.

5.1.1 Method

The study required input from all three levels of doctors in the cardiac sector. The doctors targeted were a random sample of general practitioners who refer to the hospital in question, along with all consultant cardiologists and all consultant cardiac surgeons in the hospital. It was assumed that the physicians approached would have a clear understanding of the options available to patients requiring treatment for coronary artery disease and the definitions of the investigations.

	Response	Non-response	N	Response rate %
General Practitioners	9	19	28	32
Fund Holders	4	7	11	36
Non- Fund Holders	5	12	17	29
Cardiologists	10	3	13	77
Surgeons	4	3	7	57
Overall Response Rate	23	25	48	48

Table 5-1 Response rates for the questionnaires

As all consultant cardiologists and surgeons were targeted there was no need to select to whom a questionnaire was sent. The general practitioners approached came from a list of practices that gave the address of the practice to which the GP belonged and stated whether the practice was fund holding (GPFH). The list was split into GPFH and non-GPFH and the ratio of GPFH to non-GPFH to whom questionnaires were sent were representative of the whole. In total 25% of GP practices who referred to the cardiac specialty centre were approached.

As can be seen from Table 5-1, the response rate from general practitioners was 32% which was considered low. The questionnaire was set out in an open question format which was designed to encourage the doctors to annotate their answers providing rich information as opposed to yes or no answers. It was recognised that though this format may discourage some respondents from returning the questionnaire there was an advantage to having the 'fuller' answers.

Across the factors possible to address there was nothing significant regarding the characteristics of the non-respondents.

5.1.2 Design of Survey

The aim of the questionnaire was to fill in gaps in knowledge as determined from the literature review. These gaps seemed to be related to the role of doctors in the cardiac sector and the relationship between the length of the waiting lists and the decisions made by the doctors in the service. Doctors were asked to describe any other influences that were considered to affect waiting list length.

An understanding of the cardiac pathway itself was needed and to determine this a flowchart depicting a version of the pathway was included with the questionnaire, Figure 5-2. It was based on an informal interview with a member of the surgical staff and also on an understanding of the system already gained following a study of the department for a Masters degree (Hilton 1995). The flowchart provided was the same for all doctors, irrespective of their role. It attempted to show the options open to a patient from presenting at a GP with angina (chest pain), through to discharge at whatever stage and in whatever state. It included the presence of the waiting lists on which the patient could be expected to wait.

The doctors targeted were asked to 'comment on the flowchart' and to 'sketch on the flowchart the areas over which their role has influence / control'. The aim of this was to show any areas of conflict, for instance where more than one person considered himself or herself to control, or influence a section of the cardiac pathway as well as to ensure that the pathway was correctly understood. An example of an annotated flowchart is presented in Appendix 5.

Flowchart demonstrating Queues and Responsibility

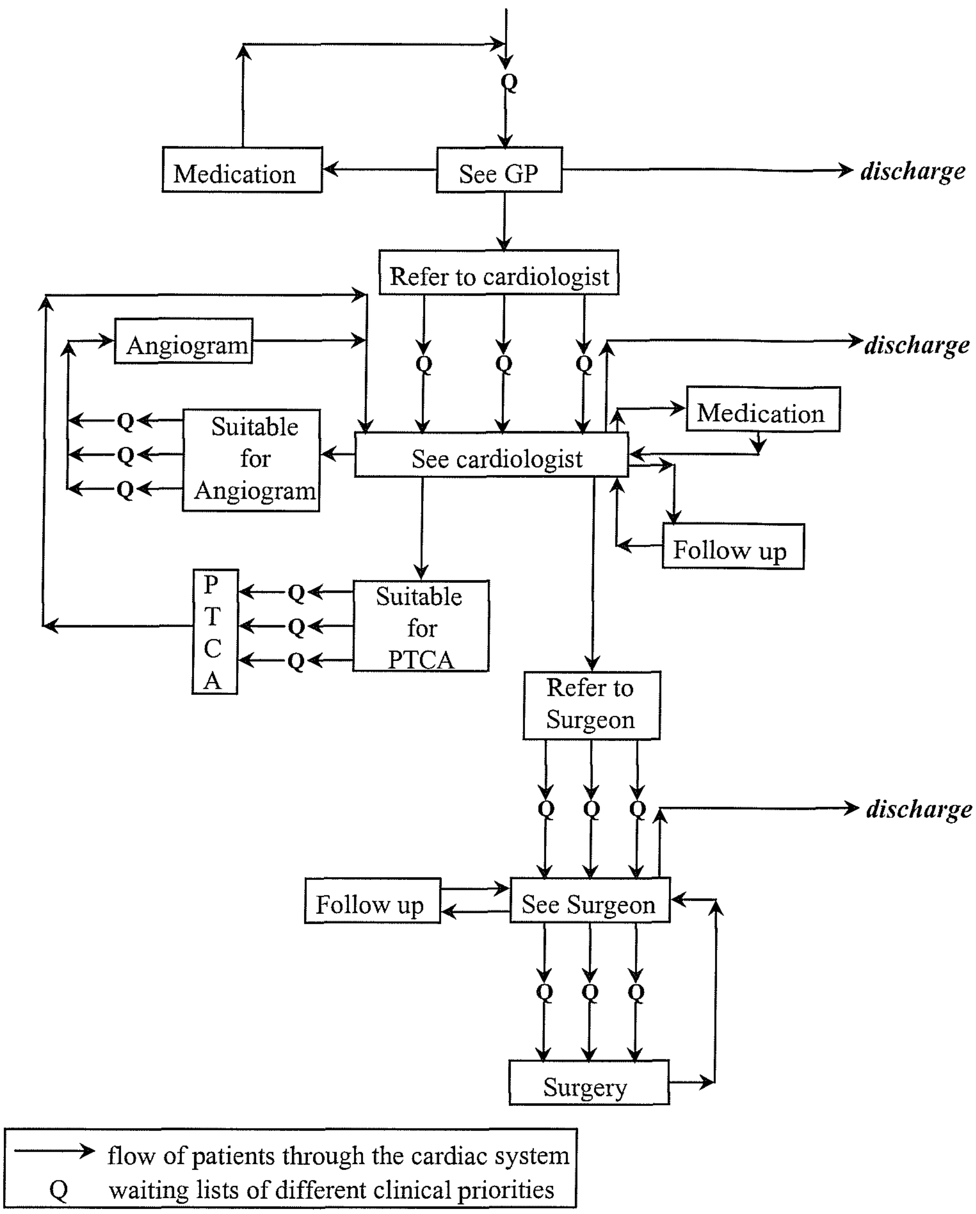


Figure 5-2 Flowchart showing patient flow through the cardiac system used in the survey of doctors

The survey questions were grouped in topic areas as follows:

- Flowchart validation
- Control over section of cardiac service
- Information provision and need
- Waiting list management
- Clinical priority allocation

- Influences
- Reasons for the presence of waiting lists
- Solutions to the presence of waiting lists

The subsequent analysis of the texts was facilitated by being able to identify groups of related questions.

5.1.3 Interviews

Following a brief initial analysis of the questionnaires, a sample of doctors was approached for further interview.

Interviewees were chosen through their questionnaire responses. All doctors were asked if they would be willing to be interviewed in the near future to further discuss their answers, and all but one were willing. However, it was not possible to interview all respondents and it was also obvious from the questionnaire that some physicians were more forthcoming than others. It was these enthusiastic doctors who were interviewed. (It should be noted that doctors were not chosen because of a specific viewpoint but because they were interested in the topic.) It was ensured that at least one doctor representing each 'role' was interviewed.

The interviews were carried out at the convenience of the interviewee and permission was given in all cases for the interview to be taped, allowing transcription of the interviews and greatly aiding subsequent analysis. The interviews were informal and unstructured, though based on the questionnaire responses of that person. References were made to comments made by other doctors, though this was done anonymously and was designed to validate some of the comments.

The information gained from the questionnaires and interviews was transcribed into The Ethnograph and analysed.

5.2 Results

5.2.1 Flowchart Validation

Q. Please comment on the flowchart.

Q. Please sketch on the flowchart the areas over which your role as a [doctor] has influence / control.

In order to ensure that an accurate System Dynamics model could be devised, it was necessary to gain an understanding of the cardiac pathway. The comments doctors made regarding the accuracy of the flowchart were usually made about the specific area of the cardiac service over which they felt they had control.

GP response

GPs comments on the flowchart were generally positive describing the representation as 'logical', 'applicable', and 'comprehensive'. Some suggestions were incorporated into the final flowchart, for instance it was observed that 'there isn't really a queue to see a GP, GPs being one of 'the only instant access parts of the NHS'. In the amended flowchart the arrival of patients is described as an average rate with no queue shown.

It was also suggested that all discharges from the hospital should be shown to go back to the GP as GPs are able to re-refer.

There were suggestions that exercise testing and open-access exercise testing should be included. This is presented in the flowchart depicting the system but has not been included in the model. The GP clinic falls outside the definition of the system boundary and so the provision of exercise testing would also fall outside the system if provided by the GP.

GPs felt that they had an influence over cardiological and surgical waiting lists, through 'speaking directly to a cardiologist if there is a problem' and writing 'letters emphasising severity'. However, some GPs stated that whilst this was possible, 'we do it cautiously' as 'excessive pleading destroys our credibility'. This line of influence was also considered difficult due to the relatively few patients seen requiring cardiac treatment. It was recognised that as a GP, only 'a small part of the cardiac workload' is seen 'so it's hard to judge priority', hence influence is exerted with care. No comments were made by GPs outside the areas over which they considered they had control. They regarded 'their area' to be their own clinic up to and including the referral to a cardiologist for further investigation.

Cardiologists response

The general consensus was that the flowchart was 'actually quite a good summary', 'excellent', and an 'accurate representation'. Some concern was expressed over clarification of the decisions available to a cardiologist.

It was thought that the flowchart as is shown, implies 'that a patient can go from cardiologist to PTCA / surgeon without ever having an angiogram which isn't the case'. An effort was made to clarify this situation by creating an additional, 'ghost' cardiologist box as shown in the amended version presented in Chapter 6. This now shows that an angiogram must be carried out prior to a PTCA or surgery.

One cardiologist specified that there were 'few discharges from surgeons without surgery', however this was not altered on the flowchart as it was considered that the option for a surgeon to consider a patient unsuitable for surgery should be represented, even if the numbers are considered to be small.

It was also observed that the option for 'outpatients to opt out of the system either not to go on, or to go privately', was not covered. However, the term 'discharge' is used here to encompass any means of a patient leaving the cardiac system, that is discharged due to completion of treatment, discharged due to unsuitability for treatment, moving out of the area, choosing to go private, choosing not to go ahead with the treatment, death or other.

Sketches on the flowchart showed that the cardiologists had control generally from the point a patient is referred to them through to the point at which they refer / discharge a patient. However, areas of influence were considered to reach further than this.

The decision taken by a GP to refer a patient for treatment is 'claimed' by cardiologists to be an area over which they have some influence. This is through the education of GPs in the appropriateness of referrals, though it was specified that control at this point was usually 'not exerted'.

Two cardiologists indicated that their influence stretched to the waiting list to see a surgeon and the waiting list for surgery. It was stated that if a patient is deteriorating then they can 'put pressure on surgeon'. In contrast to this, one cardiologist wrote specifically 'no control' across the representation of the waiting list to see a surgeon, emphasising this comment by underlining 'no' twice.

Surgeons response

Surgeons suggested the flowchart was 'valid' and covered 'most cases'. Suggestions for alterations were all targeted at the cardiologist section of the pathway, with the representation of the alternatives available to a cardiologist specified again as misleading.

One surgeon indicated that he had some influence over the decision of a cardiologist to refer a patient for treatment.

5.2.2 Control over section of cardiac sector

Q. Do you feel that you do actually have control over this area? Please explain.

Q. Does any other person / department / institution have any control over you or your section of the cardiac sector? E.g. management, your College, DHA.

Q. Would if be of benefit for you to have more control over any aspect of the cardiac service? Please explain.

These questions were designed to test the extent to which doctors felt they had control over the various areas of the cardiac sector. This information could then be used to determine whether there were any areas of conflict where more than one physician considered themselves to have significant influence.

Generally the respondents were in two minds as to whether they were in control of their area of the cardiac system and the associated waiting lists. Many agreed that they had control over any clinical decisions to be made and that they had the final say over which patients were referred or accepted for treatment stating the 'only complete control is over the decision to investigate / discharge'. However the responses were rarely a straightforward 'yes' or 'no' and were frequently annotated with explanations as to how this 'final say' was significantly influenced by external factors.

GPs response

There was no real consensus as to whether GPs believed they had control and there was some conflict in the responses given. Going by the flowchart sketches, control was held by GPs over medication, referral and discharge decisions. However, though the final say lay with the GP, particularly as to whether to refer a patient, the influence of that patient was recognised; 'patients also have influence in where referred, and when they present'.

Only one doctor stated that he had complete control over his area of the system and in addition felt that no other person or health group had any control.

When asked if a greater level of control would be beneficial, two doctors felt that any more control would be unrealistic as it is 'difficult to assess own patients without overall view of disabilities of patients referred by all GPs'. One doctor did not consider any increase in control to be of use, though he considered that he was 'mostly' in control anyway.

One GP felt that he definitely had control as he could 'prioritise referrals' and would 'speak directly to cardiologist' if there was a problem. Another felt that there was no real control as, though it was possible to 'write letters emphasising severity and phone consultants,... excessive pleading destroys credibility'.

Regarding the control or influence exerted by other people, departments or institutions, a third of GP respondents considered that no other groups had control. Two doctors chose not to answer the question and the remainder suggested a variety of controlling factors. These included waiting lists and patient behaviour.

Cardiologists response

As with the GPs, cardiologists considered that they were in control of the final say as regards clinical decisions to 'investigate / discharge'. However it was stated that often control is only 'partial' and that 'access to services and purchaser intentions outweigh your control'. Control is also 'directed to some degree by contracts, especially in the last 3-5 months of the year', as the contracted number of cases become a limiting factor.

It was suggested by one cardiologist that the only control 'on input is the no. of new patients seen in clinic'. By limiting the number of new patients seen in clinic the number of patients who can be referred or treated is restricted, however this affects the waiting lists for patients waiting to see a cardiologist. It raises the question of whether it is better to have a long waiting list to receive an assessment of a condition or to be assessed and have a long wait for treatment once details of the condition and its severity are known.

Cardiologists considered that they had insufficient control over their use of facilities with 'little control over OP [outpatient] and Cath. Lab running' available.

Asked if there were any other elements of the health service exerting control over the cardiology section of the cardiac sector the most common response was 'contractual limitations'. The 'behaviour' of management and colleagues was also regularly cited.

There was split of opinion regarding whether cardiologists would like more control in their clinical capacity, responses ranging from 'no!' to 'yes, we are all control freaks'. One cardiologist stated that it would be useful to have 'greater freedom to exercise clinical prioritisation without jeopardising longer waiters too much'. This suggests that clinical decisions are being affected by political policy.

Surgeons response

Surgeons considered that clinical decisions were within their control though the degree of control available to doctors now was considered to be less then previously 'due to political manoeuvres to reduce waiting times'.

Three out of the four surgeons specifically cited the provision of ITU (Intensive Therapy Unit) beds as influential over waiting times. It was stated that while 'some degree of control is possible ... the queue is mainly dictated by number of referrals and the availability of ITU beds'. (It should be noted that without an ITU bed being available, operations and procedures must be cancelled.)

Other elements considered to be controlling decisions in the cardiac surgical sector are management, politicians and contracted number of cases. It was suggested that if surgeons were allowed a greater degree of control they 'would work to clinical priorities rather than artificial waiting list constraints'. As with the cardiologists, this suggests that surgeons' clinical decisions are being affected by political policy.

5.2.3 Information provision and need

Q. What information regarding the waiting lists to which you refer is made available / sent to you?

Q. Is there any other aspect of waiting list information you would consider beneficial to receive? Please specify what and why.

The majority of physicians considered that the information provided regarding waiting lists and associated waiting times was inadequate, both in content and frequency of provision.

GPs response

There were a variety of responses ranging from 'nil' to 'specific' depending on doctors' satisfaction of the information provided to them. A third of general practitioners who responded stated categorically that they received no waiting list information at all. One in particular specified that he was not provided with any data and that the information he had was due to patients who 'feed back in bits'. The doctor who described the material as 'specific' also stated that it was 'inaccurate' showing that although he received some information he didn't believe it all.

Despite these specified inadequacies one family doctor stated that monthly updates were received by his practice, however this statement was qualified by the addition of 'fund-holding practice' in parentheses.

Those who felt satisfied with the information available did so for two quite contrasting reasons. Doctors in one group suggested that there was little point in taking time to interpret waiting list figures as they perceived the lists for the different cardiologists to be similar in length in the local region. They specifically alternated their referrals to encompass all cardiologists. On the other hand one clinician found 'waiting lists and reality different' and did not feel that the provision of waiting list 'facts' was in any way useful. This doctor felt satisfied with the data as he ignored it.

Those GPs who felt that more information would be useful suggested a broad range of data that could be provided. Most requested information was for waiting list information regarding the wait for cardiological investigations and for surgery. One doctor asked for information on the special interests of Consultants. A more detailed request was for information about 'which consultants seem to process people consistently and who keeps changing' and who demonstrates a 'greater willingness to redraw priorities'.

Cardiologists response

The responses received from cardiologists indicate that nearly three-quarters expressed dissatisfaction with the provision of waiting list data. The general consensus was that though some information was distributed it was 'erratic' and 'too infrequent to be useful'. One cardiologist admitted that the 'information for catheter / PTCA is in my office', yet despite this his colleagues were concerned that they had 'no info on PTCA waiting times'.

The most desired piece of information was the length of wait for surgery, 'classified according to priority high/medium/low'. Another doctor also suggested that 'risk stratification should be better'. They did not explain how this information would affect any decisions made.

Surgeons response

In contrast, the surgeons believed the information available to them was sufficient. One surgeon was the present Clinical Director and, as such, had a lot of information to hand. The surgeons seemed to be aware of their own waiting list 'content and pressures' and in addition believed that any further information that they felt would be useful would be available if they 'so wished'. It was stated that the politically sensitive figure of 'numbers on waiting lists waiting 12/12 [twelve months]' was provided.

5.2.4 Waiting List Management

Q. Do you have a personal or communal waiting list, or both? Please explain briefly how referrals are managed specifically regarding the management of different patient priorities.

Q. Do you refer to a specific or communal waiting list, or both? How does this work?

GPs response

All GPs, with the exception of three, always refer to a 'specific cardiologist'. One chose not to answer the question and the others stated that, rather than refer to a specific doctor, they referred to 'the shortest list available'.

Cardiologists response

The majority of cardiologists manage a 'personal waiting list' and 'patients are added to the list based on prioritisations'. Some consultants work from a communal waiting list, sharing between colleagues and again patients are graded according to clinical priority. The terms used to grade the patients differ between doctors. Those who specified their terminology used such wording as 'routine', 'elective', 'non-urgent', 'low', '3', '4'; 'urgent', 'semi-urgent', 'medium', '2', '5', '6'; 'unstable', 'next list', 'high', '1', '7'; 'emergency'. This demonstrates a lack of consistency between consultants.

Surgeons response

The Surgeons maintain personal waiting lists assessing 'patients clinical priority in OP [Outpatients]' and then placing them on the relevant waiting list. It was stated that at times they 'try to help each other if patients are waiting longer than 12 months' because 'the department is committed in keeping waiting times in clinics and on surgical waiting list within patient charter limits'.

Q. Do you check on the lengths of the waiting lists to which you refer prior to referring a patient for treatment?
Q. Do you consider the length of your own waiting list when accepting a patient for treatment?

These questions focussed on the effect of waiting lists on physician behaviour. The GPs, Cardiologists and Surgeons were asked different questions according to their waiting list responsibilities.

	Yes	No	Not answered
GP	4	4	1
Cardiologist	4	6	-

Table 5-2 Response distribution for the question 'Do you check waiting list length prior to referral?'

GPs responses
When asked if they checked waiting list data prior to referral of a patient there was no overriding consensus. Those who said they did check waiting list data suggested that the 'accuracy' was 'a problem'. Those who did not check felt it was unnecessary to do so as 'if they [patients] need to be referred they need referral', and 'I don't find it makes a great difference locally'.

Cardiologists responses
There was no overriding consensus as to whether waiting lists were checked prior to referral. Those who made every effort to check waiting list information did so to determine which list was the shortest in order to refer to it, 'provided the referral is not to a specific surgeon with specific expertise'.

Those who do not check feel that they 'cannot influence the waiting times for surgery' and is considered 'time consuming to do so'. It was also explained that 'if a patient needs surgery ... then the patient should be referred'. As a consequence it was recognised that the waiting list would increase but that 'in effect the waiting list becomes a political tool to support increased purchasing'.

	Yes	No
Cardiologist	6	4
Surgeon	2	2

Table 5-3 Response distribution for the question 'Do you check waiting list length prior to accepting a patient for treatment?'

Cardiologists responses

There was little consensus amongst cardiologists. Those who do check waiting list figures stated that it can affect whether or not a patient is accepted for treatment or not; 'If waiting list is very long ... only relatively high priority cases accepted into it', 'it influences your thresholds even if you don't think it does. Increase waiting list, decrease likelihood of acceptance'. One doctor also stated that if the waiting list was long they 'may defer listing someone straight away'.

Those who do not check waiting lists do not do so because, they are 'not required to' and 'because of clinical urgency'. It is felt that the 'decision should be on patient need only.' Again the role of the waiting list as a political tool was introduced; 'if list gets big – creates pressure for more resources'.

Surgeons responses

The only time waiting list information was used by the surgeons was to be able to inform cardiologists of the likely wait for their patients, and to advise them that it may be possible to 'get earlier service elsewhere'. Generally the length of the waiting list was not considered. If the patient required referral then all would be done 'to expedite that patient's admission for surgery', thus relying solely on clinical need for decisions.

Q. At what length would / does a waiting list to which you refer have an influence on your decision to refer a patient for treatment?

GPs response

Most doctors chose not to answer this question or were 'unsure'. One doctor considered that waiting lists would influence his decision if they were 'so long that no point in sending them [patients]'. The waiting list length at which this influence was thought to occur was not specified.

Cardiologists response

Generally a waiting time of 1 year was cited as the length that at which waiting list would have an influence, this length of wait being described as 'v. bad'.

Two doctors specified that waiting time is not considered as 'if patient needs a procedure, the waiting time doesn't come into this decision'; 'if the patient needs referred – he/she is referred'.

One doctor specified that '>3/12 wait for PTCA means the situation changes by the time they get there'. This has implications on costs as procedures may have to be repeated to ensure that up to date information regarding the patients' condition is available.

Q. Should waiting lists influence referrals and acceptance of a patient for treatment?

	Yes	No	Not answered
GP	4	3	2
Cardiologist	7	3	0
Surgeon	3	1	0

Table 5-4 Response distribution for the question 'Should waiting lists influence referrals and acceptance of patients for treatment?'

GPs response

Without saying whether waiting lists should have an influence on referrals for treatment, one doctor stated simply 'they do!'. The effect of the waiting list length on decision making was explained by one doctor as, 'if list is very long then may be more willing to try maximum treatment first'.

As with previous comments, it was also said that there should be no influence from waiting lists on referral decisions as 'referral should be based on clinical needs'.

Cardiologists response

Those who said that there should be no influence considered that 'waiting lists are politically powerful in that if there is a waiting list then more money is produced' and so patients should be referred to create a greater pressure for resources.

Nearly two thirds of cardiologists felt that the length of the waiting list definitely had an effect on referral and acceptance decisions. There were two ways in which the waiting lists were thought to exert an influence. These were to facilitate referral to the shortest waiting list and the effect on the clinical thresholds required for a patient to be referred for treatment. It is stated that 'long waiting lists increase costs for patients so if long, need higher threshold to refer'. In addition the political priority of long waiters 'probably raises the threshold for referral'.

Surgeons response

One surgeon commented mainly on the referral patterns of cardiologists suggesting that they 'should take note of the purchasers' contracted number of ops when deciding i.e. they should ration'. Whilst it was accepted that 'waiting lists should not influence the acceptance of patients for treatment in theory', it was also accepted that 'it should influence referrals for surgery', in order for patients to be referred to the shortest waiting list, particularly 'for a routine CABG which can be treated adequately by any surgeon'.

Q. Are there any methods by which you control referrals to your waiting lists? Please give details e.g. if you close your waiting list at what limit, why and what implications does this have?

GPs response

GPs were not aware of 'any manipulation of waiting lists'. One doctor said that he has 'been told that people have little or no chance of treatment as there are no funds, and I have seen less serious cases operated on before more serious cases because of this stupid rule about no waiting >1yr, which could discourage referral'.

Cardiologists response

No cardiologists claimed to control their waiting lists or the referrals into them in any way. It was accepted that a waiting list is a dynamic entity, that 'it gets longer then sometimes it gets shorter'. Cardiologists were, however, very aware that surgical lists are closed 'when 1 year waiters cannot be accommodated'. This 'spreads referrals round' as the closure of an individual list necessitates 'referral to another surgeon'. One doctor explained that when a waiting list is closed he usually stops 'referring to that surgeon (including PPs!)', showing how private patients can be used as a persuasive tool.

Surgeons response

Surgeons stated that 'when it is clear to a surgeon that he is accepting patients at a greater rate than he can operate on then in desperation we close our waiting list'. Surgeons were also aware that cardiologists did not like this measure to be taken as, 'the implication of closing the waiting list ... is chaos and ear ache from cardiologists and consultant colleagues'. In addition a backlash of list closure is that 'referral of private patients also disappears'.

Another method of control that is employed by one of the surgeons is to ensure that the same number of new patients are seen in out patients as can be operated on, to prevent build up of the waiting list.

5.2.5 Clinical Priority Allocation

Q. Do you allocate a priority for each patient and if so what protocol do you use?

The aim of this question was to determine whether any doctor was inclined to increase the priority on a patient in order to allow them to 'jump the queue', receiving treatment more quickly than perhaps their clinical status suggested, in addition to determining whether a priority was actually used when assessing a patient.

GPs response

GPs were split as to whether they allocated a clinical priority to their patients. Those who did not allocate a priority felt that it would be unrealistic as they 'don't have an overview of the entire workload'. Those who did allocate an urgent priority did so if the patient was 'having rapidly worsening or severe symptoms or is uncontrollable on maximal medication'. There was no protocol described by any of the GPs questioned which was applied to patients.

It was suggested that the waiting lists can affect the priority allocated to a patient, if priorities were used, '..what you do is you turn something from routine into urgent'.

Cardiologists response

All cardiologists allocate a priority to their patients, however whether or not there was a generic protocol applied for this allocation was not clear. Cardiologists who described the way in which they allocated clinical priority used differing terminology and varying levels of complexity making conclusions difficult. One doctor said that there was 'no protocol followed', though priority allocation was dependent on 'clinical assessment plus exercise test results'.

Surgeons response

All surgeons allocate a clinical priority to their patients. One surgeon said that there was 'no formal protocol' but it was stated that there were 'cardiac society guidelines'.

