WAITING TIMES FOR ELECTIVE SURGERY:

A HOSPITAL-BASED APPROACH

PROJECT REPORT

Stephen Martin*
Rowena Jacobs**
Nigel Rice**
Peter Smith**

****Centre for Health Economics, University of York**
***Department of Economics, University of York**

July 2003

Acknowledgements

This is a project report to the Department of Health. Further copies are available from Dr Alan Glanz (alan.glanz@doh.gsi.gov.uk), Principal Research Officer, R&D Division, Department of Health. Thanks are due to: the NHS staff who participated in this study; our colleagues Mark Dusheiko and Hugh Gravelle; Geoff Royston, David Bensley and Nick York in the NHS Executive; and several anonymous referees whose comments have improved the final version of this report.

WAITING TIMES FOR ELECTIVE SURGERY:

A HOSPITAL-BASED APPROACH

LIST OF FIGURES

LIST OF TABLES

WAITING TIMES FOR ELECTIVE SURGERY:
A HOSPITAL-BASED APPROACH

ABSTRACT

This report describes an extensive econometric study of hospital responses to waiting times in England. It uses the routine quarterly waiting list returns for all general acute Trusts from 1995 to 2002 to develop empirical economic models of demand side and supply side behaviour. Both outpatient and elective inpatient services are modelled. The models are developed for all specialities combined, for all routine surgery, and for each of the following individual specialities: orthopaedics, ear nose and throat, and urology. An extensive database of hospital characteristics was deployed to ensure that the models were sensitive to variations in hospital circumstances.

The results were consistent with economic theory, and with previous empirical results. On the demand side, longer waiting times serve to depress demand (in the form of additions to the waiting list) to a modest but measurable extent. On the supply side, longer waiting times serve to stimulate activity (in the form of admissions from the waiting list), again to a small but measurable extent. The study integrates these results into a systems dynamic framework to demonstrate how future policy scenarios could be explored further.

The relatively small effects detected are reassuring from a policy perspective. On the demand side, they suggest that the planned reductions in waiting times will not lead to an explosion of demand. On the supply side, they suggest that – other things being equal – Trusts will not 'ease up' on elective activity to any great extent as waiting times decrease.

The study offers advances in a number of ways. It uses a much more extensive dataset than was hitherto available; it models both inpatients and outpatients; it models individual specialities as well as combinations of specialities; it explores some novel uses of analytic techniques; and it has resulted in the development of an extensive database that may be valuable for exploring a range of other research questions.

A fuller executive summary is appended to this abstract.

WAITING TIMES FOR ELECTIVE SURGERY:
A HOSPITAL-BASED APPROACH

EXECUTIVE SUMMARY

Introduction

1. This study was commissioned by the Department of Health. It examines the influence of a number of factors - particularly waiting time - on the supply of and demand for inpatient and outpatient elective care in the English NHS. The central hypothesis is that waiting time is important both on the demand side (because a long wait might deter demand) and on the supply