Q. Do you run separate waiting lists for each clinical priority of patient?

This question was not applicable to GPs as they do not run a waiting list.

Cardiologists response

Eight out of ten cardiologists preferred not to run separate waiting lists for each priority, preferring to keep all the patients on one single list.

Surgeons response

Surgeons were split half-and-half, according to whether they ran a separate waiting list or not.

Q. Is the priority of a patient, as determined by the referree, ever undeserved on clinical grounds?

This was to determine whether the system was getting crowded with unnecessary referrals. As GPs do not receive referrals this question was only asked of cardiologists and surgeons.

	Yes	No	n/a
Cardiologists	4	4	2
Surgeons	3	0	1

Table 5-5 Response distribution for the question 'Is the priority of a patient, as determined by the referree, ever undeserved on clinical grounds?

Cardiologists response

Those doctors who suggested that patients did receive the incorrect priority allocation felt that it occurred in both directions, that is that some patients were given a higher priority then they clinically need and that 'frequently the patient has been referred with lower priority rating than judged from hospital perspective'.

Those doctors who felt that the question was not applicable explained that they 'do not take account of the priority requested by the GP'.

Surgeons response

The surgeon who considered the question to be inapplicable stated that referrers only 'rarely' allocate priority and any priority is allocated in the surgical clinic.

Two explanations were given by the remaining surgeons as to why priority allocation was, on occasion, undeserved. It was recognised that the referring physicians see only 'an individual patient' whereas the surgeon must 'assess relative to other patients' on the list. Another explanation was that the referral might have come from a registrar, suggesting that a lack of experience may be a cause for unnecessary referrals.

As with cardiologists, it was stated that the undeserved priorities were both 'too high' and 'too low'.

5.2.6 Influences

Q. Is it beneficial to belong to any particular patient group?

Whilst five doctors across the board considered that there were not patient groups to which it would be an advantage to belong, several categories were cited as advantageous, as shown in the table below. (Note that doctors were not limited to one category when answering this question.)

	Categories suggested as giving an advantage to patients						
	Age	PP	S/E	GPFH	Emp.	Other	No
GP	5	2	1	1	1	3	2
Cardiologist	2	4	1	6	1	1	2
Surgeon	2	2	-	2	1	-	1

Table 5-6 Response distribution for the question 'Is it beneficial to belong to any particular patient group?'

Key: PP – Private Patients / Insurance

S/E – Socio-economic status

GPFH – General Practice Fundholder

Emp. – Employment at risk

Other – gender, non-smoker, not answered

GPs response

As can be seen from the above table, the factors suggested as being an advantage to patients, by GPs, cover a broad range, the most popular being age as a beneficial factor. There is no overall agreement as one doctor stated 'GP FH, age, socio-economic group, - always the case!' and another answered 'no'.

Cardiologists response

Cardiologists again offered a variety of patient groups that were considered an advantage. One doctor explained that there were 'no exclusion criteria' for patients needing treatment, there was just 'more thrust' to patients in particular to 'younger working patient if job at risk'.

Surgeons response

As with both other NHS roles, surgeons recognised several beneficial patient groups. These were discussed by one doctor. With regard to the effect of age on the clinical decision it was stated 'if a patient of forty had to compete with a patient of 85 for a given operation slot then the younger person I am sure would get priority'. Socio-economic grouping was also discussed and it was said that it 'does affect the way we function in that if someone is still employed but unable to perform their work because of their coronary disease then they would by most surgeons and cardiologists, receive priority'. In addition it was explained 'there is also little doubt that those people who can afford private medicine achieved substantial reduction in waiting times (but this is not acknowledged)'.

Q. Has the previous Government's introduction of the Long Wait policy affected the waiting list problem? Please explain.

GPs response

Most GPs were 'unaware' of the effect, if any, of the Government's Long Wait policy limiting the time a patient should be expected to wait for treatment. One doctor however stated that there was a change in the order of patients treated with 'less urgent done before urgent to avoid penalties'.

Cardiologists response

A half of the cardiologist respondents said that the long wait policy had not affected the waiting list problem. The other half recognised that the policy limiting the length of time a patient should wait has 'modified' the problem as 'there maybe a 'waiting list' to get on to the waiting list'. It is stated by two of the doctors that 'undue priority on waiters overrides clinical priority', that the 'pressure with 12/12 [1 year] waiters may interfere with the passage of more clinically urgent but short wait patients'.

Surgeons response

Whilst one doctor felt that the question was ambiguous as he did not understand what was meant by the term 'long wait policy', the others felt that it had a 'very considerable effect' and was considered to be 'one of the benefits of Governmental interference'. As with cardiologists it was stated that the policy had 'shortened the waiting time of some patients at the expense of more urgent clinical patients' due to the 'emphasis to get patients done within 12/12'.

5.2.7 Reasons for the present waiting list problem

Q. Is there a specific reason for the presence of waiting lists in the cardiac department? Please explain.

This question was asked to determine if doctors within the system felt there was a specific reason for the waiting list problem.

GPs response

There were many reasons given for the long waits for patients' treatment. The most popular reason was the lack of resources, which were defined as cash, nurses, doctors and equipment. Demand for treatment was seen to be 'ever-increasing', with 'increasing screening' finding more patients requiring treatment.

Cardiologists response

As with the general practitioners, 'too many patients in a poorly resourced service' were considered to be the main reason for the waiting list problem. The lack of balance between supply and demand was mentioned where 'demand outstrips supply', and 'the demand appears to be a 'bottomless pit''. It was observed by one doctor that waiting list could be in part due to the fact that '4 hour procedures on individual patients takes time – referrals take minutes'.

Surgeons response

Surgeons agreed with their colleagues citing a 'lack of resources' and 'too many patients for the available facilities'. It was noted by one surgeon that 'an increase in … cardiologists also seems to have brought an increase in referrals', which demonstrates the complexity in the demand / supply relationship.

5.2.8 Solutions to the present waiting list problem

Q. What would you do to try to reduce the problem?

GPs response

Suggestions to this question fell into two main categories; money and education, and a belief that more of both was needed. One doctor specified that to double petrol tax could provide this extra money. Two doctors felt that to 'ban smoking advertising' would help health education.

Cardiologists response

More resources were cited as the obvious solution, resources being defined as money, doctors and facilities. Two doctors stated that an improvement in efficiency would ease the waiting list problem.

One doctor stated as a solution 'common thresholds for referral'.

Surgeons response

Money for an increase in the supply of treatments was suggested as a solution by three of the four surgeons responding. One specified that the increase in supply should be focussed on the intensive care unit to reduce cancellation of operations.

Related to the statement from a cardiologist regarding 'common thresholds', one surgeon suggested that a solution could be 'to equalise indications for referral: at present there is marked variation', so easing the waiting list problem.

5.3 Conclusion

The aim of the questionnaire was to provide information about cardiac waiting lists, their management and their construction and identification of influences present in the cardiac system

While the implications and consequences of the relationships between the influences and the doctors decision making are discussed in detail in the next chapter the variety of responses received is immediately noticeable. There are no areas covered where all doctors agree, even within their own role. This lack of continuity within the system partly explains the consistency of waiting lists. Whatever the length of the waiting list there will be physicians who act in differing ways in their clinical decision making.

This freedom provides a level of inequality for the patients who may or may not receive treatment, depending on which doctor they see. It raises questions as to whether bringing those influences and the consequences of those influences into the open, can aid in affecting doctors decision making so that a true picture of waiting lists can be achieved.

6 Influence Diagram and System Dynamics model

6.1 Introduction

Chapter 5 described the results of the questionnaires. The aim of this chapter is to draw together the collected qualitative information, produce an influence diagram and finally develop a System Dynamics (SD) model which can represent the cardiac system realistically.

6.2 Use of qualitative information in forming a quantitative model

In order to develop and run a System Dynamics model a large amount of information is required. In determining this model framework it is often stated that it is important to involve those within the environment which the model is to depict; that 'the client be an integral part of the modelling process' (Lane 1999).

A problem with this method was the difficulty in obtaining the information required in a format that could be used to create the SD diagram. To overcome this, a simplified version of the anticipated final representation was provided with the questionnaire. It also provided a medium in which corrections could be easily made through annotation. This method provided the descriptive information required without taking up excessive amounts of doctors' time. An example of an annotated flowchart is provided in Appendix 5.

Following collation of the comments made, the flowchart was amended from that shown in Chapter 5 (Figure 5.2), to that displayed in Figure 6-1.

6.3 Definition of System Boundary

When constructing a System Dynamics model it is important to know when to stop and so a boundary to the model must be defined. The model must be constructed such that the dynamics being exhibited are being generated by relationships that lie within that boundary. Aspects outside the defined boundary are considered to be unlimited i.e. the environment can provide or accept an infinite supply.

In the case of the cardiac system, the elements which are considered to be within the system are essentially hospital based. Internal system activities include outpatient clinics, procedures and review clinics for both cardiology and surgery. Also, relationships between these in terms of interdependencies, feedback, points at which patients have to wait and decisions made as to which path a patient should follow, are within the system boundary.

All patients are referred into the cardiology level via an external referral point, a GP clinic. It is assumed that the population has a sufficient prevalence of coronary artery disease to consider the supply of patients to be infinite. The system boundary is such that the visit to the GP clinic is outside the system and the decision to refer brings the patient inside the system. At the point when a patient is discharged from a cardiologist, they leave the system to then be reviewed in a GP clinic. It is assumed that there is no restriction on the number of patients who can be discharged.

Also outside the system are patients who are seen by cardiologists based at other hospitals and are then considered to require surgical treatment. These patients bypass the cardiology level of the hospital being modelled but pass into the system boundary once they are referred for an outpatient appointment with a surgeon.

In addition, political considerations are outside the system.

6.4 Flowchart verification

This section discusses the implication of the changes to the flowchart presented in Figure 5.2.

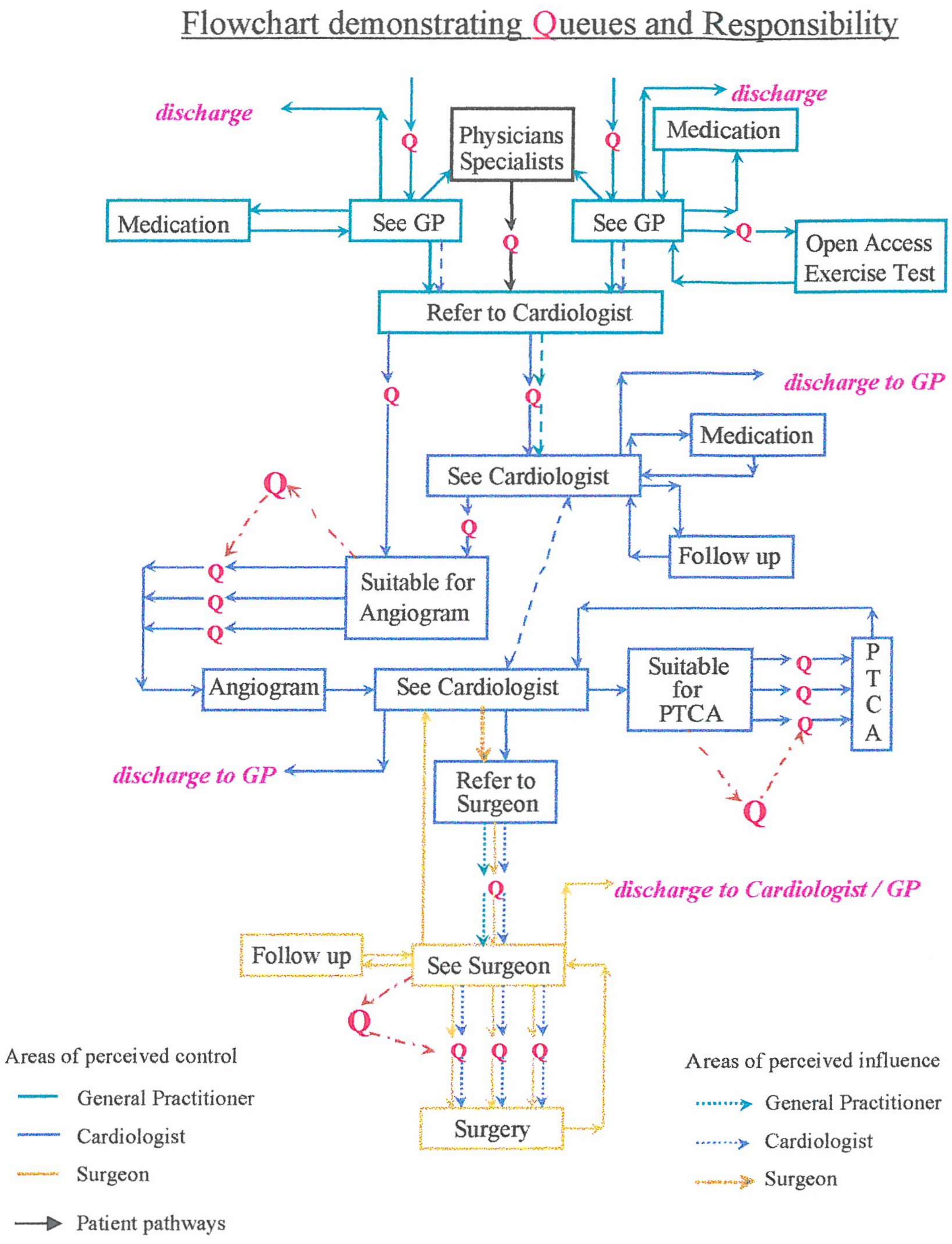


Figure 6-1 Amended flowchart showing patient passage through cardiac system and areas of responsibility for doctors

6.4.1 Portrayal of General Practitioner

In the context of cardiac referral, the General Practices can be split into two types, those who have access to open access exercise testing, and those who, to obtain an exercise test for their patients, must refer on to a cardiologist. This has been portrayed by splitting the GP boxes to reflect the availability of the exercise tests. This change was outside the system to be modelled but was considered useful to include at this stage.

In addition, referrals to the cardiologist do not only come from GPs. It is also possible for patients to be referred from a specialist in another department, in which the patient may already be receiving treatment. This has been added to the flowchart.

6.4.2 Portrayal of Cardiologist

The cardiologists pointed out that the first version of the flowchart misrepresented the pathway that would be followed by patients requiring their services. It implied that when a patient was seen by a cardiologist, they could be considered immediately for a PTCA, which is not possible without first having undergone an angiogram. They suggested that this needed to be altered to ensure that, (in translation to the SD model), patients could not follow this path. To accommodate this 'cardiologist' was split and shown as two separate stages, though linked with a dotted line to depict that it is the same doctor.

6.4.3 Colour-coding of flowchart

Form the colour coding in the diagram it can be seen immediately that there are no clear cut areas of control and that at almost every point in the cardiac pathway there is influence from colleagues over decision-making.

6.4.4 'Hidden' waiting lists

The amended diagram shows the presence of hidden waiting lists, **Q**. These are discussed in section 6.6.

6.5 Patients Charter

The Patients Charter (Department of Health 1991) was set up to improve health provision, one aspect of which was to provide a guideline for both patients and doctors determining the maximum length of time patients should be expected to wait for treatment. The specified waits were different for each specialty.

Prior to the Patients Charter, patients who were thought to be most clinically urgent were given priority and it was not necessary for doctors to consider explicitly the time the patients had waited. The introduction of the Patients Charter made this necessary and altered the balance between urgent patients and 'long-waiters'. The balance shifted from a 'worst-come first-served' culture towards 'first-come first-served', so disadvantaging high priority patients.

Doctors do not all agree with such a shift but feel obligated to treat certain patients due to pressure from management in order 'to avoid penalties' (see section 5.2.6).

In reality there is a balance to be achieved between both policies, as each have merits in their aims. Patients do not wish to wait excessive lengths of time for treatment but, understandably, they wish to be seen promptly if there is severe clinical need.

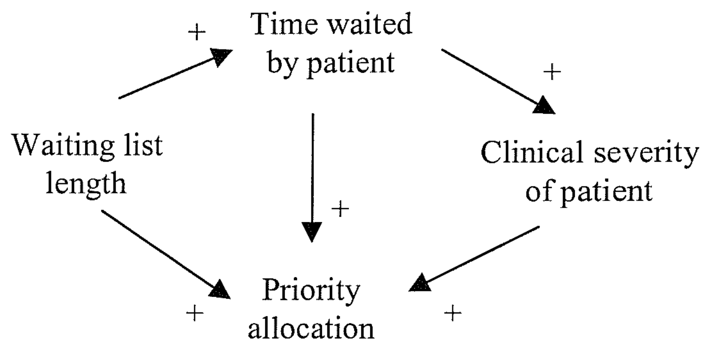


Figure 6-2 ID showing the influences on a doctor's priority allocation decision

Figure 6-2 shows that the decisions made by doctors are influenced by waiting list length and the time that a patient has already waited for treatment, in addition to their clinical status.

6.6 Hidden Waiting Lists

Once a patient has been assessed, their acceptance onto a waiting list may be delayed. The points at which there are believed to be hidden waiting lists are shown in Figure 6-1. The mechanisms for such delays are not officially recognised and can occur for a variety of reasons. (Quotations are not attributed for reasons of confidentiality but are taken from the questionnaires and interviews of general practitioners, cardiologists and surgeons.)

> *'... There is an unofficial one. You leave them on your desk for a month or two. Or your secretary holds them.'*

The patients held in this situation are waiting for referral on to a waiting list, in order to wait for treatment. They are waiting to wait. If the waiting list had been shorter, it is likely that they would have been referred immediately.

On occasion, patients are considered not to be sufficiently in need of treatment to be referred immediately irrespective of waiting list length (though extra waiting lists developed for such monitoring purposes could increase the chance of patients getting lost in the system.)

> *'There would be patients, their symptoms aren't that bad, and they've been referred, and I would try to talk them out of an operation ... when they come back into the system, I would tend to give them priority in that they've already waited in a sense, a fair time.'*

Patients who have been assessed and considered unsuitable for immediate referral to a waiting list, but are considered to have been waiting on their return, are effectively on a hidden waiting list. Their wait however is unmonitored.

The possibility of patients not requiring immediate referral to a waiting list is noted in the waiting list statistics published by the Department of Health (Department of Health 1999). The publication specifies that the figures pertaining to inpatient waiting lists do not include 'patients who are temporarily suspended from waiting lists because they are known to be not medically ready for treatment'. It is not unreasonable that patients are not placed on a waiting list for a treatment that they are not considered to require, however, the DoH publication suggests that the patients in this category have been placed on the waiting list for treatment and that the decision has been changed. This leads to a possibility for the manipulation of waiting list figures.

Another reason for cardiac patients not to be immediately added to a waiting list but to be kept 'on hold' is that surgical treatment for coronary artery disease is often considered to be a palliative procedure and patients may choose to live with the symptoms rather than risk open heart surgery.

> *'We know that in ten years time a certain number will be back for a second operation ... so in one sense the longer you put off surgery the better.'*

This is a benefit to the delay of treatment that considers the risks of going ahead.

Hidden waiting lists are represented in the flowchart but this is not carried through to the model. There is no data on the subject and, as it is a politically sensitive issue, such that not all doctors are willing to discuss the presence and implications of the lists.

6.7 Clinical Decisions

Long waiting lists may deter doctors from referring patients. This influence occurs at the General Practitioner stage as well as the cardiology stage.

> *'...if [waiting list] so long that no point in sending them.'*

> *'... if it was a short list you would catheterise them because the cost to them having surgery is lower. If it is a long list you don't catheterise them because the cost to them of having surgery is higher.'*

As coronary artery disease progresses the likelihood of a patient undergoing a cardiac event increases. Very long waiting times are associated with frequent cardiac events, at considerable cost to both patients and health care providers. Whilst some studies (Califf 1988) show that the link between severity and prognosis does not demonstrate a good correlation, this could be explained by the 'tendency of patients with more severe symptoms to receive prompter and more intensive care' (de Bono 1999) and others have shown a worse outcome in patients with the most severe symptoms (VSCSG 1981).

The waiting time experienced by a patient on a waiting list, allowing the disease to progress, is therefore significant for their response to treatment. In some cases however, as the quote states, the patient is not referred at all, as the waiting list is considered too long.

A decision about referral based on criteria other than clinical ones may give rise to unmet need in the community.

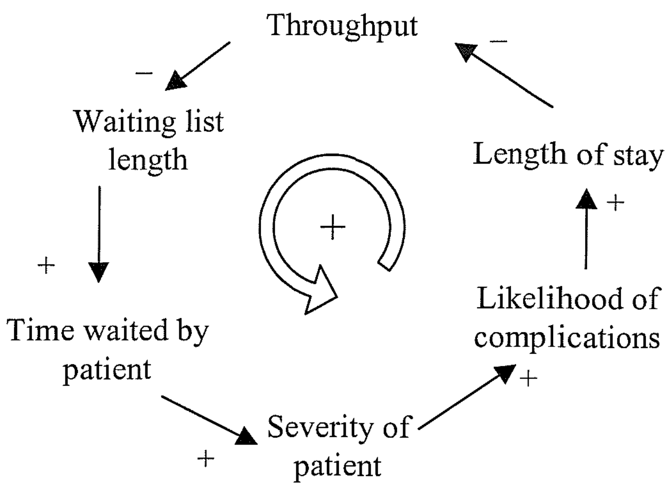


Figure 6-3 ID to show the implications of delaying treatment

Figure 6-3 shows how these factors are incorporated into the influence diagram. It shows that as the length of the waiting list increases, the delay in the provision of treatment for patients also increases. As the disease is allowed to progress without treatment, the likelihood of a cardiac event increases. With advanced disease the complications associated with any corrective procedures eventually undertaken are increased thus the costs for the hospital are greater due to increased length of stay. This in turn affects throughput and the rate of removal of patients from the waiting list.

The procedures carry a risk. For every decision to operate there is a trade-off between the benefits in quality of life and life expectancy to be achieved and the risk of surgery.

6.8 Control or Influence

It can be seen from Figure 6-1 that there are many areas where there is perceived control by one group of doctors, with influence present from another. There is room for debate as to how strong an influence must be before it can be regarded as 'controlling'. If a specific influence changes a decision then it could be said that that influence is 'controlling' the decision made.

6.8.1 General Practitioners

GPs are considered to be the gatekeepers of the NHS, being the first port of call for patients. It is a GP's role to decide how best to treat that patient and whether to refer him/her to someone with different expertise.

There are several reasons why a patient might be referred. The GP may be seeking advice as to how to proceed with a patient and so consults a specialist. The patient may require a specific investigation and is referred for that procedure with no assessment required from a specialist. The patient may be referred for an intervention, their suitability for which would be assessed by a consultant.

6.8.1.1 Education and Communication

As far as the influence over GPs is concerned, only cardiologists feel that they have an effect on the GP decision area. It is not surprising that surgeons consider that they have no influence over the general practice level of cardiac treatment provision as all patients referred to a surgeon must have been seen by a cardiologist and as such surgeons are somewhat removed from the beginning of this cardiac pathway.

The role of cardiologists influencing general practitioners takes the form of education. The influence may be implicit due to the discharge of a patient back to GP care, or explicit in the form of letters or other direct communication.

> *'...if you get a letter referring somebody you may realise they don't need to see you ......I would always write back and say you could do this and see what happens.'*

This direct communication works to inform the referring practitioner of alternative forms of treatment available as an option and implementable by a general practitioner. It also allows the referring physician to relate the advice to a specific clinical patient rather than a hypothetical example.

Despite this availability of education it is stated in the questionnaire responses that it is 'not exerted usually'. A study has been carried out by Marshall (1998) exploring just this educational interaction between general practitioners and specialists. Three models of educational interaction were identified: traditional lectures given by specialists to general practitioners, interactive clinically based teaching and informal interaction based on referrals. Whilst the theoretical value of such co-operation is still appreciated, in practical terms the questionnaire results discussed in Chapter 5 have shown that this value is not being realised.

One problem associated with such communication is the time that is required to produce, and on receipt, to read such documents so to take advantage of the information offered. One general practitioner was so inundated with paperwork due to her responsibilities within her health authority that she was unable to continue the public office (Greenhalgh 1998). Whilst this concerned a responsibility in addition to the clinical role, paperwork as a form of communication can be highly time consuming and may be detrimental to the patient.

The advantages of such communication however are varied and broad ranging. An obvious consequence of better informed doctors is better treatment provision for patients. Patients are more likely to receive appropriate treatment (assuming the appropriate treatment is available) and also are likely to be spared unnecessary referrals. Whilst cardiologists find that the majority of referrals are appropriate, some are not.

'you get a letter referring somebody you may realise they don't need to see you ... [the referral] can be silly'

The reduction of the number of unnecessary referrals is not only a benefit for the patient, but for the doctor to whom the referrals are made. It reduces time spent on patients who are not in need of specialist treatment and this in turn saves money and allows patients who are in need to be seen more quickly.

Such relationships are paramount in defining the influences present in the system. The relationships described can be portrayed in the diagram as shown below.

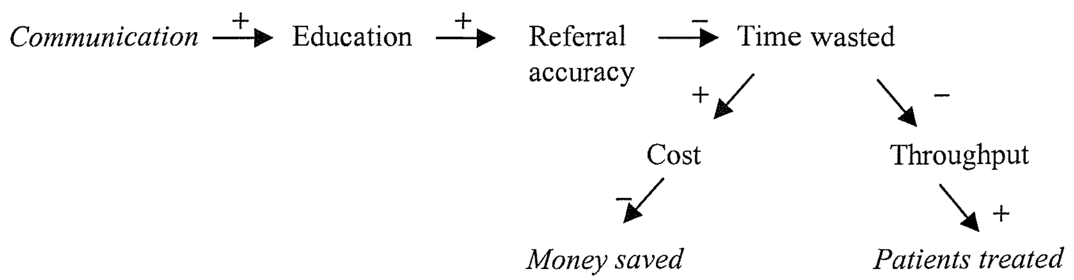


Figure 6-4 ID showing the effect communication can have on time and money

Marshall (1998) considered that it was not expertise that was needed by a GP. This can be contrasted with the response of a specialist questioned for this study, who suggests that on occasion the treatment to be followed by a specialist could easily be implemented by a GP, saving a referral at that stage of treatment.

'...do this ... let me know if the patient's not better, because it's clear we're not going to be doing anything more in this particular case.'

There is scope here for further research to determine just how much specialisation a general practitioner can be expected to have considering they cannot be expected to be as specialised as the specialist!

Consistent and accurate referrals from GPs would reduce patient inequality. Currently some consultants have little faith in the GPs communications.

> *' there is absolutely no correlation between what the GP says and what's written in the letter as to how urgent they are'.*

Whilst this was referring to risk stratification, there is obviously a belief that information from GPs is not necessarily reliable and advice based solely on this should be carefully considered.

6.8.1.2 Persuasion

Persuasion comes in the form of emotional blackmail, the pressure exerted by patients. The decision of a doctor may well be influenced by a patient who is upset about news of their condition; the doctor may then promise to provide priority treatment to calm them down. The result of such persuasion can leave a doctor with non-urgent patients marked for priority treatment. In this way, the persuasion can advance patients through the health system. It is recognised that 'GPs can be pressurised' in this manner.

Persuasion can also be carried out by the referring doctor in order to get a patient seen. This can benefit the patient but in the long run the referring doctor may lose credibility.

When patients are referred to a doctor for treatment, there is an element of trust between the doctors that the details provided regarding the patient are accurate and in no way embellished or exaggerated. However, the competitive market that was set up in the National Health Service in 1991 and was present during the survey period, also introduced an element of competition between doctors in obtaining treatment for their patients, which is affecting their patient management.

> *'There is a trick with all this in that what you do actually is you turn something from routine into urgent. ...You've got somebody who is semi-urgent needs a bypass doing, yet the funding is not there and you're told in December sorry but that patient no matter*

what will have to wait until May ... unless he goes in as an emergency.'

Here the clinical priority allocated by the doctor is elevated to achieve a quicker assessment and works to convince and persuade the doctor receiving the referral to treat the patient more quickly.

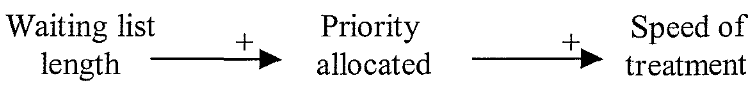


Figure 6-5 ID showing the relationship between waiting list length and the priority allocated to a patient

This fragment of the influence diagram in Figure 6-5 shows how the length of the waiting list can actually cause a patient to be seen more quickly. The negative influences are incorporated in a more complex way in the overall diagram.

6.8.1.3 Waiting list length

The reverse of this exaggeration of clinical need is also true. If a doctor is aware that the contract is approaching its limit or has already reached its limit then a patient, according to some doctors, has to be clinically more urgent before referral is considered. Also, the doctor will be more likely to consider further medical treatment, rather than choosing referral as an option.

'If list is very long then more willing to try maximum treatment.'

These comments raise many questions and demonstrate the significant affect that external factors are having on clinical decision making. There are also ethical implications associated with such a comment.

It is accepted that waiting lists may be detrimental to a patient's health due to the associated delay in treatment provision. Yates states that 'a long wait for any operation can be frustrating, inconvenient and painful, but in some extreme cases, too long a wait might mean death' (Yates, 1995).

As the above doctor's quote states that a long waiting list makes the use of maximum treatment (i.e. drug treatment) more likely, it is not unreasonable to assume that if the waiting list were not an issue the patient would be referred to a specialist as the preferred course of action. Extrapolating this idea, once the waiting list is long enough to influence the doctor, the preferred course of action is not being taken.

This interpretation is assuming that the best course of action is to refer the patient for it is possible, however, that the waiting list is causing the general practitioners to look into the available treatment more thoroughly and that without the waiting list, they are too quick to refer. Having already discussed the fact that some referrals can be inappropriate it is possible that some doctors are referring patients without sufficient cause, as an easy option. This will have an immediate affect on waiting list length. In particular, as has already been shown in discussing the role of education, it is possible that, once the patient has been referred to a specialist, the specialist will do no more than try the maximum medication treatment anyway, something that the general practitioner could do.

It can be argued that the role of a consultant is a person who can be 'consulted' but the statement is that the GP is 'more likely to try maximum treatment' if waiting lists are long, prior to referral. This demonstrates a definitive effect that waiting lists are having on clinical decision making, that is waiting list length is altering the decision made by referring practitioners.

6.8.1.4 Financial influences

Of the three cardiac roles general practitioners seem to be least affected by any direct financial influences. No mention was made in the questionnaire responses of resource constraints or finances directly influencing decisions.

6.8.2 Cardiologist

Several influences were recognised at this stage in the cardiac pathway. It is the only stage where patients are both received following referral, and also passed on and referred to the surgical level.

6.8.2.1 Education and communication

Many of the points raised regarding the education of general practitioners through returning patients also apply to the interaction between surgeons and cardiologists, though the format in which this transfer of knowledge takes place tends to be in a more informal setting. A close working environment encourages communication and therefore learning.

> *'We can always stop each other in the corridor and say will you have a look at this'*

> *'You meet someone in the corridor and they say, oh we have just catheterised this patient, would you like to operate?'*

This informal communication saves time and unnecessary bureaucracy. The initial approach does not require letter writing, and reduces the delay in receiving a response. It allows questions and queries to be dealt with quickly and informally and knowledge to be gained about the appropriateness of the referral suggestion.

A more formal method between cardiologists and surgeons is the arrangement of meetings to discuss, on a regular basis, the suitability of patients for referral and the benefit of this type of meeting is recognised. It is also thought that this could be increased.

> *'I would like to see more discussion about what actually are the indications for surgery...'*

The approach in Britain is that most consultant surgeons act independently to assess patients referred by the cardiologist and the surgeon is then responsible for managing his waiting list. There is a less insular approach in New Zealand where the Health Authority sets criteria for referral and treatment. Patients are presented at a weekly meeting at which both cardiologists and surgeons are present and 'decisions on who is accepted and rejected for surgery are made by consensus' (Bridgewater 1998). New Zealand doctors adhere rigidly to the criteria so as not to set undesirable precedents.

Accepting a patient for treatment who lies even slightly outside the specific remit outlined by the New Zealand Government is strongly resisted to avoid the decisions setting a precedent for future patients. This introduces a method of reducing the level of variety in the referral and acceptance of patients for treatment and the regular meetings between cardiologists and surgeons to discuss treatment provision discourages variance.

6.8.2.2 Waiting lists and associated waiting times

Cardiologists have admitted that the length of the waiting lists can affect their decisions and those of their colleagues. Where waiting lists are long some border-line cases may not be referred for surgery.

It would be difficult to estimate the percentage of physicians who allow waiting list length to affect their clinical judgement. Many would be unwilling to admit it. Some may not be aware that their decision would be different if treatment was more readily obtainable. It could be considered bad practice to 'allow' a clinical decision to change under such circumstances.

The representation of the length of waiting lists and the effect of this on treatment and referral decisions is shown in Figure 6-10.

6.8.2.3 Pressure from General Practitioners

Whilst the topic of persuasion has already been discussed from the point of view of the GP, section 6.8.1.2, pressure is also felt by the cardiologists. Cardiologists have a list to consider, the content of which is not known by the referring GP. Such persuasion can be considered to be detrimental to patients. It can cause a lack of trust by the cardiologist of the judgement of the referring GP due to the 'crying wolf' concept. If patients are consistently allocated a priority by the GP that implies a greater clinical severity than is actually the case, the cardiologist will learn to disregard the allocations. Most cardiologists will disregard pressure from GPs and will form their own judgement as to the urgency of the referral.

6.8.3 Surgeons

The surgical section of the pathway is only influenced in terms of factors affecting whether to accept a patient for treatment or not. Surgeons do not refer patients on for further treatment.

6.8.3.1 Waiting lists and associated waiting times

The survey showed that surgeons, as well as cardiologists, recognised that waiting lists influenced the decision to accept a patient for treatment. This is discussed in section 6.8.2.2.

It was also stated that the longer a patient waits for treatment the more likely it is that the condition of the patient changes.

> *'A greater than 3 month wait for PTCA means the situation changes by the time they get there'*

This can lead to further tests being required which has a cost implication. These relationships can be portrayed in an influence diagram as shown in Figure 6-6.

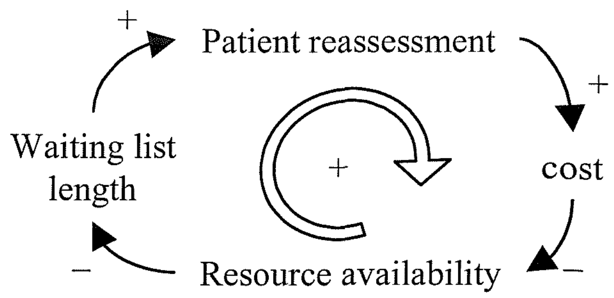


Figure 6-6 Influence diagram to show how waiting lists can affect costs

6.8.3.2 Contracts

The role of contracts plays a large part in choosing a patient for admission. A contract is agreed between the purchaser who states how many patients they wish to treat, and the provider, the hospital, who agrees to treat that number of patients through the year. If the calculation which determines the number of cases to be carried out is insufficient, then some patients will not be able to be treated, unless there is further negotiation of the contract. (Implications of changes in the contract level are discussed in Chapter 4.) Other patients can still be treated if they come from a purchasing area which still has 'room' in the contract. This is another example of the inequity present in treatment provision; in this instance the treatment is dependent on where the patient comes from.

Whilst the organisation of GP groups has altered since the start of this project contracts are still negotiated with the hospital suppliers. The contract levels set the throughput of patients for the department and this throughput is depicted in the influence diagram shown in Figure 6-11.

6.8.3.3 Politics

The introduction of the 12 month waiting limit, as stated in the Patients' Charter (Patients Charter 1991) for the provision of surgery, has changed the management of waiting lists and the policies to control them. As patients waiting over 12 months for treatment are 'not allowed' effort has had to be made to ensure that any 'long waiters' are treated, possibly before a patient of greater clinical need.

> *'You've managed to say it will be twelve months then you get ... a call from [the Chief Exec] you know, some MP's been on to him. Anyway, you get all these pressures coming in that are irrational and subjective.'*

This quote shows the pressure that politics can place on a clinician. A doctor's decision is manipulated by management into choosing a patient who the managers want treated quickly, for external reasons. This pressure comes initially from the length of the waiting list which causes the threshold a doctor applies to a patient to alter. This is discussed in more detail in section 6.9.

6.8.3.4 Pressure from Patients and their associates

There are many sources from which persuasion for quicker treatment can come. Surgeons are faced with telling patients who are deemed to require surgery that it will be twelve months before they receive that surgery. It can then be difficult not to act on the pressure that ensues from patients.

> *'you say you're probably going to wait twelve months because that is what purchasers are purchasing at the moment and some people will burst in to tears ... so you say OK I'll try and give you some priority and get you in in six months and make a little mark on their notes and it goes on the waiting list and then you realise you've done that to 90% of your waiting list.'*

Such emotional blackmail from patients can be very persuasive and it is recognised by doctors that they must 'steel' themselves against such emotion.

> *'I've had to steel myself and say I'm sorry it's going to be twelve months and there's nothing I can do about it because if I tell everybody, 'yes you're a priority', then you end up with everybody being marked priority and you've actually lost sight of the ones who really do need priority'.*

Face to face persuasion such as this is not the only manner in which patients try to gain priority treatment. Surgeons can get calls from the Chief Executive of the hospital because the patient and their family has contacted their local Member of Parliament. This level of persuasion is difficult to refuse.

Whilst this can all work in favour of that specific patient, it discriminates against the patient who is prepared to sit and wait for their turn as. ["The reasonable man adapts himself to the world; the unreasonable one persists in trying to adapt the world to himself. Therefore all progress depends on the unreasonable man." George Bernard Shaw.]

6.8.3.5 Resource availability

Resources can mean doctors, nurses, beds, intensive care facilities. If any of these resources are not available for any reason then treatment of patients is affected. Surgeons specifically mentioned that the ITU (Intensive Therapy Unit) was often blocked through lack of beds. This could be due to insufficient nurses available to staff the beds, or perhaps a patient has had to stay in the facility for longer than anticipated, causing a block. This problem has a direct effect on throughput and therefore on waiting lists. One surgeon felt that this lack of resources was a major problem as he had had to cancel about 25% of scheduled admissions through the year and saw no reason to suppose that was any different for any other surgeons in the department.

> *'a 25% cancellation rate apart from being appalling for patients and staff who have to deal with the cancelled patients it's commercially very inefficient.'*

A buffer zone to enable the facility to balance the treatment of elective and emergency patients is required. That is, the department should have sufficient facilities to cope with an influx of unscheduled admissions without this affecting the scheduled patients.

Unscheduled admissions use facilities that were to be used for scheduled admissions. The impact of this is discussed in more detail in section 6.8.3.7.

6.8.3.6 Supply-induced Demand

Increases in staffing levels is often thought to have the power to affect the waiting lists. However, this is based on a belief which was first mooted when the NHS was initially set up, that there is a finite amount of illness present in the community. It would therefore follow that if more doctors were employed to treat that illness then waiting lists would reduce.

Unfortunately, it is recognised that this result is not achieved through the introduction of new doctors.

> *'Any new cardiologist will find hidden diseases, hidden in the community because they take a more aggressive approach...then the GPs see a service and they've not been referring patients in the past because there's been no service so they start to refer the patients who should be referred'*

This can be represented as an influence diagram as shown in Figure 6-7.

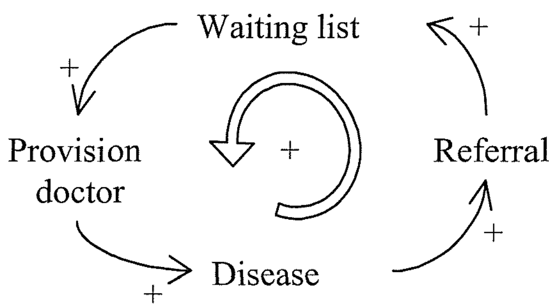


Figure 6-7 Influence diagram showing how increasing the number of doctors has an adverse effect on waiting list length

6.8.3.7 Cancellation of scheduled operations

It has already been discussed, Figure 6-3, that the length of stay of a patient relates directly to the throughput i.e. as the length of time a patient occupies a hospital bed increases, the throughput of patients per unit time is going to decrease.

An increased length of stay leads to increased occupancy and may cause cancellations of scheduled admissions. There is little slack in the system, as observed by the Surgeon quoted below and few spare beds in which to place extra, non-scheduled patients so as not to interrupt the scheduled process. If the bed is occupied then scheduled patients must be postponed.

> *'We're trying to run it [the Intensive Care Unit] too tight ... There's no flexibility and you assume that everybody goes out the next day...we've tried to run it too efficiently and in the Intensive Care situation you have to have what appears to be an excess of resources ... there has to be a buffer zone, we haven't got that, so we cancel cases.'*

Trying to run an ITU at such a high level of efficiency makes it run even less efficiently if the cancellations and associated costs are considered. Whilst it is assumed that all patients will leave the ITU the day following their operation, it is known that it is nearer 90%.

> *'We know that 90% go out the next day... but that leaves 10% who stay on and then you get an accumulation of patients staying on and it blocks the unit'.*

> *'[Cancellations] are almost always due to Intensive Care problems'.*

The influences outlined here can be demonstrated in an influence diagram, as shown in Figure 6-8 below.

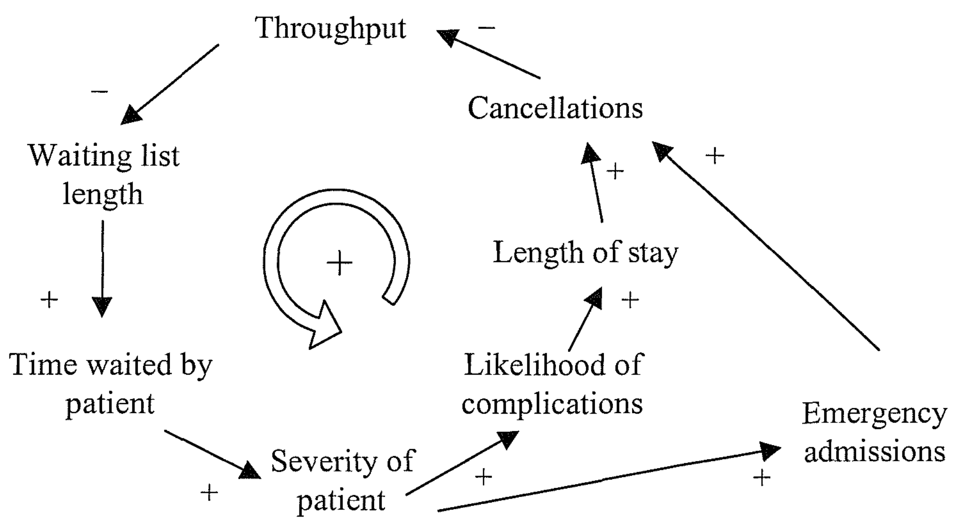


Figure 6-8 ID to show the effect of the length of stay on cancellations

The implications of patients who require a longer time to be treated are recognised by medical staff.

> *'I've got a guy in Intensive Care who was almost dead ... and every day he's in Intensive Care it cancels another operation'.*

It is not always possible to predict which patients will require a greater length of time in the Intensive Care Unit. If it were predictable, choices could be made regarding who should be treated. The ethics of treating one person in favour of perhaps 30 others (assuming an ITU stay of 1 month which is unusual but not impossible), is grounds for debate but is beyond the scope of this thesis.

6.8.3.8 Qualitative Precursors to cancellations

As well as the physical effect of cancellations on throughput, there is a psychological and physical effect on the staff who have to explain to patients the need for a cancellation and who have to subsequently counsel and calm them.

The stress associated with incessant cancellations can and does take its toll on the overall health of staff. In particular the health of nursing staff, whose presence is required in order to keep beds open, is affected.

> *'25% of my operations are cancelled because of Intensive Care problems. ...This leads to ... terrible stress for all concerned, medical, nursing, the patient administrative'.*

> *'As I'm sure you're aware, as the pressure builds up, the sickness rate goes up'.*

The above relationships that have been observed and commented on by medical staff can be shown in the form of an influence diagram, Figure 6-9.

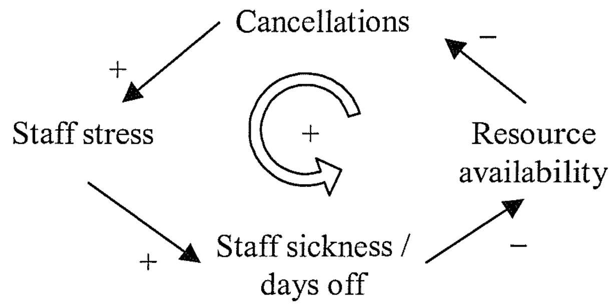


Figure 6-9 ID to show the effect of cancellations on staffing levels

The above diagram shows that as stress levels amongst staff increase so does the number of days taken off through ill health. As staffing levels fall, beds must be closed, most likely to be within the Intensive Care Unit, and cancellations occur, compounding the stress felt. This is a vicious circle.

ITU shortages can also be due to patients requiring their bed for longer than predicted.

6.8.4 Summary of Control and Influence

Such influences as have been discussed above seem to be taking the relevance of the clinical aspect away from medicine by focussing on bureaucracy, administration and number crunching. Many questions appear to have to be asked by the doctor before the clinical state of the patient can be addressed e.g. are the resources available? has the patient already been waiting for treatment? do contracts allow for this patient to be treated?

The only factor over which doctors feel there is some control is their decision regarding referral and treatment provision. However, this is being affected by long waiting lists. Doctors' referral behaviour is likely to be affected to differing degrees as some consciously refuse to be influenced and some explicitly respond to long waits. In addition, there has already been shown to be a marked difference between the reality of waiting list length and the perception of waiting list length.

Whilst it was not brought up in the questionnaire responses, private practice has been identified by researchers as an influence on waiting lists. The books published on waiting lists (Yates 1987, Frankel and West 1993) state that there is little but anecdotal evidence to support the hypothesis that long waiting lists are sometimes associated with surgeons who do a lot of private practice. However there is one small study by Ian Harvey (Yates 1995) who looks at the average waiting list between 2 groups of Surgeons, one of which does private practice, the other not. Those with no private practice had an average waiting list of 111 patients, whilst those with private practice had an average waiting list of 286. Harvey argued that data provided only a broad indication and did not determine any cause or effect. Yates, in whose book this paper is mentioned (Yates 1995) questions whether it is significant that this type of study is so difficult to do and does it mean that there is something to hide.

6.9 Risk stratification and Variation - implications

It has been shown that many GPs do not allocate a priority to a patient when referring them and if they do cardiologists often ignore it. In each case this is because the referring physician does not know how the waiting list, on which they wish to put their patient, is made up. It is not unreasonable to suppose that the waiting list and its constitution is affecting the priority given to a patient. It introduces an element of luck into the speed at which a patient receives treatment.

Inequality can be extreme. One doctor may consider a patient to require treatment, and another doctor may consider the same patient unsuitable for treatment, or to not need treatment at all. This was recently highlighted under the headline 'Second hospital saves heart girl' (BBC News, 1999). The parents of a two-year-old girl, who were told by one hospital that their daughter was too delicate for a life-saving operation, managed to secure the treatment at another cardiac centre with a believed 80-85% chance of survival.

In addition, waiting list management is made more complex by decisions made such as the following.

> *'two of my patients were handed over to other surgeons from my waiting list ......and were told that they didn't need surgery when I had actually got them on my waiting list for surgery.'*

Such significant professional variation in the considered appropriate treatment for patients makes the management of waiting lists more complex than initially supposed. Doctors may be regarded as having thresholds for decision making. These thresholds are dynamic because they are affected by waiting list length as shown by Figure 6-10.

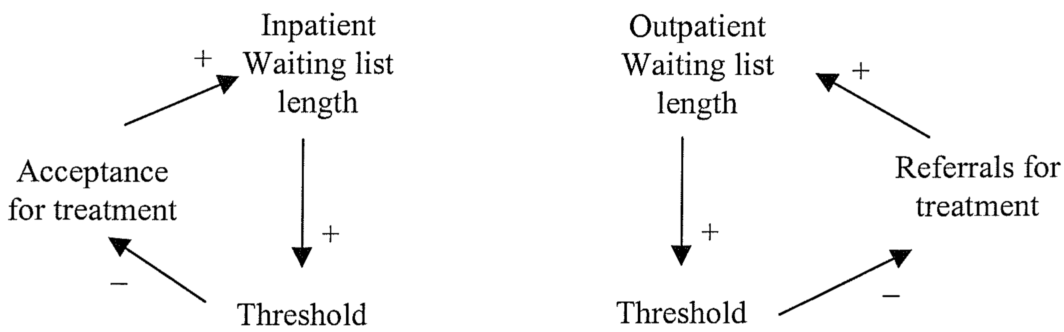


Figure 6-10 ID showing the consequences of a dynamic threshold allocation

6.10 Information provision

The majority of doctors across all roles considered that the information provided regarding waiting lists and associated waiting times was inadequate, both in content and frequency of provision. Even if the information was recognised to be available, not all doctors would make use of it.

> *'Time consuming to do so, lists perceived as being similar length'*

This comment was referring to the surgical waiting however the number of patients on the doctors waiting lists ranges from 29 to 95.

From the point of view of general practitioners again it was considered that waiting lists were similar.

> *'I don't find it makes a great difference locally ......[Waiting lists] much the same'*

General practitioners refer to cardiologists and if this view, that cardiology waiting lists are all much the same, is compared with the stated length of time patients are expected to wait according to the cardiologists themselves, it can be seen that there is a discrepancy between perception and reality. The perception is stated that there is little difference locally and yet the number of patients on a cardiology waiting list varies from 1 to 140.

This shows that the perception that waiting list length is similar is misplaced in the cardiac system and provides evidence to back-up the argument that accurate information on waiting list length should be provided regularly and frequently. This is particularly important as GPs are affected by the length, or perceived length of the waiting list. Information should be provided as GPs use it to manage their referrals, as stated below.

Whilst it was stated that some waiting list information was provided to GPs, it was also stated that accuracy was a problem. However, it is possible that GPs distrust the waiting list information because it does not agree with a prior belief.

The use of the information relating to waiting lists was specified by both cardiologists and general practitioners to be to identify the shortest list to which to refer. This contradicts the use of waiting list length as a means of portraying excellence, (Yates 1987), that those doctors with the longest waiting lists are those most favoured by doctors referring.

> *'Ssurgeons are by definition, I think, insecure and they need constant reassurance that what they're doing is correct and you get that from the referrals.'*

The doctors indicated that the prime concern was to find a list that would provide treatment for their patient with the least delay.

> *'...refer generally to shortest waiting list.'*

It was also shown that knowledge of waiting list length and associated waiting time was used to influence the decision to refer or accept a patient for treatment. For this reason, there is an argument that doctors should not be given any level of responsibility for their waiting lists and should not have access to information regarding the length of their waiting lists. This would prevent them becoming a factor in deciding on treatment provision for a patient and would then produce an accurate representation of need for those services as the waiting list would be unaffected by manipulations influenced by its length. However, doctors have a responsibility for their patients and by association their waiting lists. It would be impractical for doctors to not be aware of their waiting lists or the waiting lists of others.

6.11 Influence Diagram

The discussion drawing on the responses to the questionnaires and the interviews has highlighted many influences which have been examined and displayed throughout the chapter in the form of influence diagrams. These fragments are now drawn together to produce an overall representation of the system. The role of the influence diagram is not only to show that a specific characteristic of an environment affects another, but how this takes place and the consequences. Joining the fragments produces further connections and feedback loops, few of which are controlling, the majority being reinforcing.

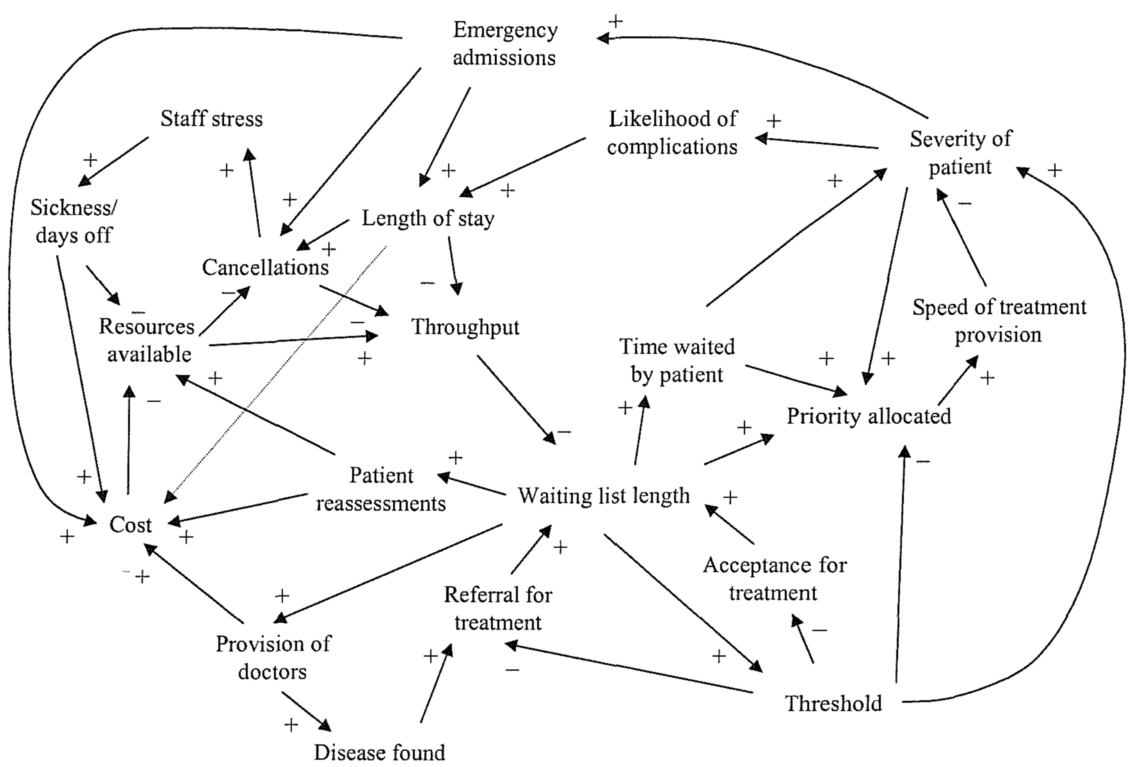


Figure 6-11 Influence Diagram

(NB – the link between length of stay and cost has been depicted by a shaded arrow in order to show the link clearly as it has had to cross other lines. There is no significance in this.)

6.11.1 Influence Diagram statistics

Following the information provided through questionnaires and interviews many ID's were devised using quotes to illustrate the relationships portrayed. These were connected together to provide a detailed representation of the cardiac system, centred around waiting lists.

The ID consists of 20 influences which have been identified as affecting waiting lists and the decisions regarding those waiting lists. There are 68 loops present. It is interesting to note that the vast majority of loops can be seen to be reinforcing, with few enabling control of the system through negative feedback. Many of the loops are similar in their make up but all 68 do involve a slightly different pathway through the diagram.

6.12 Qualitative relationships as reasons for quantitative inputs

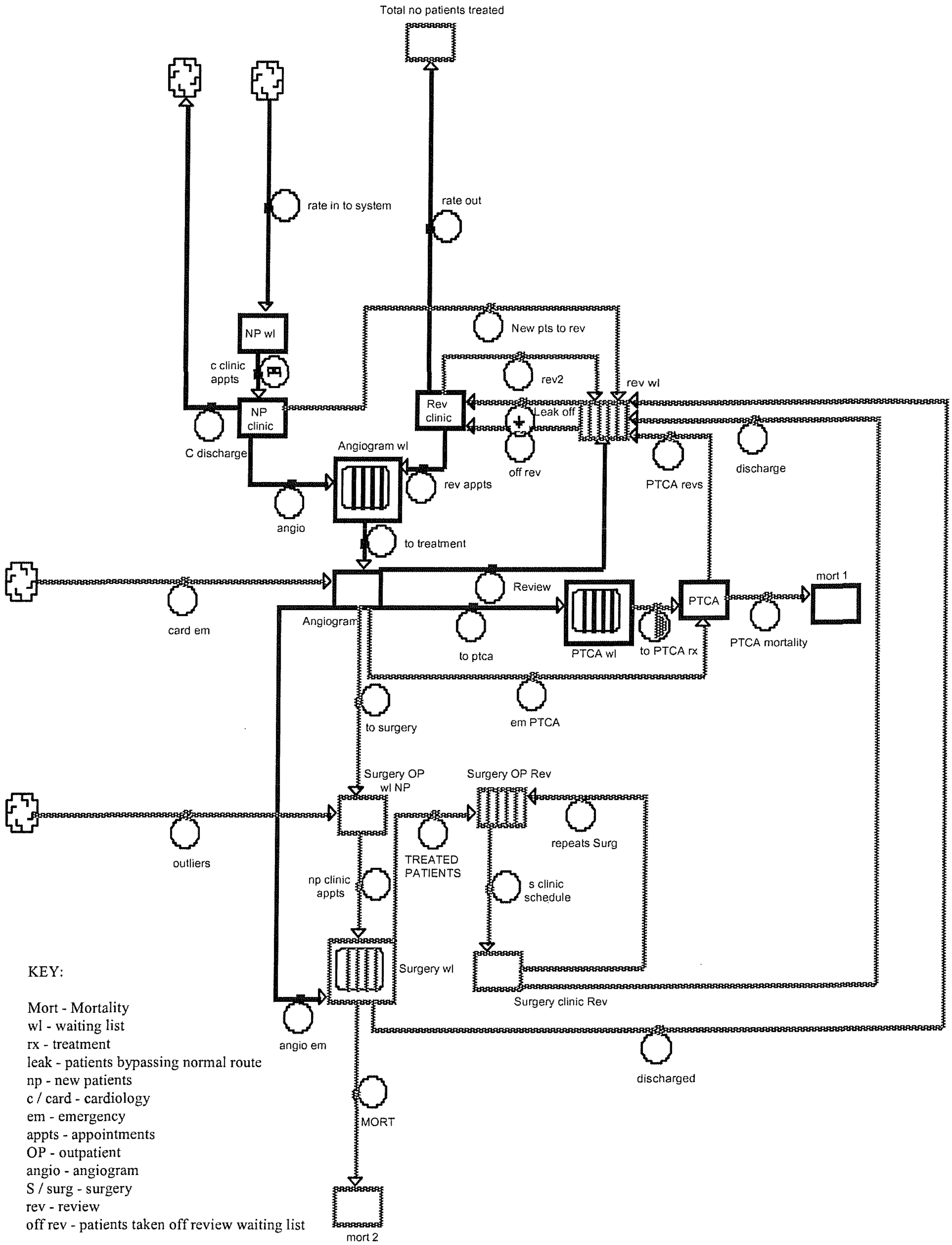
It is not always necessary to model every qualitative influence perceived, in a quantitative manner. As has been discussed in Chapter 3, much understanding of the relationships is gleaned from representations such as the causal loop diagram and general discussion of the system.

The implications of certain influences are modelled as the result of interactions between qualitative factors whose relationships are depicted and understood through the use of influence diagrams. The cause of any effects is understood through reference to qualitative representations.

For example, System Dynamics is a macro approach and is not interested in the detailed allocation of resources even though they may be implicated in cancellations. At this stage the balance between lack of nurses and lack of beds as the cause for ITU cancellations is not of interest. However, it is known that the cancellations are due to either a lack of nurses or beds. For the quantitative modelling aspect, the effect of the cancellations on other departments within the system is of interest and so a change in ITU cancellations is modelled, not a more micro approach looking at the change in nursing availability or the variable availability of beds.

6.13 System Dynamics model

To further investigate the interaction of the qualitative influences identified and their effect on the waiting lists present in the cardiac system, the influences and the effects of these influences were combined with the flowchart to develop a System Dynamics model. An outline of the SD model constructed, without the many connectors and ghost icons, is shown in Figure 6-12.



KEY:

Mort - Mortality
wl - waiting list
rx - treatment
leak - patients bypassing normal route
np - new patients
c / card - cardiology
em - emergency
appts - appointments
OP - outpatient
angio - angiogram
S / surg - surgery
rev - review
off rev - patients taken off review waiting list

Figure 6-12 Simplified SD model representing the cardiac pathway

6.13.1 General formulation

The model was built around the initial flowchart that was constructed for the questionnaires. The portrayal in Figure 6-12 is simplified in that some constructs, for instance ghost icons (icons which have been copied from one area of the model to another for convenience) are not shown, nor are all the calculation connections. Inclusion of every connector causes the model to look messy and does not add to the general understanding of the flows represented.

6.13.2 GP representation

The GP area is at the top of the model with patients arriving along '*rate into the system*'. This represents the referrals of patients from GP clinics into the cardiology system, which is hospital based.

6.13.3 Cardiology representation

Cardiology clinics are controlled by the number of appointments which are available each week to certain classes of patients. Note that the cardiology clinics are split into two. One set of appointments is allocated to patients who have not been assessed by a cardiologist before, and the other set of appointments is given to patients who are attending the clinic to be reviewed, having previously seen the doctor. Within the hospital the clinics are run as one.

The model requires patients to wait to be seen in the clinic, represented by the stock '*NPwl*' (New Patient waiting list). Patients are removed from this list at a rate determined by '*c clinic appts*' (cardiology clinic appointments). This rate is set by the hospital.

The patients are then passed to the clinic, shown as the stock '*NP clinic*', where a cardiologist makes a decision regarding the treatment the patient requires. There are three options available to a cardiologist:

1) the patient is considered unsuitable for treatment, for whatever reason, and is discharged from the cardiac system;

2) the patient is considered suitable for further medical treatment or review of symptoms and is referred to the review clinic for a future appointment;
3) the patient is considered suitable for treatment and is referred for an angiogram, a diagnostic technique to further investigate a patient's condition.

Once a patient is referred to be seen in the review clinic, '*Rev clinic*', they are assumed to be seen every 6 months and they wait in a queue represented as the stock '*rev wl*'. It is possible for these patients to be seen before 6 months and this is shown by the '*leak off*' rate. The '*off rev*' represents the number of review clinic appointments that are determined by the outpatient department of the hospital, in conjunction with the doctor conducting the clinic.

Cardiologists have three options with regard to the patients they see in the review clinic:

1) the patient requires a further consultation and is given another appointment for the review clinic in 6 months time - *rev2*
2) the patient has been treated sufficiently and is discharged from the cardiac system - *rate out*
3) the condition of the patient has changed sufficiently to require an angiogram and the patient is referred on to the angiogram waiting list - *rev appts*

It can be seen that patients can be placed on the angiogram waiting list from either the new patient clinic or the review clinic. The angiogram waiting list is represented by the stock '*Angiogram wl*'. The model diagram shows that this stock is a sub-model, the use of which will be discussed below. In summary, patients are placed on a waiting list, by a cardiologist, according to the severity of their condition. There are three waiting lists, all of which are represented in the sub-model.

Patients are removed from the waiting lists according to the number of slots that are available each week in the catheter laboratories at the hospital. This is defined in the rate '*to treatment'*. At this stage patients receive their angiogram, following which a decision is made by the cardiologist as to the next treatment for the patient. Some patients are admitted for an angiogram as an emergency shown as '*card em*'. There are five options available to the cardiologist:

1) the condition of the patient is found not to be severe and they are referred to the review clinic for a check-up in 6 months time - *Review*
2) the condition of the patient is found to require a PTCA and the patient is referred to that waiting list - *to ptca*
3) the condition of the patient is found to require a CABG and the patient is referred to that waiting list - *to surgery*
4) the condition of the patient is considered to be severe and they are admitted as an emergency for a PTCA - *em PTCA*
5) the condition of the patient is considered to be severe and they are admitted as an emergency for a CABG - *angio em*

If a patient is considered to be an emergency they by-pass the waiting lists, going straight to the treatment stock. If they are not an emergency they are placed on the relevant waiting list.

Patients referred for a PTCA are added to the PTCA waiting list, which, as with the angiogram waiting list, is portrayed as a sub-model. The sub-model represents the different priorities that a patient can be given for treatment and is shown by the stock '*PTCA wl*'. Patients are taken off the list according to the number of slots available for the procedure and is represented in the model by the rate '*to PTCA rx*'. (NB rx is an abbreviation for treatment).

Both scheduled and emergency admissions feed into the stock '*PTCA*' where treatment is provided. This results in patients being reviewed in clinic following a successful outcome, '*PTCA revs*', or the patient dying, '*mort 1*'.

6.13.4 Surgery representation

Those patients who were to be considered for surgery are placed on the outpatient waiting list of a surgeon, '*Surgery OP wl NP*'. This waiting list does not have separate priorities within it. Patients can also be placed on this list from cardiologists not based within the hospital, shown on the model as '*outliers*'. The number of clinic appointments available is determined by the outpatient appointment and the doctors running the clinics and is portrayed as the rate '*np clinic appts*'.

The surgery sub-model incorporates the decision made in clinic regarding what the patient requires in the form of treatment, the different waiting lists run for the patients, cancellations that occur and the schedule that controls the number of patients who should be able to be treated each week. This sub-model is discussed in detail below.

Once treated, surgical patients either die, '*mort 2*', at rate '*MORT*', or are given an appointment to be seen in the review clinic, '*TREATED PATIENTS*'. Having been reviewed the patients can either be required to see a surgeon again, '*repeats Surg*', or be discharged back to the cardiologist, '*discharged*', who will see them within the review clinic mentioned above. The likelihood of a patient being required to see a surgeon again is small but is possible, for instance, if the wound is not healing properly.

6.13.5 Sub-models

Sub-models are provided by the software (STELLA) as a tool to managing model complexity. They provide a means of 'drilling-down' into the various stages of the process, to represent sub-processes with a greater degree of detail. It is designed to encapsulate detailed structure, so adding layering to the model.

There are three sub-models used in the model demonstrated here; one for the angiogram waiting lists, one for the PTCA waiting lists and one for the surgical waiting lists. Sub-models were chosen for these due to the complexity of the interaction between the lists. As an example the sub-model designed for the surgical waiting lists is shown in Figure 6-13. Similar sub-models were used to represent the other procedures. The sub-models are similar in structure to the model presented in Chapter 4.

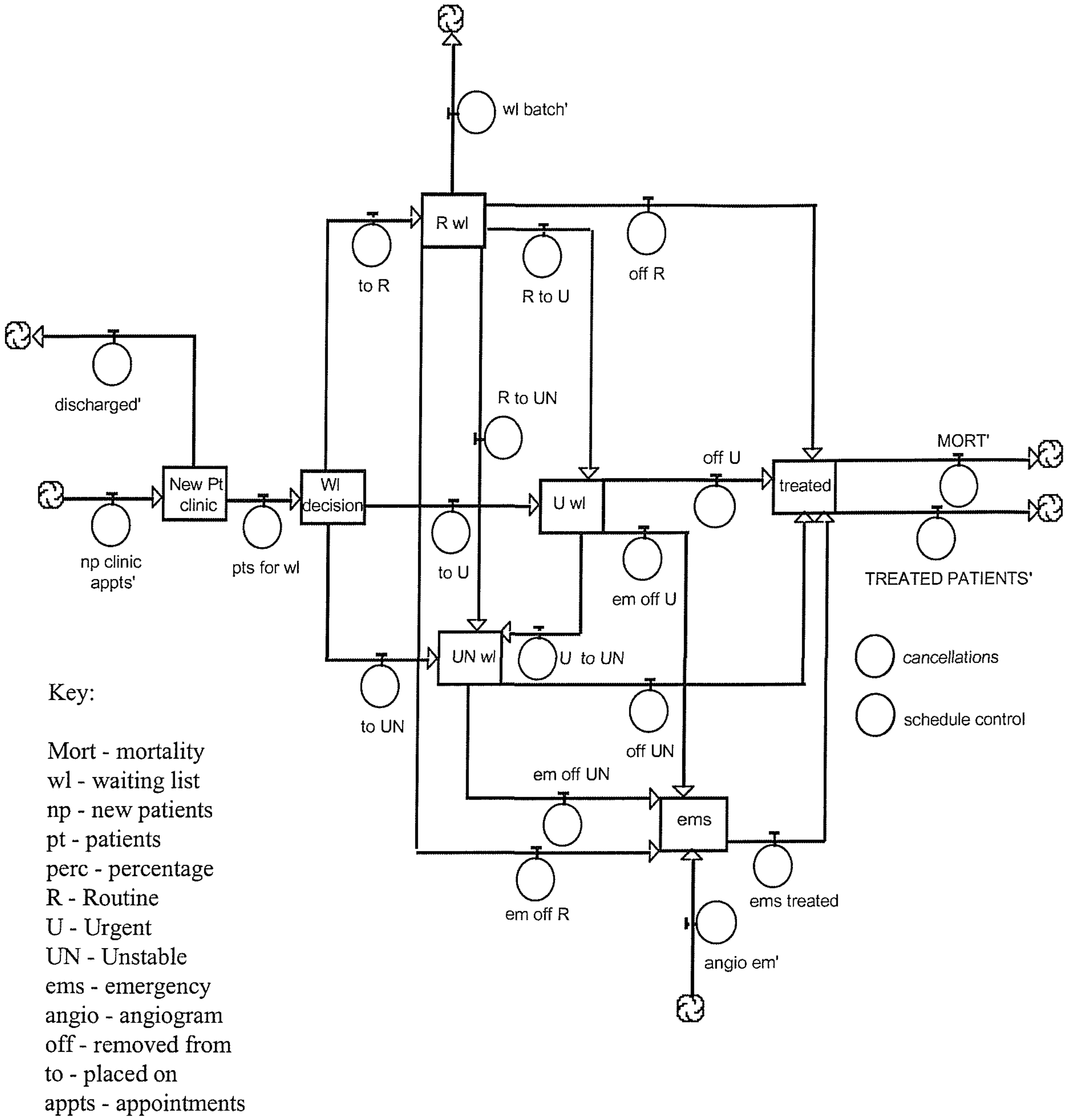


Figure 6-13 Example of a sub-model – Surgical Waiting Lists

Once within the sub-model patients are seen in the *'New pt clinic'*, where a surgeon has two options with respect to the patients on going treatment;

1) the patient is considered unsuitable for surgery and is discharged back to the cardiologist - *discharged*

2) the patient is considered suitable for surgery and is placed on a waiting list for surgery - *pts for wl*

If the patient is to be placed on a waiting list the severity of that patient must be assessed and this provides the surgeon with three further options;

1) the patient is considered able to wait for treatment and is placed on the routine waiting list - *to R* and onto *R wl*

2) the patient is considered to be able to wait for treatment, but not too long and is placed on the urgent waiting list - *to U* and onto *U wl*

3) the patient is found to have unstable angina and is placed on the unstable waiting list - *to UN* and onto *UN wl*

Once the patient is placed on a waiting list they do not have to stay there. As has been discussed previously, coronary artery disease is progressive and the condition of a patient may change over time. As such, there are links between the waiting lists, '*R to U*', '*R to UN*' and '*U to UN*'. Also, patients may be admitted from the waiting list as an emergency. This is also portrayed, '*em off R*', '*em off U*' and '*em off UN*'.

All the patients who are taken off the waiting lists are treated, this treatment being either successful, '*TREATED PATIENTS*', or unsuccessful, '*MORT*', as mentioned on the upper level of the model. The rates at which the patients are removed from the waiting lists are determined by the number of slots allocated to CABG surgery each week, '*schedule control*'. In turn, the theatre schedule is affected by cancellations, '*cancellations*'.

Sub-models for modelling the waiting lists associated with angiograms and PTCAs are based on the same format.

6.13.6 Feedback within the model

The stages at which feedback occurs are incorporated within the model. The first example is the effect of the waiting list length for new patients referred into the cardiac system on the referral rate of those patients. Any changes in referral patterns will happen at the extremes. In theory there are two extremes that could be affected but, as we live in an altruistic society, emergencies will still be treated. There will not be a situation where someone is turned away if there is a chance that they could be saved. As such referrals will not alter at that end of the spectrum. So, based on the explicit relationship as defined in responses, e.g. *'waiting list got shorter ......doing patients with a lower threshold'*, feedback is modelled with reference to the routine waiting list. As the waiting list increases the referral rate decreases, and vice versa. This is achieved using a graphical function within the software and is shown in Figure 7.2.1.

6.13.7 Loops within the model

Not all patients are treated successfully first time through the cardiac system and as such it is possible for patients to return for further treatment without having left the system. There are several examples of this, one of which is shown in Figure 6-14.

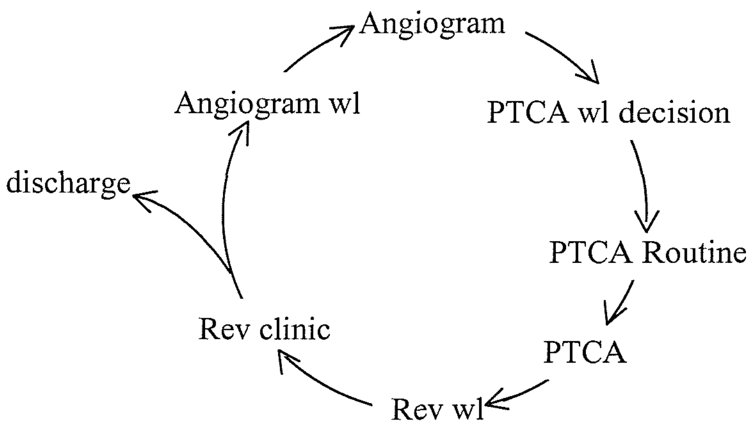


Figure 6-14 Loop showing a possible pathway within cardiac system

Figure 6-14 shows a possible pathway for a patient within the cardiac system. The patient would have been placed on the angiogram waiting list, would then receive treatment, and, based on the results of the angiogram, would be considered suitable for a PTCA. Once on the PTCA routine list the patient is treated and then reviewed in clinic. At this stage it is possible that the treatment has not worked sufficiently well and the patient must be referred for further treatment. To ensure that the doctors know the situation within the chest, a further angiogram is required, completing the loop.

There are many examples of loops within the model. The above one could apply to any of the three PTCA waiting lists. There are also loops involving surgery and less complicated ones with respect to the review clinics to which patients can return. An example of each is shown in Figure 6-15 and Figure 6-16.

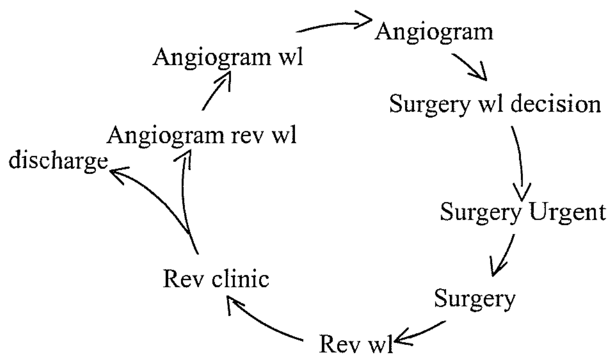


Figure 6-15 Loop present involving surgical waiting list

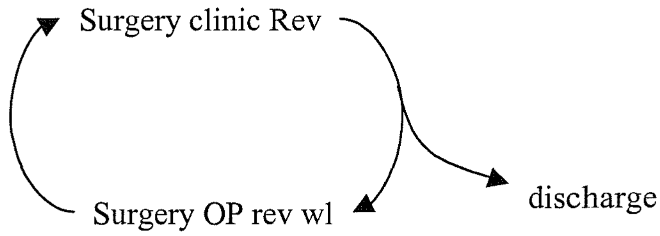


Figure 6-16 Loop present demonstrating that model allows patients to return for further appointments if necessary

6.13.8 Running the model

Following completion of the construction of the model and the collection of the quantitative data from the participating hospital the model was run, simulating the cardiac department. Observations were then made regarding the waiting list lengths and interactions and the results are discussed in Chapter 7. Different scenarios are simulated to see how a decision made now could affect waiting list trends in the future.

7 Results

7.1 Introduction

The model presented in Chapter 4 was created in order to determine the suitability of System Dynamics in waiting list research. The logic on which it is based assumes that patients are chosen according to their clinical priority, that is, emergencies are treated first and if there are theatre slots available any unstable patients waiting are treated. If there are still resources available those patients who have been classified as urgent are treated and finally routine patients. It was used to evaluate the effects of contract levels on and the interactions between the different waiting lists present in just the surgical department.

The model presented in Chapter 6 is designed to represent the whole cardiac department and is based on the logic that doctors admit patients from different groups at an estimable rate.

The aim of this thesis is to explore the behaviour of cardiac waiting lists, in particular to investigate the effects of policy changes across the medical / surgical boundary on waiting lists. This chapter explains data and departmental changes which took place during the development of the second model and uses it to implement different scenarios. These look at how the waiting lists react to changes in the parameters defining the system. There are many scenarios that could investigated given the size of the model but just a few are presented here. These are then discussed.

7.2 Data

System Dynamics requires a significant amount of data. These were collected with the co-operation of the information services department of the hospital and the doctors participating.

On several occasions the information sought was not available as it had not been considered sufficiently important by the hospital to be collected. (It is hoped that this thesis will demonstrate the importance of data collection). In such instances the doctors involved were asked to use their experience and expertise to approximate the values needed. These were then collated and used.

Some of the values provided by the hospital were static figures, for example, the number of patients referred to the hospital over six months. Distributions were applied, under the advise of doctors, to provide variability. Distributions used were the Normal distribution and Random or Uniform distribution as appropriate. The distribution means used the averages provided by the hospital.

All the equations defining the system can be found in Appendix 4.

7.2.1 Feedback

System Dynamics allows for relationships to be represented graphically. Although no exact figures were available for the feedback phenomenon, figures were quantified by doctors' expert opinions.

Feedback was identified as being present between doctors' decisions to accept and refer patients for treatment and the length of time the patients were going to have to wait. An example of a feedback graph is shown Figure 7-1. Similar graphs were used in the following places: decision to refer for cardiology consultation, decision to place patient on angiogram waiting list, decision to place patient on PTCA waiting list, decision to refer patient for surgical consultation and decision to place patient on CABG waiting list.

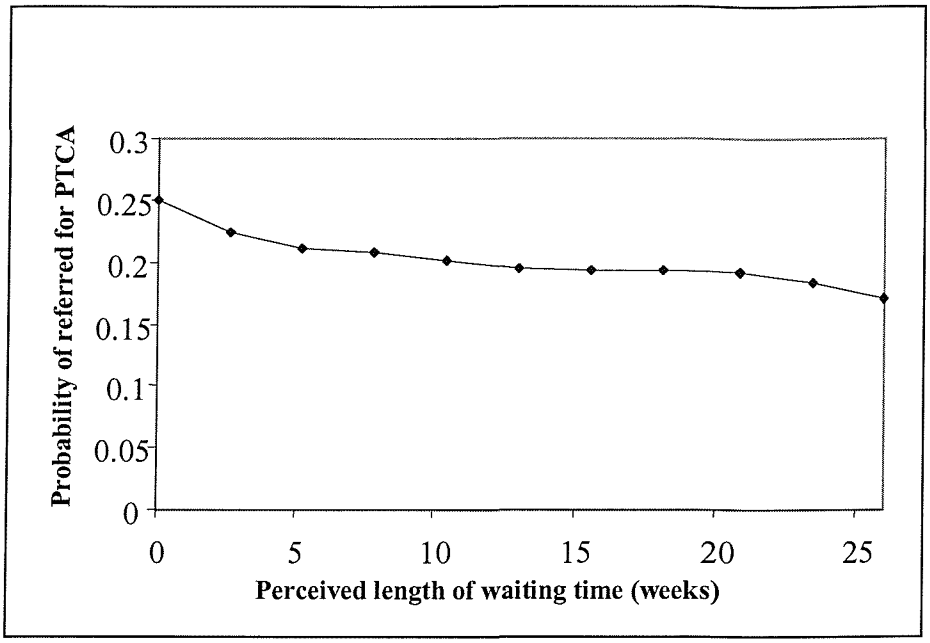


Figure 7-1 Demonstration of the way feedback is quantified in the model

The x-axis is the length of wait that is perceived to exist by the doctor making the decision. As this wait increases the likelihood of a patient being referred or treated decreases. Doctors thought that the probability of a patient being suitable for PTCA was 20% and recognised that feedback would apply most at the extremes of the waiting list. The average probability shown in the graph is 0.2. The waiting list, while it may have a wait of longer than 26 weeks, was considered not to influence decisions any further after that.

7.2.2 Scaling

The waiting lists are represented in the model by a reservoir. When dealing with the outflows of a reservoir care must be taken to understand the way in which the software carries out its calculations. If there is more than one outflow from a reservoir stock, assuming a negative stock is not allowed, the software applies a priority to the outflows. The first outflow from the stock gets 'first crack' at the content of the stock. For example, in terms of the cardiac model, patients seen in a clinic could be either 'discharged', 'treated' or 'referred' to another doctor. The software allocates an order to these options so that if the first output to be created was 'discharged' priority would be given to this calculation. The number of patients then to be discharged would be calculated and those left in the clinic, if any, would be applied to the next calculation, say 'treated'. Again, if any patients are left, the software then calculates how many patients should be 'referred'.

This created a bias in the way patients were allocated from a clinic. In order to overcome this, to allow variability and to ensure that always exactly 100% of patients were allocated, the model applied a percentage of patients for each outflow. This was then calculated, scaled and then applied to the reservoir.

As an example Table 7-1 shows that there are three waiting lists (WL) available for a surgeon to decide to place a patient on; routine (R), urgent (U) and unstable (UN). The probability of a patient being placed on a routine was estimated by surgeons to be random between 0.45 - 0.75, urgent was random between 0.15 – 0.35 and unstable was random between 0.05 – 0.1. It can be seen that if the top end of all these defined random ranges is chosen by the software then more than 100% of patients would be placed on a waiting list. Similarly, if the bottom end of all the ranges is chosen less than 100% of patients would be allocated to a waiting list. To overcome this the distribution results were scaled.

	WL	Probability
Waiting list decision	to R	RND (0.45-0.75)
	to U	RND (0.15-0.35)
	to UN	RND (0.05-0.1)

Table 7-1 Probabilities associated with a surgeons decision to place a patient on a waiting list.

To scale the results the samples for each distribution were summed and the samples then divided by that sum giving a scaled value for each decision.

R+U+UN = sum scaled R = R / sum

scaled U = U / sum

scaled UN = UN / sum

7.3 Changes to the System

The model was initially designed based on figures provided by the hospital and expert approximations when data were not available. During the time taken to develop the model two changes in departmental procedure were introduced within the system. These were incorporated into the model.

The first change to be included was the purchase of a Mobile Catheter Laboratory (MCL). It was important to include the MCL as it directly increased the number of angiograms which could be carried out. This increase in provision was modelled at the time the MCL was initialised. On speaking with doctors within the system it was considered that the availability of the MCL reduced the pressure on the main hospital laboratories and the number of laboratory slots allocated to PTCAs increased.

The second change included was because the hospital introduced a waiting list initiative during the development of the model. As a result of this initiative two batches of patients were removed from the waiting list and operated on, over and above the scheduled patients. These were included in the model.

7.4 Details of simulation run

Each simulation run spanned 500 weeks, approximately 10 years. DT used was 0.125. 12 iterations of each scenario were carried out to enable averages to be calculated. The results presented are based on the mean result in each case. Random number seeds are included in the equations and need to be changed manually for each iteration. The SD software does not facilitate the use of multiple iterations.

7.5 Validation of model

Validation of the model was achieved in two ways. Firstly, the doctors who contributed to the project gave specific feedback verifying the structure of the System

Dynamics diagram. Secondly, the hospital gave figures for comparison with the model at three points in the simulation run. The points used were the start point i.e. week 0 , week 30 and week 65. The present is equivalent to week 75. Table 7-2 shows the number of patients known to be on the waiting lists, the number of patients predicted by the model to be on the waiting lists and the accuracy of these figures.

The '% difference of model mean to actual' compares the value obtained from the model with the real value from the hospital and presents the difference as a percentage of the real value. It can be seen that all model values are within 10% of the actual values.

	Validation points (weeks)		
Angiogram	0	30	65
Actual no. patients	**324**	**438**	**403**
Model no. patients (mean)	324	418	410
standard deviation from mean	0	19.8	14.4
% diff. of model mean from actual	0.00	4.57	1.74
% Range*	0 - 0	3.06 - 6.19	0.77 - 3.89
PTCA	0	30	65
Actual no. patients	**57**	**67**	**56**
Model no. patients (mean)	57	63	61
standard deviation from mean	0	4.3	5.1
% diff. of model mean from actual	0.00	5.97	8.93
% Range*	0 - 0	2.40 - 8.49	3.53 - 12.11
CABG	0	30	65
Actual no. patients	**380**	**414**	**407**
Model no. patients (mean)	380	397	433
standard deviation from mean	0	18.9	29.6
% diff. of model mean from actual	0.00	4.11	6.39
% Range*	0 - 0	1.54 - 6.72	2.35 - 10.6

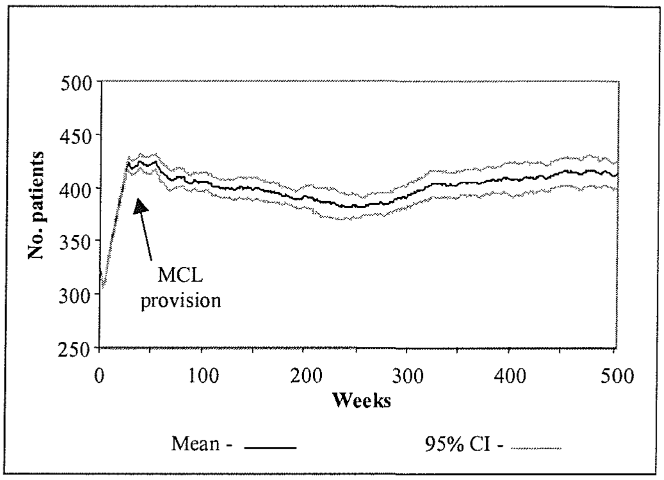
* - range of deviation from the model based on 95% confidence limits

Table 7-2 Table to show the actual and modelled figures for the waiting lists

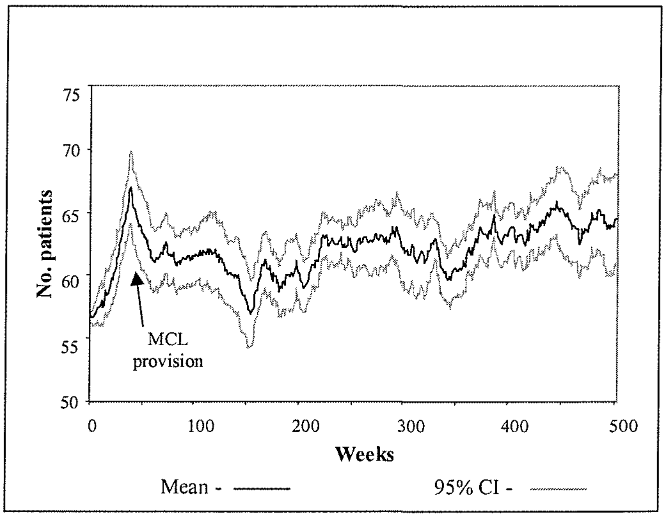
Overall, the table demonstrates that the accuracy of the model is good and can be used to investigate the behaviour and interaction of the waiting lists under different conditions.

7.6 Stability of the model outputs

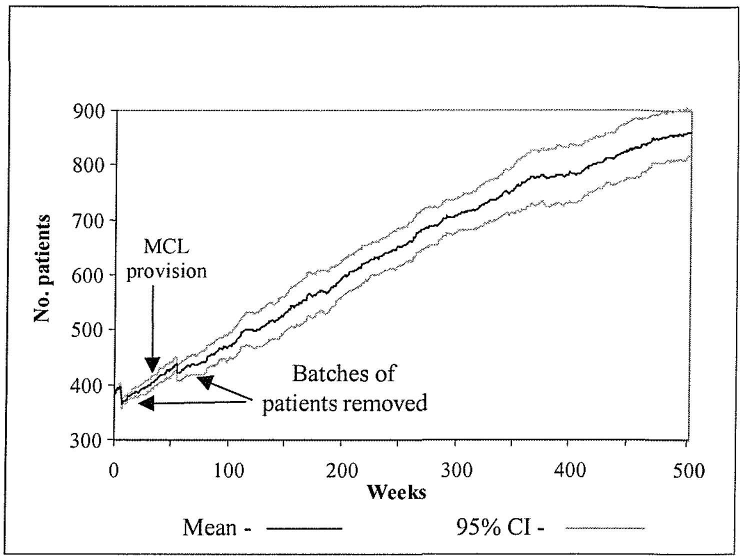
The following graphs portray the mean model outputs for the total number of patients on the waiting lists for each of the treatments explored. The 95% confidence limits of the data points are also shown on the graphs. These are very close to the mean value and demonstrates that the model is stable in its outputs.



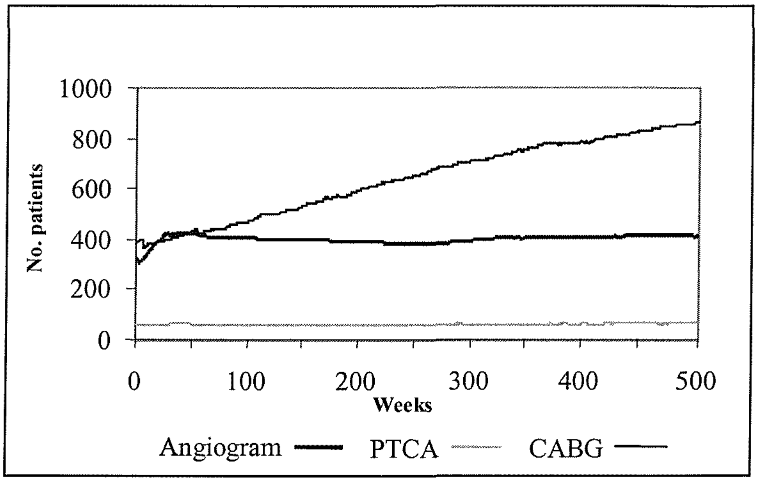
(a)



(b)



(c)



(d)

Figure 7-2 95% CI of mean waiting lists for

a) Angiogram b) PTCA c) CABG d) all on the same scale

7.6.1 Angiogram waiting list

The mean angiogram waiting list shows an initial rise up to the time of the provision of the MCL. It falls steadily for about three and a half years before this downward trend reverses and the list begins to rise again. It should be noted that the list falls from its height of 425 to 385 at 250 weeks which is still higher than its initial value at the start of the simulation of 324.

7.6.2 PTCA waiting list

The mean PTCA waiting list shows an initial rise up to the time of the provision of the MCL, after which it falls quickly. Despite this fall the waiting list does not reach the start point low of 57. After 3 years the waiting list follows an upward trend and after 10 years the waiting list has increased by nearly 15%.

7.6.3 CABG waiting list

The upward trend followed by the waiting list for surgical patients is clear. There is no effect on this list by the provision of the MCL as it provides no increase in facilities for surgical patients. After 10 years the waiting list is seen to have more than doubled, increasing by nearly 130% from 380 patients to 860.

7.7 Routine and Urgent waiting lists

The doctors estimated the current split between routine and urgent patient on the waiting list.

Figure 7-3 shows the general trend of the total number of patients on the waiting list is rising. It would not be unreasonable to expect similar trends in the waiting lists which make up this total. However, Figure 7-3 demonstrates this is not the case. The routine and urgent waiting lists can display almost opposite dynamics. Initially both the routine and urgent waiting lists increased. The extra capacity provided by the MCL absorbed more urgent patients and reduced the urgent waiting list for about 4 years. The routine list continued to increase, though at a reduced rate once the MCL was introduced.

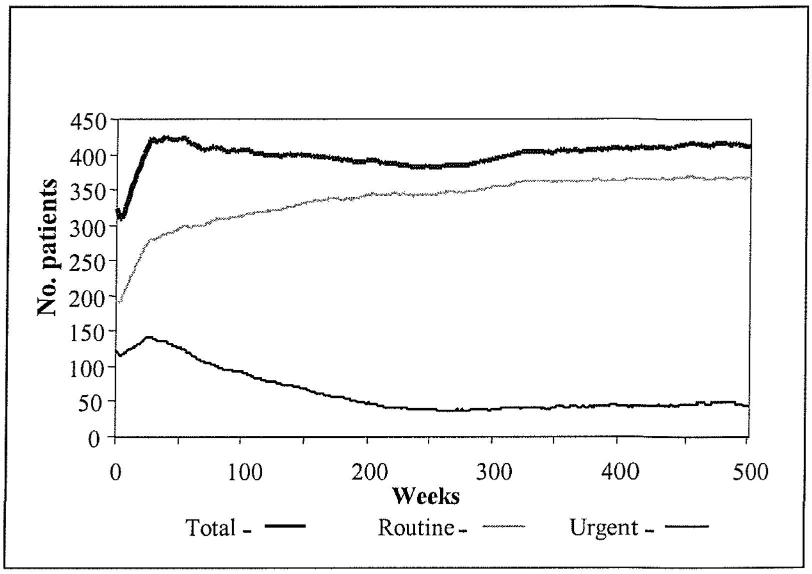
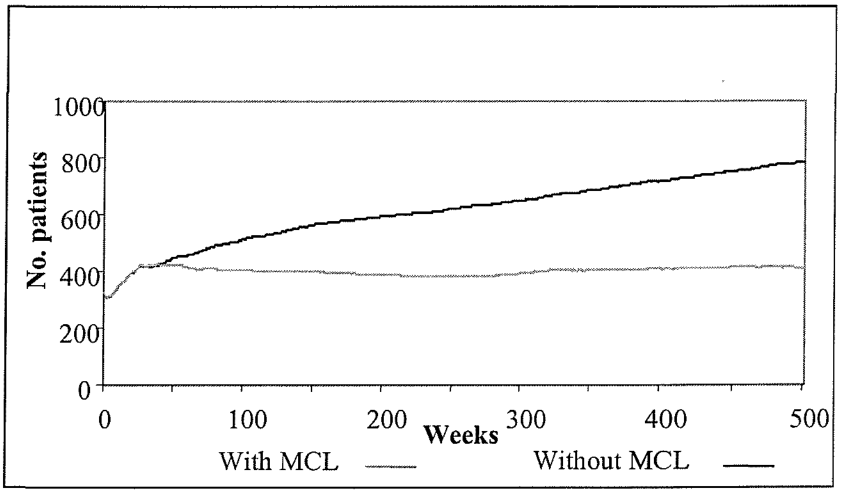


Figure 7-3 Dynamics of the routine and urgent waiting lists

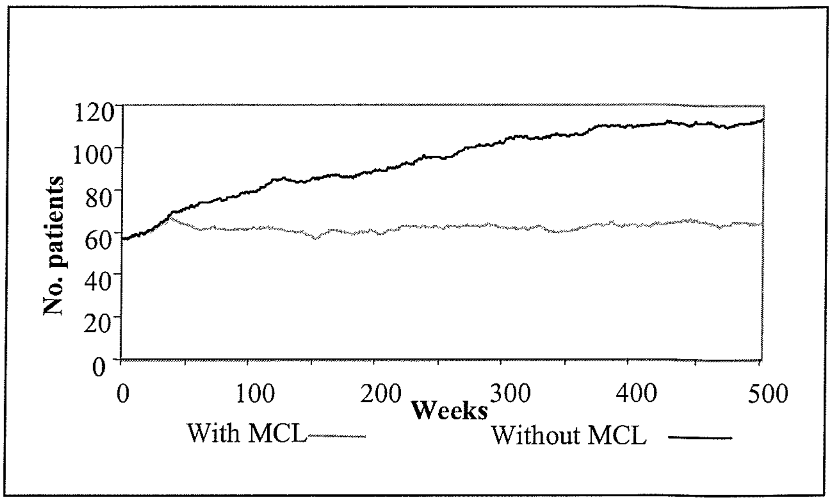
The implications and importance of differing dynamics will be discussed in Chapter 8.

7.8 Waiting list trend with no MCL

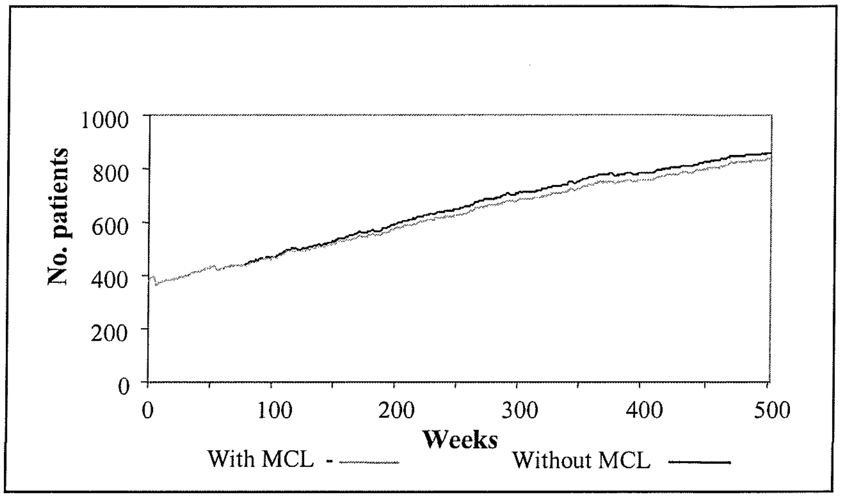
The purpose of providing the MCL was to reduce waiting lists. In order to investigate whether the decision had had this effect the model was run without the introduction of the MCL. As was seen in Figure 7-2 (a), the introduction of the MCL seemed to have a positive effect on the length of the angiogram waiting list.



(a)



(b)



(c)

Figure 7-4 Effect of the MCL on waiting lists

a) angiogram b) PTCA c) CABG

Figure 7-4 (a & b) show that if the MCL had not been provided the waiting lists for Angiogram and PTCA would have risen at a much greater rate than with it.

What is less obvious is why there is so little effect on the CABG waiting list (Figure 7-4 (c)). It is either possible that the extra patients referred after an angiogram were found not to require surgery or that there was a bottleneck in the system. This can be determined by observing the surgical outpatient waiting list shown in Figure 7-5.

Figure 7-5 shows that there is a reversal in the initial downward trend of the waiting list at the time of the introduction of the MCL. The increase in the outpatient waiting list suggests the second hypothesis, that more patients are referred to the surgical waiting list but there is a bottleneck in the system preventing the patients being seen by the Surgeon.

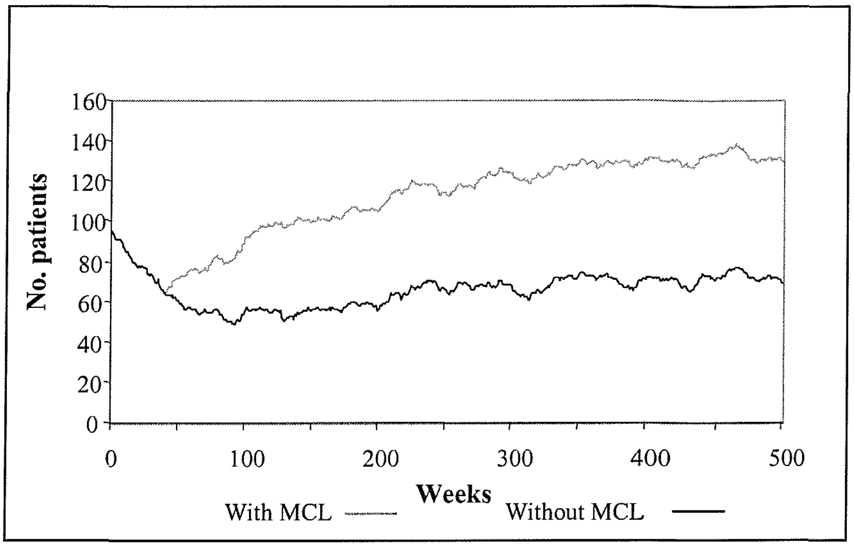


Figure 7-5 Effect of the introduction of the MCL on the surgical Outpatient waiting list

Patients are placed on the outpatient waiting list at a greater rate, but there has not been a concurrent increase in resources within the surgical department. This means that, at whatever rate the patients are referred, they are seen at the same rate, resulting in an increase in the waiting list for assessment.

The initial decrease that can be observed in Figure 7-5 is likely to be explained by the presence of a bottleneck earlier on in the system, as shown by the increasing angiogram waiting list. As this bottleneck is relieved and more patients are investigated, the resources at the surgical outpatient stage are used more.

7.9 Feedback

In analysing the responses from the questionnaires it became clear that there was feedback in the referral behaviour of doctors. The majority of doctors recognised this, though several said that waiting list length should not have any effect on decisions.

The results are from the model described in section 6.11 which included feedback; waiting lists lengths alter the threshold doctors apply to their patients for referral and treatment. In the following scenario this feedback loop, shown in Figure 7-6 was broken to determine its influence. The results can be seen in Figure 7-7 (a-c) and are discussed in section 7.15.3.

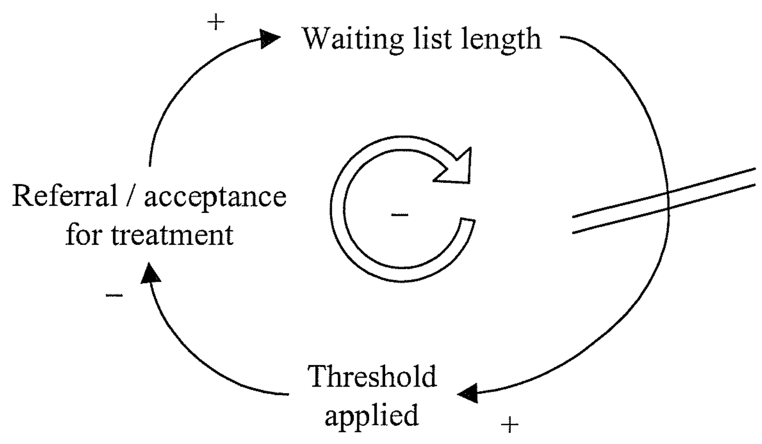
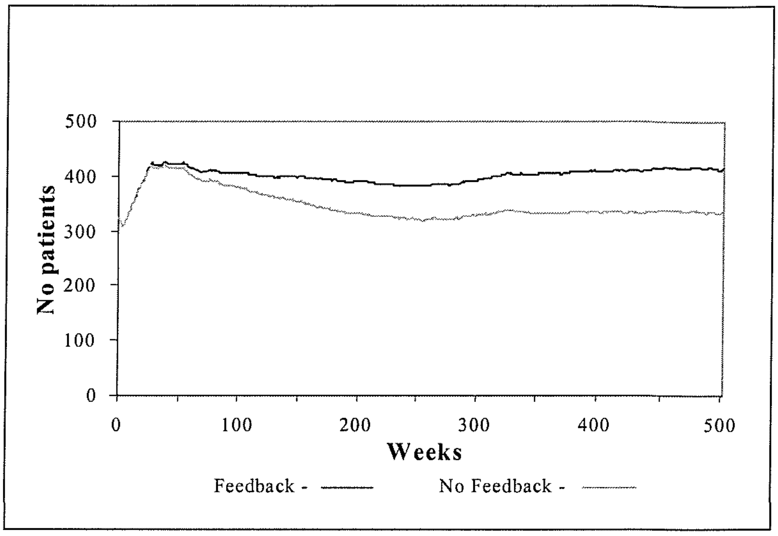
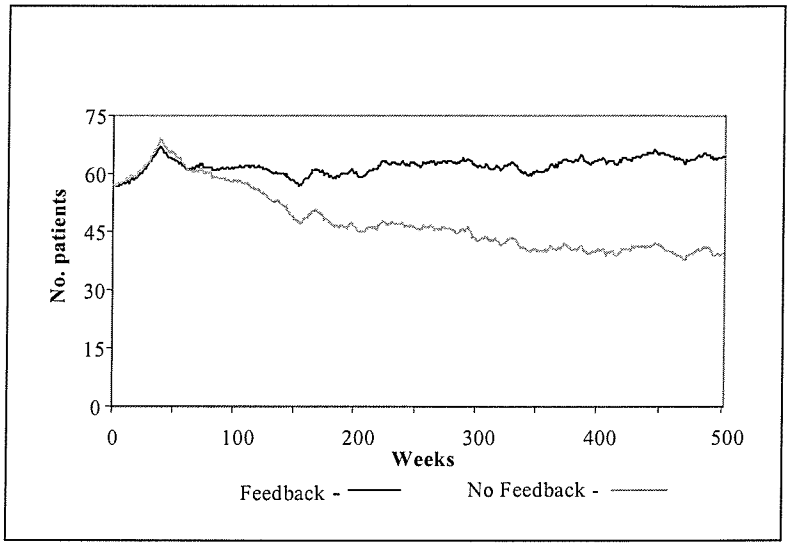


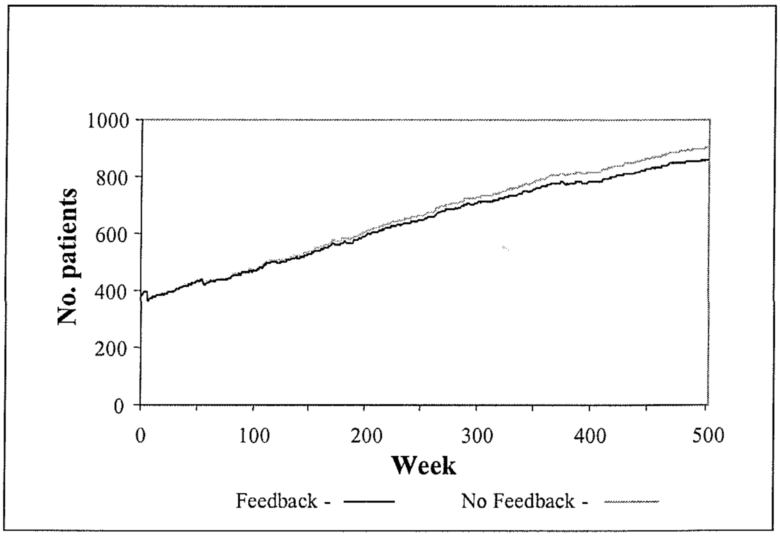
Figure 7-6 Figure to show the feedback loop present in clinical decision making



(a)



(b)



(c)

Figure 7-7 Effect of feedback on waiting lists

a) angiogram b) PTCA c) CABG

Waiting list	Week	Difference between waiting lists with and without feedback (no. patients)	% change from feedback
Angiogram	200	60	-15%
	400	75	-18%
PTCA	200	14	-23%
	400	23	-38%
CABG	200	13	+2%
	400	33	+4%

Table 7-3 Table to show the actual difference between waiting lists with and without feedback at week 200 and week 400

The angiogram and PTCA waiting lists show a decrease if the feedback loop is broken. The CABG list is hardly affected at all. This demonstrates that feedback is strongest within the cardiology section.

7.10 Increase in CABG facility

The following scenario investigated the effect of increasing the number of CABG procedures. The model was run with feedback still present to determine what increase in the number of CABG procedures would be required to reduce the waiting list length. The increase was introduced in week 75 of the simulation, equivalent to the present.

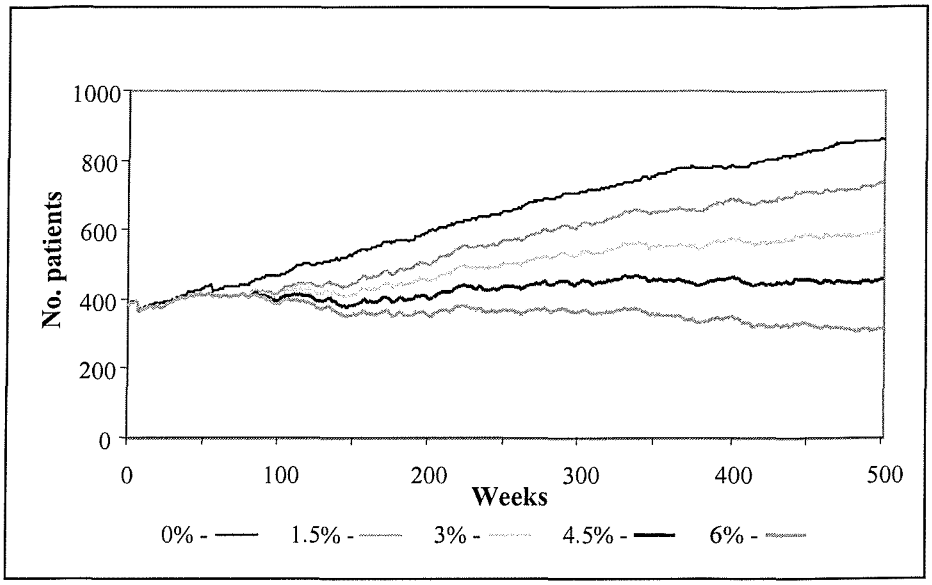


Figure 7-8 Effect of increasing CABG facilities

Figure 7-8 shows that increasing CABG procedures by 6% is sufficient to cause the waiting list to reduce, overcoming the effect of feedback.

7.11 Waiting Times

This chapter has discussed waiting list lengths rather than waiting times. It is recognised that waiting times are an important measurement for hospitals due to Government recommendations, (Patients Charter 1991). System Dynamics does not however have the facilities to calculate the waiting times of individual entities as would be possible with, for example, Discrete Event Simulation. SD does allow calculation of the average time it takes patients to pass through a stock or waiting list but in order to do this, the software changes the stock to a queue ensuring that patients are seen on a first in first out basis. This is unrealistic, however it gives an approximate measurement of waiting list times.

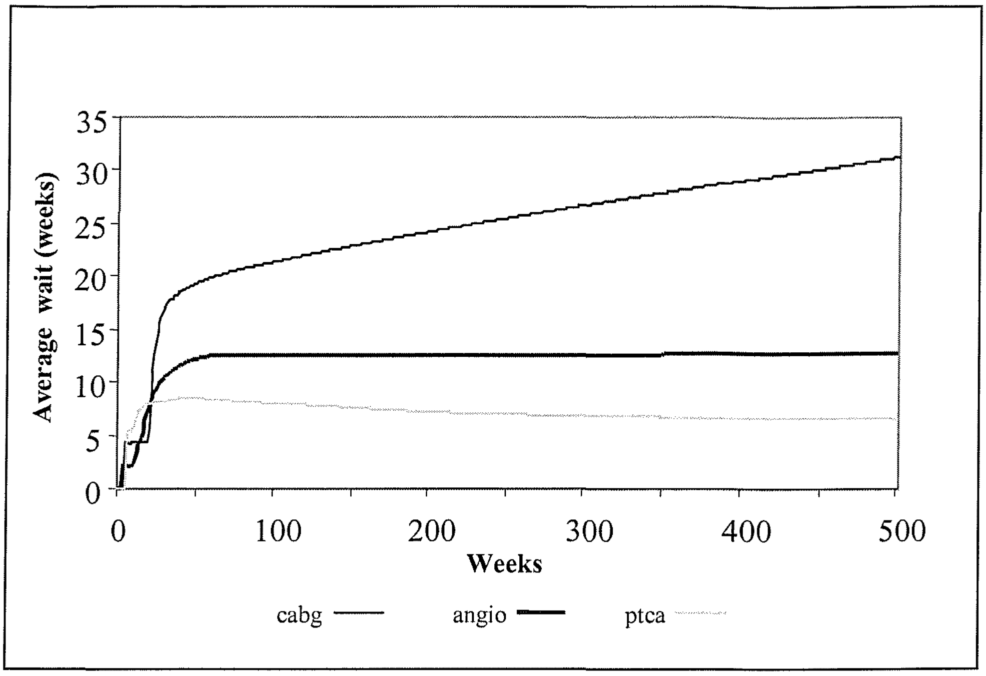


Figure 7-9 Average wait for patients

Figure 7-9 shows that the longest wait experienced is for coronary artery bypass grafts and the least for percutaneous transluminal coronary angioplasty. The fact that the waiting times are seen to rise from zero is due to the way in which the software calculates the value. It can be seen that the waiting time graphs follow the trend of the waiting list length graphs, Figure 7-2. This is to be expected as it is accepted that as waiting lists get longer patients will have longer to wait.

7.12 PTCA/CABG split

When a patient has been seen by a cardiologist and is considered suitable for further treatment the cardiologist decides whether to refer him/her for a PTCA or for surgery (CABG). Cardiologists and surgeons have estimated the PTCA/CABG split as 20%/50% respectively, the remaining 30% being considered unsuitable for either procedure. This balance could be affected by many elements, for example waiting list lengths, improvements in outcomes for one procedure or another, funding allocations.

Increasing the proportion of patients who are referred for PTCA to 21% and in turn reducing those referred for surgery, the simulation shows the following effect on waiting lists.

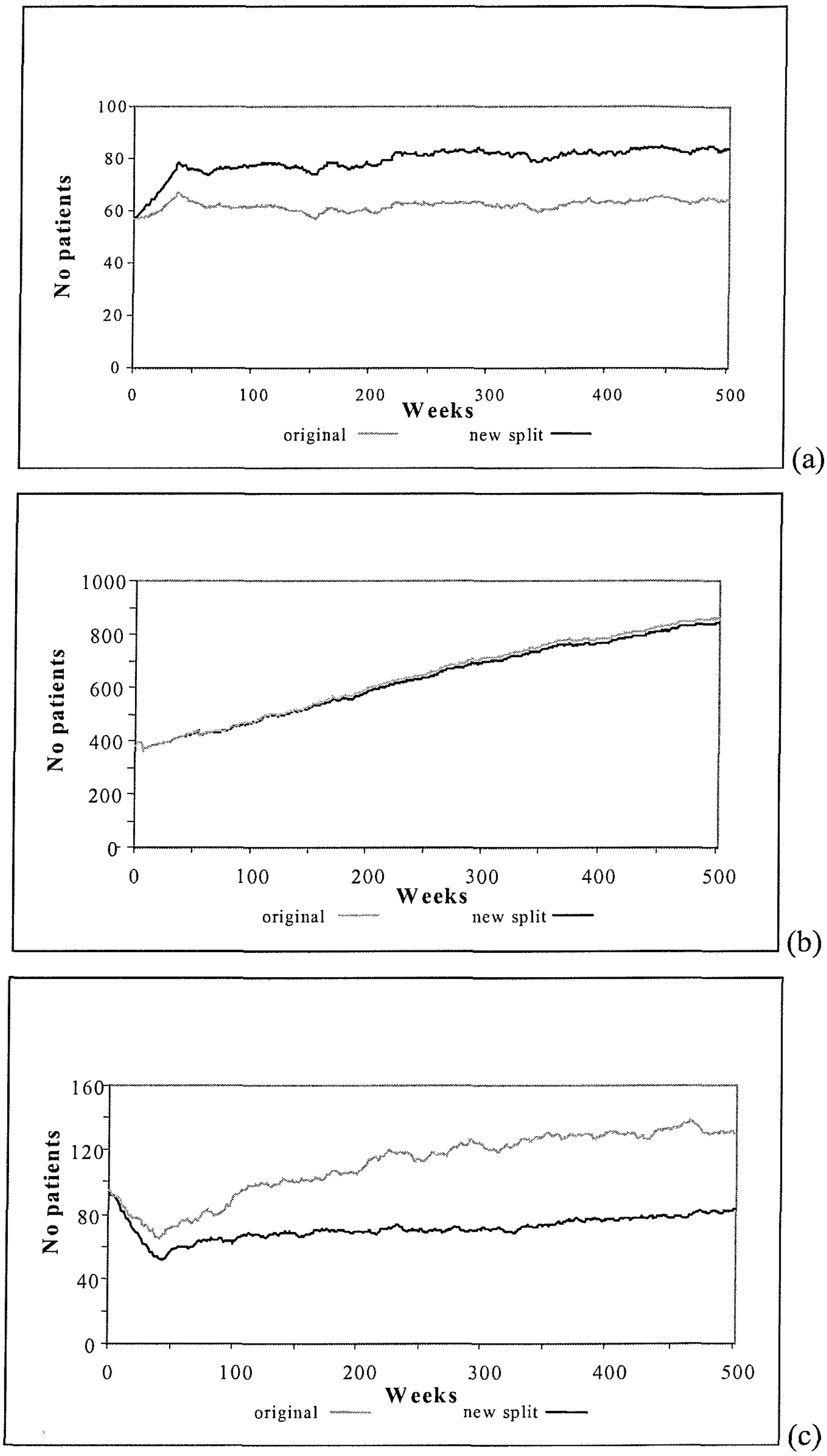


Figure 7-10 Effect of altering the balance of referrals of patients for

a) PTCA b) CABG c) Surgical Outpatients

It is initially surprising that, with fewer patients being referred for surgery, there is no significant change in the surgery waiting list, Figure 7-10 (b). At week 200 the difference in the number of patients is 11 and at week 400 it is 16. As was concluded in section 7.8, this lack of change is due to the presence of another waiting list i.e. the outpatient waiting list for surgery. Looking at that waiting list, Figure 7-10 (c), it can be seen that it is lower than it was with the original split of patients between PTCA and CABG. The difference observed at week 200 is 35 patients and at week 400 it is 54 patients. As fewer patients are referred for surgery, the outpatient list is reducing and there is no associated reduction in the waiting list for surgery as no concurrent increase in CABG facilities have been provided.

The PTCA waiting list is the most affected as it now has more patients being referred to it and the facilities, as they stand, cannot cope. The waiting list therefore increases at a greater rate, Figure 7-10 (a). The difference in number of patients on the PTCA waiting list with both CABG/PTCA splits at week 200 is 17 and at week 400 it is 19.

7.13 Patients referred to Cardiology

Patients come into the cardiac system from the general population, referred by GPs. This referral rate is affected by the length of the waiting list for cardiology outpatient clinics, another example of feedback within the system. The difference at this stage of the system is that the actions are occurring across the system boundary i.e. GPs are based outside the hospital and are referring in to the hospital system. The communication of information across this border, both physical and metaphorical, takes time, and a delay has been included at this stage. Delays are not included at the other feedback stages as much communication occurs in the corridors of the hospital and, though this is informal, it still allows information to be passed quickly. The waiting list for newly referred patients to be seen in a cardiology clinic is as shown in Figure 7-11.

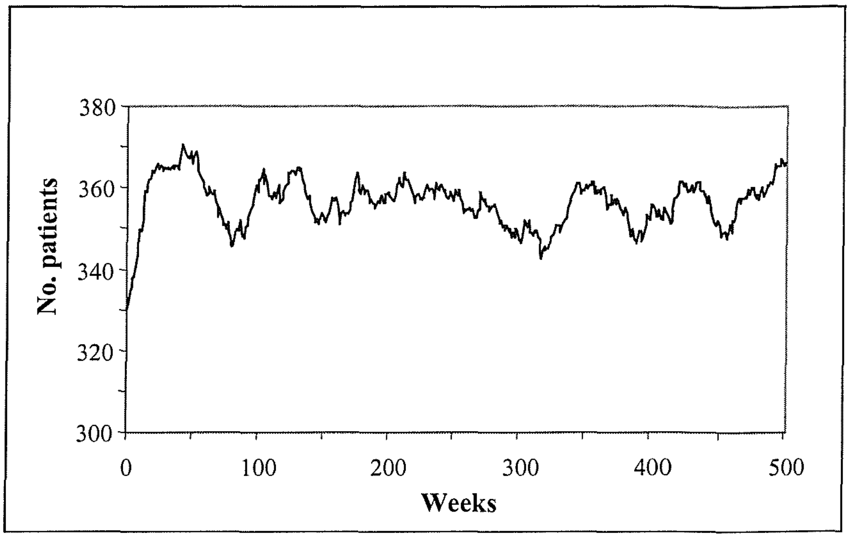


Figure 7-11 Waiting list for newly referred cardiology patients

This waiting list seems to oscillate at about 355 patients. The feedback mechanism is keeping the waiting list at that level causing it to oscillate. With the rates of arrival and the number of patients who can be seen within the clinics, the outpatient list appears to be quite stable.

7.14 Cancellation rates for surgery

Referring back to Chapter 5 which presented the responses of doctors to the questionnaires distributed, one of the solutions put forward to combat waiting lists was to focus on the intensive care unit in order to reduce cancellation of operations. This final scenario demonstrates the effect on surgical waiting lists if the proportion of operations that had to be cancelled was reduced.

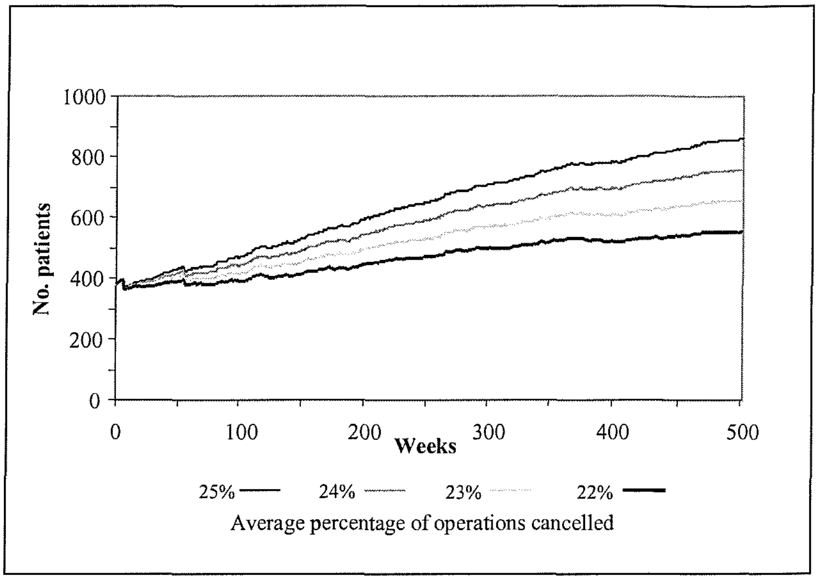


Figure 7-12 Effect on the surgical waiting list of reducing the cancellation rate for surgical operations

The average cancellation rate was determined to be 25% of operations. If this average rate was reduced then the rate at which the waiting list increases can be seen to reduce, as shown in Figure 7-12.

Figure 7-13 shows the effect that occurs on the angiogram waiting list when surgical cancellations decrease. There is not a large change but it can be seen that, over time, the waiting list is longer. This is discussed in section 7.15.7.

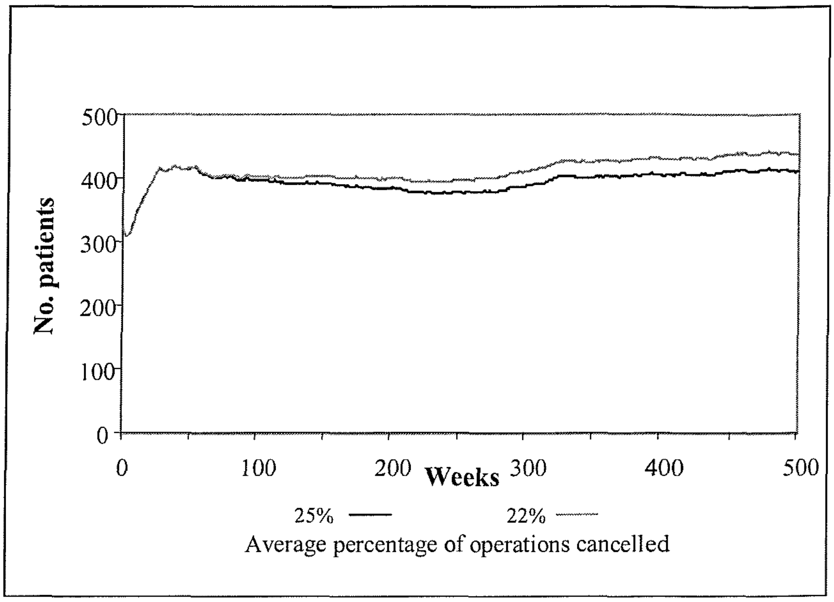


Figure 7-13 How reducing the cancellation rate in surgery affects the Angiogram waiting list

7.15 Discussion

7.15.1 Routine and Urgent Waiting lists

Figure 7-3 shows the importance of looking at the composition of waiting lists. The composition could be monitored to ensure that the patients on each list are treated fairly. If the routine waiting list is increasing and the urgent list is reducing, for example, the balance between the two with regard to admissions could be altered to admit more routine patients. It should be noted that this would be instead of, and not as well as, urgent patients.

7.15.2 Mobile Catheter Laboratory

The provision of the Mobile Catheter Laboratory was designed to improve waiting lists for cardiac patients and it has provided a benefit for those patients not requiring surgery as they will have been assessed and treated. However, the patients needing surgery do not receive it any more quickly, they simply wait at a different place in the system. The graphs demonstrate that cardiology waiting lists are reduced but there is little effect seen in the surgical waiting list. A resource bottleneck is highlighted at the point of the surgical outpatient waiting list. In order for patients throughout the cardiac sector to benefit such bottlenecks need to be addressed throughout the system.

There is an argument to suggest that this is acceptable as the patients have received an initial assessment and therefore doctors have some idea of the severity of the patient's condition. If the extra resources had not been made available then the patient would not have received the initial investigation required for diagnosis. However, there is a negative side to this situation.

Patients are referred to an outpatient waiting list having already had an angiogram. As this list increases, the more likely it is that the angiogram will become out of date and will need to be done again. In addition, the knowledge that there is at least a 95% chance of needing surgery (from the questionnaires surgeons report that a maximum of 5% of patients are considered unsuitable for surgery) will increase anxiety for the patient. Fitzsimons (2000) reports that, for patients waiting for heart surgery, anxiety and uncertainty are important indicators of a negative outcome. The costs of waiting to patients are discussed in section 2.7.

This analysis is not suggesting that the increase in cardiological facilities is undesirable but is highlighting that not everyone benefits overall.

7.15.3 Feedback

The effect of breaking the feedback loop is much stronger with respect to the angiogram and PTCA waiting lists than with CABG lists. The two cardiology lists decrease without feedback. This suggests that feedback affects clinical decisions which are stabilising waiting lists.

Referring back to the questionnaire responses this behaviour can be explained.

> *'If waiting list is very long ... only relatively high priority cases accepted into it'*
> *'Increase waiting list, decrease likelihood of acceptance'*

With feedback, as the waiting list drops, patients are accepted and referred for treatment who do not have such a high clinical need. With no feedback present, as the waiting list drops, the trend continues. It suggests that there are sufficient facilities to meet a clinical demand of a certain level but that, due to a reduction in the waiting list, referrals increase and maintain the list.

With regard to the CABG waiting list, little effect is seen. This suggests that feedback is not a large issue in accepting patients for surgery. The small effect that is seen shows the waiting list increasing if feedback is removed, the opposite effect to that seen in cardiology. In surgery, therefore, it can be assumed that there are insufficient facilities to cope with the present clinical demand and that clinical decisions are working to control the waiting list. Whilst this may seem counter-intuitive the direction of the effect is dependent on the behaviour of the doctors.

The effect of feedback on the surgical waiting list is not a strong one. The final total of patients on the waiting list after 10 years of clinical decisions influenced by feedback is only 4.7% less than the waiting list without feedback.

7.15.4 Increase in CABG

It is necessary to consider the effect of feedback when trying to reduce waiting lists through an increase in the supply of treatments and/or procedures. It has already been stated that if waiting lists decrease, referrals are likely to increase and vice versa. Therefore, if waiting lists are to be reduced any increase in facilities must be sufficient to overcome any influence of feedback. The model, because it incorporates feedback, allows the level of resource increase required to reduce waiting lists to be determined.

It is shown in Figure 7-8 that the resource availability for surgery would have to be increased by 6% to reduce waiting lists in this sector. It should be remembered that System Dynamics does not incorporate constraints therefore it is not possible to say what specific resources are needed to eliminate the bottlenecks. It identifies that more operations need to be carried out but does not advise on how this is to be achieved.

In theory the increase in throughput could be achieved in two ways. More facilities could be provided and working practice could continue as at present or investigation could be made into a way of reducing the number of cancellations so that more operations could be carried out using the existing facilities. About 25% of patients have their procedure cancelled in surgery, generally due to a lack of available ITU beds. All patients undergoing a CABG are expected to spend one day in ITU. Sick patients are known to present an increased risk in surgery and therefore are more likely to stay in an ITU bed for more than one day. Investigating whether organising the operating list to have less serious patients operated on at the beginning of the week, with those patients who are more likely to need longer in ITU operated on on a Friday, may be beneficial.

The above suggestion may work if it is the number of physical ITU beds which are limiting throughput. If, however, the number of available ITU beds is limited due to insufficient numbers of nurses, a cause of cancellation suggested in the questionnaires, then it would be expected that altering patient scheduling would have little effect. Ways would then need to be investigated which would increase the number of ITU nurses. Referring back to the influence diagram presented in section 6.11 it is shown that cancellations cause stress amongst staff, which in turn is known to have a detrimental effect on staff health causing an increase in sickness and days off. This results in fewer nurses able to work, increasing stress levels, an example of positive feedback.

Policies that will reduce stress levels for nurses at work can be investigated, whether they be financial reward, more nurses to relieve work load, more holiday or the effect of reduced waiting lists and cancellation rates. Discussion of these possibilities is outside the scope of this thesis. It should be recognised however that attempts are being made to improve working conditions for nurses in terms of career structure and pay, and initiatives are being set up to increase recruitment.

> *Between now and 2004 there will be, 7,500 more consultants, 2,000 more general practitioners, 20,000 more nurses and over*

6,500 more therapists and other health professionals. We will achieve [this] by increasing throughput from training, modernising pay structures and increasing earnings, improving the working lives of staff and recruiting more staff from abroad .

The public want to see better, fairer rewards for NHS staff. The Government shares this ambition. For the last two years pay awards recommended by the independent pay review bodies have been implemented in full. Since 1997 nurses have had a 15% pay rise.

We will move quickly to increase incentives for staff to join or re-join the NHS in those parts of the country where labour shortages are most serious. Improving the working lives of staff contributes directly to better patient care through improved recruitment and retention.

(NHS Plan 2000)

7.15.5 Waiting Times

It has only been possible to calculate the average time that patients spend on the waiting list for each procedure. In practice some groups of patients would be admitted sooner and some much later.

Patients have been found to want more information regarding the waiting time for their surgery, (Fitzsimons 2000). It would reduce anxiety for patients if this information could be provided though care should be taken in the communication of any such information. The anxiety of patients and their families will not be helped if a waiting time is quoted which then cannot be honoured.

7.15.6 PTCA/CABG split

The effects of the cardiology decision to refer to PTCA or CABG further highlights that it is vitally important to appreciate that the departments on the medical/surgical border affect each other. Decisions in one sector may optimise that sector but may cause sub-optimisation in another. It is not appropriate to look at the sectors individually, their interaction needs to be appreciated, and the department viewed holistically.

It should be noted that the emphasis of these findings is not on the actual numbers but on the fact that certain waiting lists are affected by the balance of referrals and others are not, that some waiting lists which are affected are in a different department from the initial decision and the importance of the direction of any change noted.

This scenario and the increases in facility provision as described in section 7.15.2 highlight the importance of communication and co-operation between sections within a department.

7.15.7 Cancellation rates for surgery

The model has been able to show that a reduction in the cancellation rates of operations for surgery reduces the surgical waiting list by increasing the number of patients who are treated in the surgical section. It is not a surprising result as it is intuitive that if fewer patients operations are cancelled, the more patients are treated and the lower the waiting list will be.

Less intuitive is the reason for the angiogram waiting list to increase, albeit slightly, if surgical cancellation rates decrease, Figure 7-13. This is likely to be due to the fact that, if more patients are treated, more are seen in cardiology clinics, and so more are likely to come through for reassessment or further procedures, staying in the system. The change in cancellation rates does not alter the number of new patients referred to Cardiologists and so the angiogram waiting list increases.

7.16 Summary

The above presentation of results demonstrates that there is significant interaction of waiting lists between departments and across the medical / surgical boundary. Policy changes in one sector have an affect on other sectors and the waiting lists associated with them. The increased understanding of these interactions gained from this modelling will enable the consequences of decisions made to be anticipated and met.

The significant role of feedback that has been shown is of particular interest. The explicit modelling of this phenomenon has brought a greater understanding of the behaviour of doctors in response to non-clinical factors.

In addition, the demonstration that the individual waiting lists, which make up the total number of patients waiting for a specific treatment, possess different dynamics is important. Awareness of such information would enable the referral and treatment practices of doctors to be more in tune with the numbers of patients waiting.

Both the quantitative results presented above and the qualitative information from previous chapters will be discussed and conclusions drawn in Chapter 8.

8 Conclusion

8.1 Methodologies

This thesis has made use of several methodologies which have been combined to take advantage of the best each has to offer. The approaches have provided much relevant information and encouraged participation in the project by those who work in the system. Such a level of involvement provides a feeling of ownership of the model and an increased belief in the outputs. Many of the outputs have been discussed with representatives of the departments.

Both the qualitative and quantitative elements have yielded interesting findings demonstrating the importance of both types of analysis.

8.1.1 Questionnaires

The use of questionnaires to gather initial qualitative information allowed a number of personnel to be approached for opinions and data with limited interference to their routine. The information received was relevant and informative due to the level of annotation possible. It is possible that a decrease in the annotation required may have improved the response rate from general practitioners in particular. Useful information would, however, have been lost.

8.1.2 Interviews

The interviews and direct access to personnel provided clarification on several points made in the questionnaires and a much better understanding of the system was gained. In fact there was a two way trade of information. Although all questionnaire responses were confidential, it was possible for me to respond to comments within the interview in terms of what had been suggested in the questionnaires.

The questionnaires indicated that it would be helpful to provide referring doctors with information on waiting lists to aid patient management. In interview, this topic was discussed with the doctor who was in a position to provide the information and he appreciated receiving this information. The interviews therefore did not just have a benefit for the model but also worked to improve dialogue within the system.

The use of a diagram within the questionnaire to portray an initial structure proved beneficial. It enabled each person contacted to express their opinions on the structure, providing their own version through annotations. These were then amalgamated and the final version presented to the interviewees for validation.

8.1.3 The Ethnograph

The Ethnograph allowed specific passages to be retrieved quickly and accurately. The coding element of The Ethnograph, supposed to help with sorting the text, was found to be of limited value. It was found to be easier to sort the text by the question number and analyse the range of responses question by question.

8.1.4 System Dynamics

System Dynamics uses qualitative and quantitative information. This information needs to be collected and prepared prior to analysis using SD techniques. The questionnaire and interview methods discussed above were used. This was necessary as SD is not designed to provide a robust framework for this data gathering stage.

The use of System Dynamics as a way of studying waiting lists has proved very valuable. The macro view which is provided in this model has allowed deductions to be made with a limited requirement for quantitative data. The model can clearly present relationships and consequences and is thus of use for planning purposes. In this way consequences of a decision can be understood and decisions can be made to include ways to combat any undesirable outcomes predicted.

A specific advantage of SD is the opportunity to model feedback which has been shown in this model to have a significant effect on the dynamics of the system.

The inflexibility of the SD software with regard to cycle-time is a disadvantage when looking at the type of model where time could be of interest. The immediate assumption that material must follow a first-in-first-out path is unrealistic. An improvement to this would be to enable the reservoir to remain a 'jumbled group of entities' whilst maintaining any time stamping they had received.

8.2 Information availability

8.2.1 Information for doctors

There is a fine line between the provision of data that is considered of use and the provision of so many figures and charts that the data is ignored and / or becomes difficult to utilise efficiently. This suggests that the information that should be provided should be what is asked for by the doctors, not what is considered to be appropriate by others. In the questionnaire responses information was requested regarding waiting list lengths, waiting list times and speed of processing of patients. This is an example of where communication could be enhanced. If certain doctors are asking for information that they know they could use then systems could be set up to capture that data.

The timing of information provision is also very important if it is to be trusted. If doctors are expected to manage referrals then any information must be accurate and up to date.

8.2.2 Information for research

In terms of quantitative data it would be useful for more specific data about treatment rates according to certain categories of patients to be collected. This would allow further analysis of the interactions of the different waiting lists present. The problem experienced here was that the doctors themselves do not always record the priority of patient and rarely record the specific category of patient when they are treated. In order to collect the data the doctors would have to alter their working routine slightly.

The information gained, for the purposes of an SD model, was sufficient and produced a comprehensive model. However, as the dynamics of the different waiting lists have been shown to be different and interacting, it would be interesting to look further at this aspect of clinical practice.

8.3 Confusion with regard to clinical descriptions

Another aspect of communication in the cardiac system is the use of certain terminology and how this is defined. This result was highlighted in the qualitative stages of the study. Doctors were asked to state how long they thought patients of certain priorities would have to wait for treatment. The interesting information here was not the figures they stated but how they defined their categories of patients. There seemed to be no categories used which were common to all. The categories used are presented in Chapter 5.

8.4 Waiting lists and their influence on doctors decisions

It has been reported recently that surgeons have little control over general surgical waiting lists (Aiono 2000). This is to do with the control that is exerted by contracts over the number of patients who can be treated, that is, taken off the waiting list. It has also been claimed in a recent report that 'surgeons control the waiting lists' (Light 1997).

Ultimately waiting lists are controlled by doctors and their decisions. The final say in who comes off and who goes onto a waiting list rests with the doctor. However, the doctor must work under the influence of external factors for instance, contract numbers. So, whilst doctors are able to choose who is to be treated they are effectively told between whom they can choose and how many they can choose. They are also influenced by the length of the waiting lists leading to the element of feedback.

The feedback appears to alter the thresholds that doctors apply to their patients in order to prioritise them on clinical grounds, as discussed in section 6.9. If this threshold level were held constant, as is assumed when the feedback loop of the model is broken, the dynamics of the waiting list are very different, section 7.9.

As can be seen from the flowchart annotations and comments, doctors themselves accept a level of control over their system. If the number of available procedures, as determined by contract levels, decreases, waiting lists will increase. This increase can be controlled by doctors who are able to limit those added on to the waiting list to those who are deemed sickest. So, due to external control of availability and the onus to reduce waiting, doctors are left no option but to limit referrals on to lists, thereby controlling waiting lists.

8.5 Waiting lists as a performance measure

Governments are often judged by the number of people waiting for treatment but waiting lists are a poor performance measure. The complexity of the model demonstrates how much is going on 'behind the scenes' and the previous section shows that there are many factors affecting the final figure of the number waiting. A statement of the number of people waiting makes no mention of the severity of those patients, the type of hospitals, the number of nurses, doctors, beds that are available, the contracts that have been set for the population, individual efficiency of doctors, lengths of stay or success rates. All of these factors affect a waiting list and yet just the number is quoted.

8.6 Medical / Surgical boundary

System Dynamics requires a boundary to be metaphorically placed around the system to be studied. In this model the boundary was also a physical one, separating community based and hospital based doctors. Within the model there was a further boundary identified which was the medical / surgical boundary and one of the objectives of the study was to examine whether the consequences of decisions made in the medical department affect the running of the surgical department and vice versa.

It could be asked whether this is really a boundary or not. In terms of treatment provision it should be assumed to have a boundary as it requires a specific referral for a patient to go from one to another. The two sections are staffed by different personnel and receive specific funding. However, the results from the simulation have demonstrated that the departments are very closely linked. Decisions made in one department have a direct affect on the other. This was shown in section 7.8 when treatment provision was increased in the cardiology department and the outpatient waiting list in the surgical department increased. Also, a change in waiting lists was seen when cancellation rates in the surgical department were reduced. This meant that more patients were referred back to cardiologists causing more to remain in the system.

This interaction across the perceived boundary suggests that, for decision making purposes, no boundary should be considered. When decisions are made they should be made holistically, considering the effects that could occur across the whole system. The model would enable unexpected consequences to be anticipated and met before other departments are put under pressure.

8.7 Optimising

The dynamics of the waiting lists were of particular interest in this study. The concept of optimisation of a department in terms of waiting list length was drawn from the analysis of the way in which the waiting lists interacted. The consideration of attempting to optimise the running of a department is linked to the idea of boundaries. To make a decision to move toward optimising the running of one department will have an affect on another. To optimise one does not necessarily optimise another and, if viewed as a whole, the system may in fact function less well following the change. To optimise the system as a whole it may require departments viewed individually to operate sub-optimally. This could prevent the over-burdening of a department and the staff, for instance.

This emphasises the use of a model formulated in SD. It allows a holistic view of a system and the general trends associated with specific decisions can be identified. The model presented has allowed investigation of how decisions made in cardiology have encouraged the creation of long waiting lists in surgery.

8.8 Hidden waiting lists

The study aimed to explore what factors the presence of waiting lists affected and the identification of the existence of hidden waiting lists was very interesting. The information came from questionnaires but mainly interviews. It was not possible to include this in the quantitative model as the information is politically sensitive and was difficult to acquire, but from a qualitative point of view the implications can be discussed.

The concept of hidden waiting lists is linked to the effect of feedback where, if the waiting list is perceived to be long, thresholds change and a patient must be more clinically in need to be accepted for treatment. These patients are not referred at all. The hidden lists are created when these patients are held back from joining a waiting list. The implication of this occurrence is that patients are denied treatment due to the length of the waiting list and that, if the waiting lists were not so long then the patient would be offered treatment.

The process is unofficial and involves doctors leaving notes on a desk to get around to looking at them later. These patients are waiting to wait. It is accepted that these patients may be initially considered unsuitable for treatment and that with time, as the disease progresses, the condition of the patient may become more suited to the treatment. If it is only the clinical condition of the patient that is determining this decision then that is right. However, looking at the following direct quote from a cardiologist suggests otherwise.

> *'if it was a short list you'd catheterise them ...... if it is a long list you don't catheterise them.'*

This is another example of doctors influenced by waiting list length. Whilst this thesis is not looking at the moral nature of patient referral and acceptance, it could be questioned as to whether the ethics of denying a patient treatment or postponing referral for treatment due to the length of a waiting list are acceptable.

8.9 Implications for staff and patients

The implications of long waiting lists for patients have been discussed at length throughout the thesis. It has been stated that the longer waiting lists are, the longer patients must wait and the worse their condition becomes before they are treated. In the last section it was also explicitly reported that long waiting list are sometimes a reason for patients to be denied treatment. Staff also are affected by waiting lists as was stated in the questionnaires.

8.10 Improvements

In terms of quantitative results certain points within the system were identified as stages which could be improved. The increased provision of cardiology treatments improved the waiting lists for that section of the cardiac system but increased the outpatient waiting list for surgery. Focus now needs to be on the provision of outpatient appointments enabling patients to be assessed more quickly.

With the parameters as they are at present the surgical waiting list is predicted to continue to increase. Decisions made to improve the throughput at the outpatient level will cause more patients to be considered suitable for surgery and so more pressure will be placed on the waiting lists for admission. This is an example where consequences can be anticipated and met. If there is an increase made in outpatient assessment there needs to be a concurrent increase in inpatient treatment availability otherwise patients are just passed on to another waiting list and have not really gained. This is particularly important when looking at the surgical waiting list because even without an increase in patients referred to surgery the waiting list can be seen to be increasing.

8.11 Costs

Although this thesis was not focussing on the issue of costs, the reduction of waiting lists and developing a greater understanding of waiting lists and their interaction can lead to savings. The most obvious cost to waiting lists is due to the increased severity of patients which leads to them requiring more care and a longer stay in hospital, as shown by the influence diagram in Figure 6-11. In addition there is the cost due to the diminished health of the staff.

8.12 Further research

Exploration into the behaviour of cardiac waiting lists has shown that there are a myriad of factors affecting the list dynamics and any research that works to further the understanding of this subject will be of benefit to doctors and patients.

8.12.1 Operation scheduling

Investigation in to the effect of specific scheduling would be of interest, in particular for the running of the surgical department looking at the effect of treating patients with a higher risk on Fridays. This might mean that, if ITU was blocked, it would be so over a weekend when there are no scheduled admissions. This may help to improve the throughput of patients through the reduction of cancellations.

8.12.2 Performance measure

Waiting lists are often used as a measure of success of a Government, a doctor, a hospital, but it has been shown that it is inappropriate due to the many factors that it is hiding. Further research to develop a benchmarking system that would allow like to be compared with like would be of use to hospital and doctors and would make available a sensible way of assessing the functioning of a hospital.

8.12.3 Modelling of severity of patients

Much has been said regarding the role of thresholds as applied to patients in order to determine whether they should receive treatment or not. Analysing the responses it has been determined that as waiting lists get shorter patients of less clinical need are accepted for treatment. Using, for instance, Parsonnet scoring, further research could be done to determine the real effect of waiting lists on the overall severity of patients accepted and referred.

8.12.4 Implications of waiting lists on the health of staff

It is not only patients who are affected by the waiting lists, in terms of personal health. The implications of long waiting lists also spill over into the health of doctors, nurses and administrative staff which has consequences for the running of a department.

The responsibility of nursing staff of having to communicate with the patients and inform them of postponements and cancellations is recognised as particularly stressful. This is enhanced because with heart disease treatment provision is seen as life-saving by patients, even though it is often considered palliative by doctors.

Doctors have the additional stress of having to manage a waiting list for which they are considered responsible. As has been discussed above, they have no control over how many patients can be treated from the list as this is determined by contract levels. If blame is to be allocated to doctors for having long waiting lists there is an onus on the doctors to keep waiting lists short. As it has been shown that the only way to do this is to alter thresholds for patients being placed on the list, doctors are having to compromise their own standards. This is in itself stressful.

The presence of stress in the work place causes a vicious circle to develop. The more staff who are stressed, the more time off work they need. As a consequence less staff are available for work, workloads increase for those able to work and this places them under more stress. In addition certain measures designed to reduce stress such as the provision of a higher holiday entitlement actually means that staff are legitimately away from work for longer so more staff are need to cover the same work. If more staff cannot be found then workload increases. If temporary or 'bank' staff are employed, the cost is greater so reducing the ability to fund other permanent nurses. In addition the experience of the ward is less so increased supervision is required increasing workload and increasing stress.

Further research would be valuable to investigate how much waiting lists contribute to stress in the work place.

8.12.5 Costs / savings

Investing in the reduction of waiting lists will bring about savings in sick pay associated with time off work making more money available for further investment in either tangible facilities or in making staff more appreciated, whether through salary or holiday entitlement. It should be noted that increased holiday entitlement actually means that staff will spend less time on wards and so more staff will be required to cover the same workload.

Further research could look at the costs and/or savings associated with waiting lists and their identified consequences.

8.13 Conclusion

Waiting lists have no advantage to those who have to work under their influence. They are detrimental to the health of patients and health workers. They cause doctors to have to compromise their decision-making as waiting lists draw attention away from the clinical need of the patient.

System Dynamics, both qualitative and quantitative, has been particularly useful in allowing a holistic view of one of the worst waiting list systems in the health service. Its use in further researching waiting lists would be recommended.

Appendix 1 Coronary Artery Disease and Treatments

Coronary Artery Disease

Coronary artery disease (CAD) is both the single largest cause of death and the single main cause of premature death in Britain. Some deaths occur suddenly as a result of an acute coronary occlusion whereas others occur slowly over a period of weeks to years as a result of progressive weakening of the heart pumping process. The information regarding CAD described in this appendix is taken from Guyton – A Medical Physiology (1991).

Risk factors

It is generally accepted that the main risk factors for CAD are:

- Cigarette smoking
- Raised plasma cholesterol
- Raised blood pressure
- Lack of physical activity
- Stress
- Genetic susceptibility
- Diet

Many of the above factors can be influenced by changes in behaviour, resulting in beneficial effects. As these factors can be influenced it is considered that much heart disease is preventable.

Anatomy

The most frequent cause of diminished coronary blood flow is atherosclerosis. This is where large quantities of cholesterol gradually become deposited in the arteries and often become calcified. The result is the development of plaque which either blocks or partially blocks blood flow, starving the heart muscle of the nutrition and oxygen it requires. In severe cases this leads to a heart attack or myocardial infarction, which can be fatal.

Symptoms

In most people who develop progressive constriction of their coronary arteries pain called *angina pectoris* is experienced. This generally felt during exercise or times of emotion or stress. It is described as hot, pressing and constricting and can vary in strength. The pain is generally felt across the chest and down the left arm.

Treatments

The treatment chosen for patients with coronary artery disease depends on the severity of the disease and as such differs from patient to patient. Treatment of coronary artery disease and angina is not always a life saving operation but is also considered to be a palliative procedure, that is, a method by which pain and discomfort can be reduced.

Medication - angina, in some cases, can be easily controlled by medication which comes in two main sorts; those that dilate the vessels so allowing more blood through, and those acting on the sympathetic nervous system reducing the amount of blood required by the heart.

Angiogram - whilst not strictly a treatment in itself it is a necessary procedure to determine the anatomy of the coronary arteries and is a diagnostic aid. It involves the injection of a dye into the coronary arteries. This dye can be monitored as it passes through the arteries and any narrowing or blocks can be identified.

Angioplasty - this is an invasive procedure where a balloon-tipped catheter is passed into the coronary system until it straddles the occlusion. The balloon is then inflated stretching the artery and restoring blood flow.

Coronary Artery Bypass Graft - this is a surgical procedure which involves taking a vein, usually from the leg, and attaching it to the coronary artery, thus bypassing the block. Results from this type of surgery have been especially good causing it to be the most common cardiac operation performed. This treatment is not considered to be a permanent cure.

Appendix 2 System Dynamics Notation

Influence Diagram notation

Figure A2-1 displays the notation used when creating a causal loop diagram. The direction of influence is shown by the arrow notation, so it can be seen that hunger influences the decision to eat. However it is not sufficient only to know that one element acts upon another, the nature or direction of this influence is also necessary, as denoted by the 'plus' or 'minus' sign at the head of the arrow. [It should be noted that in this thesis the notation used is the 'sign type'. Link polarity can also be demonstrated using the 'letter type' notation where + ≡ **s** and - ≡ **o**.]

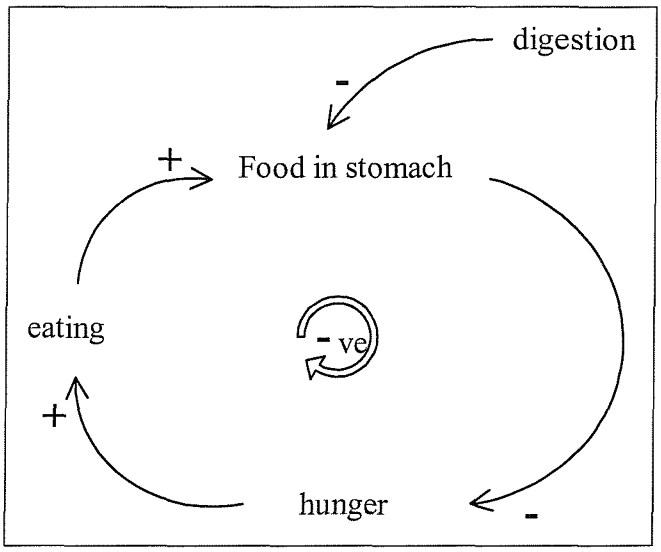


Figure A2-1 Influence diagram to demonstrate notation

Looking at the influence of hunger on eating, it is shown that, assuming availability of food, as the level of hunger increases, eating increases, that is, an increase in one causes an increase in the other. Such a relationship is denoted by a positive sign, '+' sign [or **s**], where a change in the influencing variable may produce a change in the same direction of the influenced variable, or add to the value of that influenced variable.

In contrast the amount of food in the stomach influences hunger, but in a negative way. As the amount of food present increases, the hunger felt decreases, so this is represented by a '-' sign [or **o**], so denoting the negative relationship, where a change in an influencing variable may produce a change in the **o**pposite direction in the influenced variable, or subtract from the value of that influenced variable, (Lane 2000b).

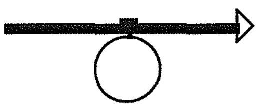
An important aspect of this approach is that the elements can link up to form a loop and so can demonstrate feedback. The direction of this feedback can also be depicted on the influence diagram, as shown by the central circular arrow. This notation summarises the direction of the overall influence or loop polarity. Figure A2-1 displays an example of a negative loop. A negative feedback loop controls the elements involved, keeping them around a standard level, stabilising the loop. A positive feedback loop demonstrates no such stabilisation and can spiral out of control, reinforcing itself with each pass. [If the letter type convention was being used a positive loop would be denoted by 'R', a **r**einforcing loop, and a negative loop would be denoted as 'B', a **b**alancing loop.]

Using the sign type, in order to determine whether a loop is positive or negative the number of signs can be counted. If a loop has an odd number of signs in a negative direction it is a negative feedback loop. If the number of negative signs is even then it is a positive feedback loop, reinforcing (because two –ve signs equal a +ve sign).

Following this simple framework complicated systems can be built up and the relationships between the elements can be demonstrated.

System Dynamics Flow Diagram Notation


- signifies a stock which functions as an accumulator, e.g. food in the stomach.


- identifies a flow which feeds into and out of stocks.


- a source or sink shows an unlimited supply or unlimited capacity for the absorption of 'stuff'.


- connectors link together elements of the diagram, with some exceptions.

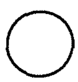

- converters convert inputs to outputs but do not accumulate like stocks.

Figure A2-2 Key to notation for System Dynamics Flow Diagrams, (STELLA)

Figure A2-2 displays the notation used in the formation of SD Flow Diagrams. Using these symbols the Flow Diagram is constructed and an example is presented in Figure A2-3.

The 'cloud' placed at the extreme left of the model represents an infinite source of 'stuff', which in this case is food. The model assumes that food is in plentiful supply and can be eaten as and when chosen. From the cloud comes a flow which feeds directly into a stock. This flow defines the rate of food consumption, described as eating, and the stock is the stomach, which accumulates the food. The flow defining the rate at which this store of food is reduced is labelled digestion and the amount of food digested flows to an infinite sink, as depicted by the second cloud.

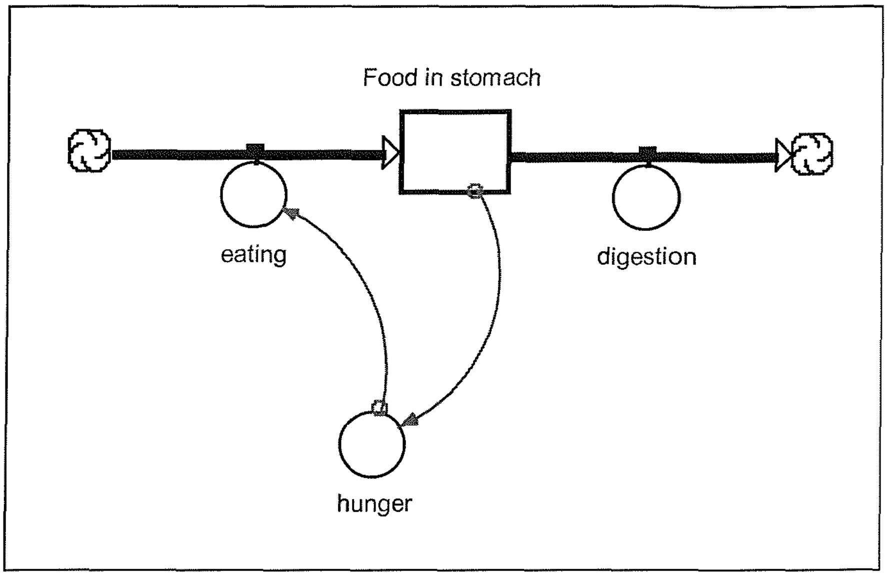


Figure A2-3 Example of a simple model using SD notation

Those elements which have been mentioned so far produce a linear diagram; food into and out of a stock with no external influence. However introducing the concept of hunger to the model enables the circular nature of the process to be demonstrated. Hunger is a 'soft' variable and is displayed as a converter. This influences the rate at which eating occurs, that is, the hungrier one is, the more one eats. Hunger is also influenced by the amount of food that is stored in the stomach, that is, the more food in the stomach, the less hunger will be felt. Hunger is linked to the other two elements by connectors demonstrating negative feedback.

System Dynamics Calculations

The following description of the calculations present in the STELLA software is taken from the Technical Documentation provided with the software, (Richmond 1997).

The finite difference equations on which the calculations are based involves a two step initialisation phase and a three step iterative evaluation phase.

Initialisation Phase:

1. Create a list of all equations in required order of evaluation.

2. Calculate initial values for all stocks, flows and converters (in order of evaluation).

Iteration Phase:

1. Estimate the change in stocks over the interval DT; Calculate new values for stocks based on this estimate.
2. Use new values of stocks to calculate new values for flows and converters.
3. Update simulation time by an increment of DT. Stop iterating when Time ≥ simulation To Time.

With regard to step one of the iteration phase there are three algorithms available in the software for the estimation of the change in stock over dt; Euler's, 2nd order Runge-Kutta and 4th order Runge-Kutta. Runge-Kutta methods have been specifically designed for continuously varying systems and do not deal well with integer values, or queues, conveyors and ovens. Euler's method is also required, and is used automatically by the software, if cycle-time metrics are required.

Euler's method is the simplest used by the software and the computed values for flows provide the estimate for the change in corresponding stocks over the interval DT.

Choosing DT

DT is the interval of time between calculations and is expressed in the time unit chosen for the model, for instance weeks. If DT is 1.0 then a round of calculations is performed once each week. If DT is 0.25 then a round of calculations is performed every ¼ of a week. Therefore, DT represents the smallest time interval over which a change in the model can occur.

There are several considerations when choosing a value for DT. Using a large DT e.g. >0.5 allows models to be run quickly as there are fewer calculations to be carried out, but the results are likely to be jerky. With smaller values for DT computer speed will be impaired but the results will be smoother and the results more precise.

A DT of 0.25 suffices for most models and if a smaller DT is required a number from the sequence $(1/2)^n$ is recommended due to the binary arithmetic used by the computer.

Appendix 3 DATA I

System Equations

emergency(t) = emergency(t - dt) + (rate_on_emergency + upgrade_Uns_to_Em - rate_off_emergency) * dt

INIT emergency = 0

rate_on_emergency = ROUND(RANDOM(0,1,1))

upgrade_Uns_to_Em = 0.033*upgrade_Uns

rate_off_emergency = ROUND(rate_on_emergency)+upgrade_Uns_to_Em

no_emergency(t) = no_emergency(t - dt) + (rate_off_emergency) * dt

INIT no_emergency = 0

rate_off_emergency = ROUND(rate_on_emergency)+upgrade_Uns_to_Em

no_routine(t) = no_routine(t - dt) + (rate_off_routine) * dt

INIT no_routine = 0

rate_off_routine = ROUND(x)

no_unstable(t) = no_unstable(t - dt) + (rate_off_unstable) * dt

INIT no_unstable = 0

rate_off_unstable = ROUND(z)

no_urgent(t) = no_urgent(t - dt) + (rate_off_urgent) * dt

INIT no_urgent = 0

rate_off_urgent = ROUND(y)

routine(t) = routine(t - dt) + (rate_on_routine - upgrade_R_to_Ur - upgrade_R_to_Uns - rate_off_routine) * dt

INIT routine = 0

rate_on_routine = ROUND(RANDOM(8,15,1))

upgrade_R_to_Ur = 0.05*upgrade_R

upgrade_R_to_Uns = upgrade_R'*0.05

rate_off_routine = ROUND(x)

unstable(t) = unstable(t - dt) + (upgrade_R_to_Uns + rate_on_unstable + upgrade_Ur_to_Uns - upgrade_Uns_to_Em - rate_off_unstable) * dt

INIT unstable = 0

upgrade_R_to_Uns = upgrade_R'*0.05

rate_on_unstable = ROUND(RANDOM(1,6,1))

upgrade_Ur_to_Uns = 0.033*upgrade_Ur

upgrade_Uns_to_Em = 0.033*upgrade_Uns

rate_off_unstable = ROUND(z)

urgent(t) = urgent(t - dt) + (upgrade_R_to_Ur + rate_on_urgent - upgrade_Ur_to_Uns - rate_off_urgent) * dt

INIT urgent = 0
upgrade_R_to_Ur = 0.05*upgrade_R

rate_on_urgent = ROUND(RANDOM(5,12,1))

upgrade_Ur_to_Uns = 0.033*upgrade_Ur

rate_off_urgent = ROUND(y)

contract_level = 1200

maximum_no_pts = contract_level/52

total_patients_waiting = emergency+routine+unstable+urgent

total_pts = no_emergency+no_routine+no_unstable+no_urgent

total_throughput=rate_off_emergency+rate_off_routine+rate_off_unstable+
rate_off_urgent

upgrade_R = routine

upgrade_R' = routine

upgrade_Uns = unstable

upgrade_Ur = urgent

x = maximum_no_pts-(rate_off_emergency+rate_off_unstable+rate_off_urgent)

y = maximum_no_pts-(rate_off_emergency+rate_off_unstable)

z = maximum_no_pts-rate_off_emergency

Appendix 4 Data II

Baseline DATA

Sources: H – Hospital Information Services
C – Cardiologists
S – Surgeons

Initial waiting list figures

Variable	Value	Source
Cardiology Outpatient waiting list	328	H
Angiogram waiting list (total)	324	H
PTCA waiting list (total)	57	H
Surgical Outpatient waiting list	95	H
CABG waiting list (total)	380	H

Appointment / procedure availability

Variable	Value (p.w.)	Source
Cardiology Outpatient appointment availability (total)	348	H
Appointments for new patients	45	H
Appointments for review patients	303	H
Angiogram availability - before MCL	34	H
- after MCL	increase 9%	H
PTCA availability - before MCL	≈7	H
- after MCL	≈ 8	H
Surgical Outpatient appointment availability (total)	85	H
Appointments for new patients	27	H
Appointments for review patients	58	H
CABG availability	≈ 22 (max 40)	S
CABG cancellation probability	≈ 0.25	S

Expert approximations for patient transfer

Variable	Value	Source
Cardiology clinic assessment ---		
Discharged	≈ 20%	C
medical treatment	≈ 45%	C
angiogram waiting list	≈ 35%	C
Angiogram ---		
medical treatment	≈ 30%	C
PTCA waiting list	≈ 20%	C
CABG waiting list	≈ 50%	C
Surgical clinic assessment ---		
Discharged	max 5%	S
CABG waiting list	≈ 95%	S

Mortality rates

Variable	Value	Source
Mortality from PTCA	≈ 0.9%	H
Mortality from Surgery	≈ 1.3%	H

System equations

Angiogram(t) = Angiogram(t - dt) + (to_treatment + card_em - to_ptca - em_PTCA - to_surgery - Review - angio_em) * dt

INIT Angiogram = 35
to_treatment = to_treatment'
card_em = RANDOM(0,2,2)
to_ptca = scaled_a_to_ptca
em_PTCA = scaled_a_em_to_ptca
to_surgery = scaled_a_to_surg
Review = scaled_a_to_rev
angio_em = .005*Angiogram
mort_1(t) = mort_1(t - dt) + (PTCA_mortality) * dt
INIT mort_1 = 0
PTCA_mortality = .9/100*PTCA
mort_2(t) = mort_2(t - dt) + (MORT) * dt
INIT mort_2 = 0
MORT = MORT'
NP_clinic(t) = NP_clinic(t - dt) + (c_clinic_appts - C_discharge - angio - New_pts_to_rev) * dt

INIT NP_clinic = 30
c_clinic_appts = NORMAL(40,10,3)
C_discharge = (RND_discharge*NP_clinic)/100
angio = (RND_angio*NP_clinic)/100
New_pts_to_rev = (rev*NP_clinic)/100
NP_wl(t) = NP_wl(t - dt) + (rate_in_to_system - c_clinic_appts) * dt
INIT NP_wl = 328
rate_in_to_system = IF(TIME<13)THEN(RANDOM(40,45,1))ELSE(delayed_info)
c_clinic_appts = NORMAL(40,10,3)

PTCA(t) = PTCA(t - dt) + (em_PTCA + to_PTCA_rx - PTCA_mortality - PTCA_revs) * dt

INIT PTCA = 0
em_PTCA = scaled_a_em_to_ptca
to_PTCA_rx(i) = to_PTCA_rx(o) * CONVERSION MULTIPLIER
CONVERSION MULTIPLIER = 1

PTCA_mortality = .9/100*PTCA
PTCA_revs = PTCA-link_ptca_revs

Rev_clinic(t) = Rev_clinic(t - dt) + (Leak_off + off_rev - rev_appts - rev2 - rate_out) * dt

INIT Rev_clinic = 0
Leak_off = LEAKAGE OUTFLOW
LEAKAGE FRACTION = .2
NO-LEAK ZONE = 13
off_rev = CONVEYOR OUTFLOW
rev_appts = .12*Rev_clinic
rev2 = .65*Rev_clinic
rate_out = .2*Rev_clinic
rev_wl(t) = rev_wl(t - dt) + (PTCA_revs + Review + rev2 + discharge + New_pts_to_rev + discharged - off_rev - Leak_off) * dt

INIT rev_wl = 5250
TRANSIT TIME = 26
INFLOW LIMIT = INF
CAPACITY = INF
PTCA_revs = PTCA-link_ptca_revs
Review = scaled_a_to_rev
rev2 = .65*Rev_clinic
discharge = .5*Surgery_clinic_Rev
New_pts_to_rev = (rev*NP_clinic)/100

discharged = discharged'

off_rev = CONVEYOR OUTFLOW

Leak_off = LEAKAGE OUTFLOW

LEAKAGE FRACTION = .2

NO-LEAK ZONE = 13

Surgery_clinic_Rev(t) = Surgery_clinic_Rev(t - dt) + (s_clinic_schedule - repeats_Surg - discharge) * dt

INIT Surgery_clinic_Rev = 0

s_clinic_schedule = CONVEYOR OUTFLOW

repeats_Surg = .1*Surgery_clinic_Rev

discharge = .5*Surgery_clinic_Rev

Surgery_OP_Rev(t) = Surgery_OP_Rev(t - dt) + (repeats_Surg + TREATED_PATIENTS - s_clinic_schedule) * dt

INIT Surgery_OP_Rev = 0

TRANSIT TIME = 12

INFLOW LIMIT = INF

CAPACITY = INF

repeats_Surg = .1*Surgery_clinic_Rev

TREATED_PATIENTS = TREATED_PATIENTS'

s_clinic_schedule = CONVEYOR OUTFLOW

Surgery_OP_wl_NP(t) = Surgery_OP_wl_NP(t - dt) + (outliers + to_surgery - np_clinic_appts) * dt

INIT Surgery_OP_wl_NP = 95

outliers = NORMAL(8,3,4)

to_surgery = scaled_a_to_surg

np_clinic_appts = NORMAL(27,4,5)

Total_no_patients_treated(t) = Total_no_patients_treated(t - dt) + (rate_out) * dt

INIT Total_no_patients_treated = 0

rate_out = .2*Rev_clinic

avge_time_on_NPwl = NP_wl/c_clinic_appts

avg_time_angio_wl = CTMEAN(to_treatment)

avg_time_ptca_wl = CTMEAN(to_PTCA_rx)
avg_time_surg_wlnp = CTMEAN(np_clinic_appts)
Delay_info = DELAY(avge_time_on_NPwl,13,RANDOM(40,45,6))
link2 = em_PTCA
link_ptca_revs = PTCA_mortality
max_angio_wl = CTMAX(to_treatment)
max_ptca_wl = CTMAX(to_PTCA_rx)
max_surg_wlnp = CTMAX(np_clinic_appts)
min_angio_wl = CTMIN(to_treatment)
min_ptca_wl = CTMIN(to_PTCA_rx)
min_surg_wlnp = CTMIN(np_clinic_appts)
no_emergency_pts = card_em+ems_treated
rev = 100-(RND_discharge+RND_angio)
RND_discharge = RANDOM(10,30,7)
scaled_a_em_to_ptca = (scale_a_em_to_ptca/Sum_scales)*Angiogram
scaled_a_em_to_surg = (scale_a_em_to_surg/Sum_scales)*Angiogram
scaled_a_to_ptca = (scale_a_to_ptca/Sum_scales)*Angiogram
scaled_a_to_rev = (scale_a_to_rev/Sum_scales)*Angiogram
scaled_a_to_surg = (scale_a_to_surg/Sum_scales)*Angiogram
scale_a_em_to_ptca = NORMAL(.005,.001,8)
scale_a_em_to_surg = NORMAL(.005,.001,9)
scale_a_to_ptca = Graph_ptca
scale_a_to_rev = (0.5-Graph_ptca)+(0.5-Graph_Surg)
scale_a_to_surg = Graph_Surg

Sum_scales =
SUM(scale_a_em_to_ptca,scale_a_em_to_surg,scale_a_to_ptca,scale_a_to_surg,scale_a_to_rev)

time_on_surg_OP_wl = Surgery_OP_wl_NP/np_clinic_appts
Total_deaths = mort_1+mort_2
delayed_info = GRAPH(Delay_info)

(0.00, 53.2), (1.30, 47.6), (2.60, 45.8), (3.90, 45.2), (5.20, 44.4), (6.50, 43.6), (7.80, 43.0), (9.10, 41.4), (10.4, 39.8), (11.7, 36.6), (13.0, 29.6)

Graph_ptca = GRAPH(PTCA_wl_time)
(0.00, 0.249), (2.60, 0.223), (5.20, 0.211), (7.80, 0.207), (10.4, 0.201), (13.0, 0.195), (15.6, 0.193), (18.2, 0.193), (20.8, 0.192), (23.4, 0.184), (26.0, 0.171)

Graph_Surg = GRAPH(time_on_surg_OP_wl)
(0.00, 0.555), (2.60, 0.51), (5.20, 0.5), (7.80, 0.495), (10.4, 0.48), (13.0, 0.48), (15.6, 0.47), (18.2, 0.47), (20.8, 0.46), (23.4, 0.445), (26.0, 0.37)

RND_angio = GRAPH(avg_time_angio_wl)
(0.00, 35.0), (5.20, 30.8), (10.4, 29.5), (15.6, 28.8), (20.8, 28.0), (26.0, 27.5), (31.2, 27.0), (36.4, 26.5), (41.6, 25.8), (46.8, 25.3), (52.0, 21.8)

Angiogram_wl = Angio_wl_decision + Angio_Urgent + for_treatment + Angio_routine + Angio_unstable

rev_appts = .12*Rev_clinic
angio = (RND_angio*NP_clinic)/100
to_treatment = to_treatment'

Angio_routine(t) = Angio_routine(t - dt) + (on_angio_R - AR_to_AU - off_angio_R - AR_to_AUN - angio_R_em) * dt

INIT Angio_routine = 192
on_angio_R = .46*Angio_wl_decision
AR_to_AU = .004*Angio_routine
off_angio_R = (A_scaled_R/100)*angio_sched
AR_to_AUN = .01*Angio_routine
angio_R_em = em_factor_R

Angio_unstable(t) = Angio_unstable(t - dt) + (on_angio_UN + AU_to_AUN + AR_to_AUN - off_angio_UN - angio_UN_em) * dt

INIT Angio_unstable = 10
on_angio_UN = .15*Angio_wl_decision
AU_to_AUN = .005*Angio_Urgent
AR_to_AUN = .01*Angio_routine
off_angio_UN = (A_scaled_UN/100)*angio_sched
angio_UN_em = em_factor_UN

Angio_Urgent(t) = Angio_Urgent(t - dt) + (on_angio_U + AR_to_AU - off_angio_U - AU_to_AUN - angio_U_em) * dt

INIT Angio_Urgent = 122
on_angio_U = .39*Angio_wl_decision
AR_to_AU = .004*Angio_routine
off_angio_U = (A_scaled_U/100)*angio_sched
AU_to_AUN = .005*Angio_Urgent
angio_U_em = em_factor_U

Angio_wl_decision(t) = Angio_wl_decision(t - dt) + (rev_appts' + angio' - on_angio_U - on_angio_R - on_angio_UN) * dt

INIT Angio_wl_decision = 36
rev_appts' = rev_appts
angio' = angio
on_angio_U = .39*Angio_wl_decision
on_angio_R = .46*Angio_wl_decision
on_angio_UN = .15*Angio_wl_decision
for_treatment(t) = for_treatment(t - dt) + (off_angio_U + off_angio_R + off_angio_UN + angio_R_em + angio_U_em + angio_UN_em - to_treatment') * dt

INIT for_treatment = 35

off_angio_U = (A_scaled_U/100)*angio_sched
off_angio_R = (A_scaled_R/100)*angio_sched
off_angio_UN = (A_scaled_UN/100)*angio_sched
angio_R_em = em_factor_R
angio_U_em = em_factor_U
angio_UN_em = em_factor_UN
to_treatment' = for_treatment
angio_sched = IF(TIME<38)THEN(NORMAL(34,6,61))ELSE(NORMAL(37,6,62))
A_scaled_R = (A_scale_R/A_sum)*100
A_scaled_U = (A_scale_U/A_sum)*100
A_scaled_UN = (A_scale_UN/A_sum)*100
A_scale_R = NORMAL(37.2,17.7,12)
A_scale_U = NORMAL(45.9,11.9,13)
A_scale_UN = NORMAL(32.8,13.1,14)
A_sum = A_scale_R+A_scale_U+A_scale_UN
em_factor_R = (5.8/100)*off_angio_R
em_factor_U = (6.1/100)*off_angio_U
em_factor_UN = (10.5/100)*off_angio_UN
sum_angio_wls = SUM(Angio_routine,Angio_unstable,Angio_Urgent)
time_angio_Rwl = CTMEAN(off_angio_R)
time_angio_UNwl = CTMEAN(off_angio_UN)
time_angio_Uwl = CTMEAN(off_angio_U)
time_on_angio_wls = sum_angio_wls/angio_sched

PTCA_wl = PTCA_wl_decision + PTCA_Urgent + for_PTCA__rx + PTCA__routine + PTCA_unstable

to_ptca = scaled_a_to_ptca
to_PTCA_rx(o) = to_PTCA_rx'
for_PTCA__rx(t) = for_PTCA__rx(t - dt) + (off_PTCA_U + off_PTCA_R + off_PTCA_UN - to_PTCA_rx') * dt

INIT for_PTCA__rx = 0
off_PTCA_U = PT_scaled_U*PTCA_sched

off_PTCA_R = PT_scaled_R*PTCA_sched
off_PTCA_UN = PT_scaled_UN*PTCA_sched
to_PTCA_rx' = for_PTCA__rx

PTCA_unstable(t) = PTCA_unstable(t - dt) + (on_PTCA_UN + PU_to_PUN + PR_to_PUN - off_PTCA_UN) * dt

INIT PTCA_unstable = 5
on_PTCA_UN = 0.07*PTCA_wl_decision
PU to PUN = .01*PTCA_Urgent
PR to PUN = (.01*PTCA__routine)
off_PTCA_UN = PT_scaled_UN*PTCA_sched

PTCA_Urgent(t) = PTCA_Urgent(t - dt) + (on_PTCA_U + PR_to_PU - off_PTCA_U - PU_to_PUN) * dt

INIT PTCA_Urgent = 15
on_PTCA_U = 0.29*PTCA_wl_decision
PR_to_PU = .005*PTCA__routine
off_PTCA_U = PT_scaled_U*PTCA_sched
PU_to_PUN = .01*PTCA_Urgent
PTCA_wl_decision(t) = PTCA_wl_decision(t - dt) + (to_ptca' - on_PTCA_U - on_PTCA_R - on_PTCA_UN) * dt
INIT PTCA_wl_decision = 6
to_ptca' = to_ptca
on_PTCA_U = 0.29*PTCA_wl_decision
on_PTCA_R = 0.64*PTCA_wl_decision
on_PTCA_UN = 0.07*PTCA_wl_decision

PTCA__routine(t) = PTCA__routine(t - dt) + (on_PTCA_R - PR_to_PU - off_PTCA_R - PR_to_PUN) * dt

INIT PTCA__routine = 37
on_PTCA_R = 0.64*PTCA_wl_decision

PR_to_PU = .005*PTCA__routine

off_PTCA_R = PT_scaled_R*PTCA_sched

PR_to_PUN = (.01*PTCA__routine)

PTCA_sched = IF(TIME<38)THEN(NORMAL(7,3,55))ELSE(NORMAL(8,3.5,56))

PTCA_wl_time = (PTCA__routine+PTCA_Urgent+PTCA_unstable)/PTCA_sched

PT_scaled_R = (PT_scale_R/PT_sum)

PT_scaled_U = (PT_scale_U/PT_sum)

PT_scaled_UN = (PT_scale_UN/PT_sum)

PT_scale_R = NORMAL(6,1.5,17)

PT_scale_U = NORMAL(3,2,68)

PT_scale_UN = NORMAL(2,1,19)

PT_sum = PT_scale_R+PT_scale_U+PT_scale_UN

sum_ptca_wls = SUM(PTCA_unstable,PTCA_Urgent,PTCA__routine)

time_ptca_rwl = CTMEAN(off_PTCA_R)

time_ptca_unwl = CTMEAN(off_PTCA_UN)

time_ptca_uwl = CTMEAN(off_PTCA_U)

Surgery_wl = decision + U_wl + R_wl + treated + UN_wl + ems

np_clinic_appts = NORMAL(27,4,5)

angio_em = .005*Angiogram

TREATED_PATIENTS = TREATED_PATIENTS'

MORT = MORT'

discharged = discharged'

wl_batch = wl_batch'

ems(t) = ems(t - dt) + (em_off_UN + em_off_U + em_off_R + angio_em' - ems_treated) * dt

INIT ems = 0

em_off_UN = .01*UN_wl/52

em_off_U = .005*U_wl/52

em_off_R = .005*R_wl/52

angio_em' = angio_em

ems_treated = ems

New_Pt_clinic(t) = New_Pt_clinic(t - dt) + (np_clinic_appts' - pts_for_wl - discharged') * dt

INIT New_Pt_clinic = 35
np_clinic_appts' = np_clinic_appts
pts_for_wl = (1-scaled_D)*New_Pt_clinic
discharged' = scaled_D*New_Pt_clinic

R_wl(t) = R_wl(t - dt) + (to_R - off_R - R_to_UN - R_to_U - em_off_R - wl_batch') * dt

INIT R_wl = 250
to_R = scaled_R*wl_decision
off_R = R_over_sum*no_neg
R_to_UN = .001*R_wl
R_to_U = .001*R_wl
em_off_R = .005*R_wl/52
wl_batch' = IF(TIME=5)THEN(31)ELSE(IF(TIME=54)THEN(18)ELSE(0))

treated(t) = treated(t - dt) + (off_R + off_UN + off_U + ems_treated - MORT' - TREATED_PATIENTS') * dt

INIT treated = 0
off_R = R_over_sum*no_neg
off_UN = IF(wl_comparison<=UN_wl)THEN(wl_comparison)ELSE(UN_wl)
off_U = U_over_sum*no_neg
ems_treated = ems
MORT' = (mort_perc/100)*treated
TREATED_PATIENTS' = ((100-mort_perc)/100)*treated

UN_wl(t) = UN_wl(t - dt) + (to_UN + R_to_UN + U_to_UN - off_UN - em_off_UN) * dt

INIT UN_wl = 5
to_UN = scaled_UN*wl_decision
R_to_UN = .001*R_wl
U_to_UN = .001*U_wl
off_UN = IF(wl_comparison<=UN_wl)THEN(wl_comparison)ELSE(UN_wl)
em_off_UN = .01*UN_wl/52
U_wl(t) = U_wl(t - dt) + (to_U + R_to_U - U_to_UN - off_U - em_off_U) * dt
INIT U_wl = 125
to_U = scaled_U*wl_decision
R_to_U = .001*R_wl
U_to_UN = .001*U_wl
off_U = U_over_sum*no_neg
em_off_U = .005*U_wl/52
wl_decision(t) = wl_decision(t - dt) + (pts_for_wl - to_R - to_U - to_UN) * dt
INIT wl_decision = 35
pts_for_wl = (1-scaled_D)*New_Pt_clinic
to_R = scaled_R*wl_decision
to_U = scaled_U*wl_decision
to_UN = scaled_UN*wl_decision
avg_time_Rwl = CTMEAN(off_R,0,1)
avg_time_UNwl = CTMEAN(off_UN,0,1)
avg_time_Uwl = CTMEAN(off_U,0,1)
cancellations = NORMAL(.25,.08,20)*33
max_time_Rwl = CTMAX(off_R,0,1)
max_time_UNwl = CTMAX(off_UN,0,1)
max_time_Uwl = CTMAX(off_U,0,1)
min_time_Rwl = CTMIN(off_R,0,1)
min_time_UNwl = CTMIN(off_UN,0,1)
min_Uwl = CTMIN(off_U,0,1)
mort_perc = RANDOM(1.1,1.5,21)

no_neg = IF(schedule_control)>=0THEN(schedule_control)ELSE(0)

R = NORMAL(16,2,22)

R_over_sum = R/surm

scaled_D = scale_D/sum1

scaled_R = (scale_R/sum1)

scaled_U = (scale_U/sum1)

scaled_UN = (scale_UN/sum1)

scale_D = Graph_surg_IP

scale_R = RANDOM(.45,.75,23)

scale_U = RANDOM(.15,.35,24)

scale_UN = RANDOM(.05,.1,25)

schedule_control = NORMAL(33,3,39)-cancellations

sum1 = scale_R+scale_U+scale_UN+scale_D

sum_surg_wls = SUM(R_wl,UN_wl,U_wl)

Surgerywl_time = (R_wl+UN_wl+U_wl)/schedule_control

surm = R+U+UN

time_on_R_surg_wl = R_wl/off_R

U = NORMAL(7,1.5,27)

UN = NORMAL(4,1,28)

UN_over_sum = UN/surm

U_over_sum = U/surm

wl_comparison = UN_over_sum*no_neg

Graph_surg_IP = GRAPH(time_on_R_surg_wl)

(0.00, 0.0682), (5.20, 0.0741), (10.4, 0.0762), (15.6, 0.0766), (20.8, 0.0773), (26.0, 0.0783), (31.2, 0.0786), (36.4, 0.0801), (41.6, 0.0811), (46.8, 0.0874), (52.0, 0.0962)

Appendix 5 Examples of Raw data

THEATRE RECEPTION - DO NOT REMOVE

OPERATING LIST - CARDIOTHORACIC SERVICES

TUESDAY 7TH JANUARY 1997

UNIT NO	NAME	AGE	WARD	OPERATION	SURGEON	P
THEATRE ONE: [redacted]				GA: [redacted]	8:30 AM	2
[redacted]	1688	68	27	CABG (UWL)	[redacted]	3
		~~67~~	~~27~~	~~CABG (UWL)~~ cancelled		7 7
		~~66~~	~~27~~	~~CABG X 1 (CANC)~~		
				N.I.T.U.B.		
THEATRE TWO: [redacted]				GA: [redacted]	8:30 AM	4
[redacted]		~~74~~	~~30~~	~~CLOSURE ASD (CANC X 1)~~ no itu bed.	[redacted]	2
	cancelled	4MTH	23	~~REPAIR CAVSD~~		
			27A.	NPITUB.	[redacted]	
			27A.		[redacted]	
THEATRE THREE: [redacted]				GA: [redacted]	8:30 AM	1
[redacted]	1087	58	25	CABG (CANC X 1)	[redacted]	1
		~~68~~	~~27~~	~~CABG + MVR (UWL)~~		6 6
				cancelled NITUB.		
THEATRE FOUR: [redacted]				GA: [redacted]	8:30 AM	3
[redacted]	1089	63	27	CABG	[redacted]	4 3
		~~50~~	~~9A~~	~~CABG (URG)~~ N.I.T.U. BED		5 5

ANAESTHETIC ROOM - THEATRE 4

DR GA:

CARDIOVERSIONS

[redacted]		~~24~~	~~CARDIOVERSION~~	cancelled (flu) [redacted]	
[redacted]	17	24	CARDIOVERSION	[redacted]	

3233.

P = Priority

[redacted]

Figure A5-1 Example of a theatre timetable

CARDIAC CATHETERISATION LIST

MONDAY 19 MAY 1997

UNIT NO	NAME	AGE	WARD	PROCEDURE	CONS/OPERATOR
ROOM 1					
CLOSED - SERVICING					
ROOM 2 - 9.30 START					
~~[redacted]~~		~~87~~	~~24~~	~~Pacemaker~~	[redacted]
9.30 START					
① [redacted]	[redacted]		5/9A	RT HEART [redacted]	[redacted]
ROOM 3 - 8.30AM					
[redacted]	[redacted]	87	24	Box change	[redacted]
[redacted]	[redacted]	77	24	Box change	[redacted]
[redacted]	[redacted]	63	24	Pacemaker	[redacted]
PM					
2 [redacted]	[redacted]	73	24	Pacemaker	[redacted]
[redacted]	[redacted]		9	Cos Angio.	[redacted]

Figure A5-2 **Example of a Catheter Laboratory timetable**

[redacted]

Flowchart demonstrating Queues and Responsibility

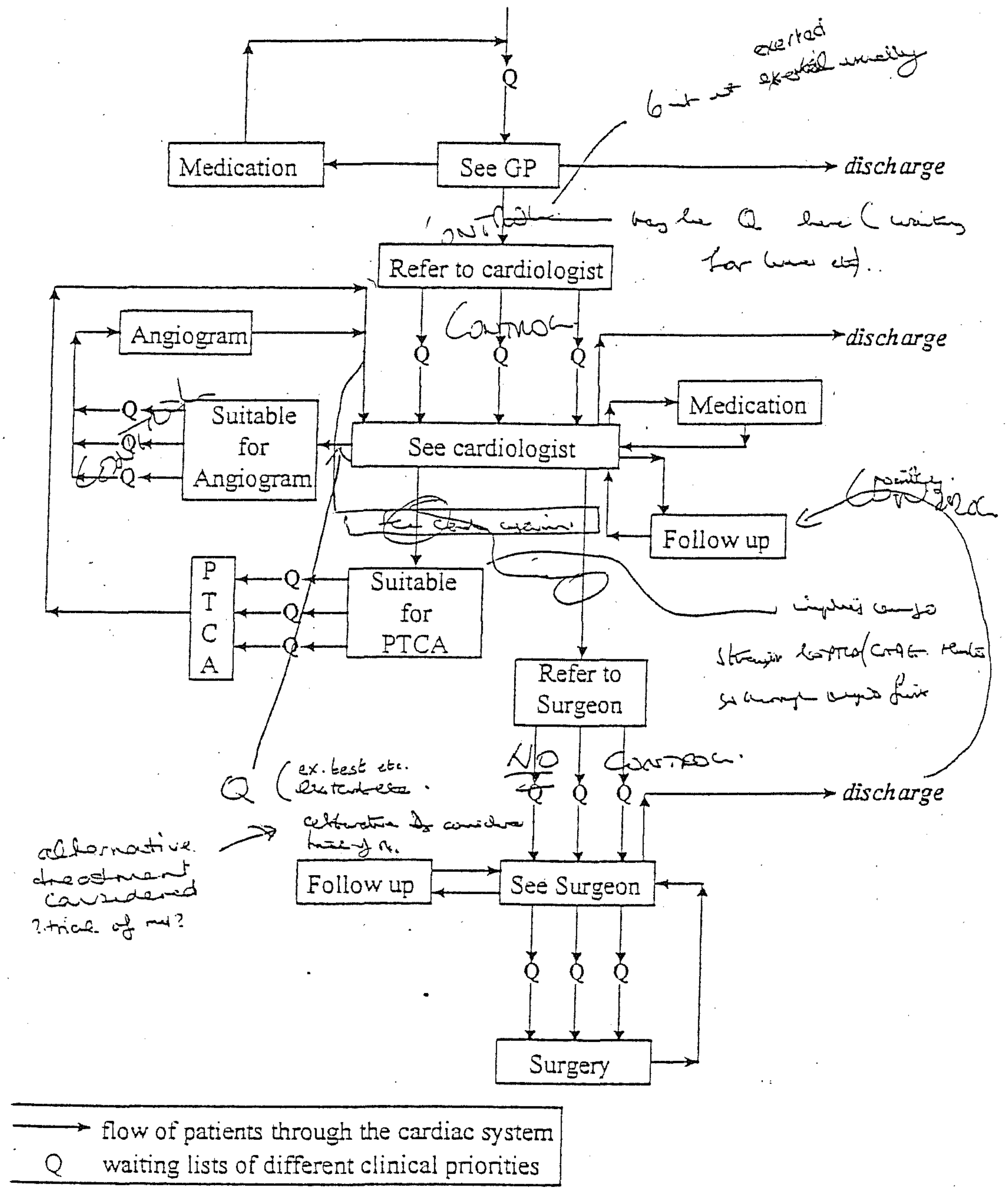


Figure A5-3 **Example of an annotated flowchart**

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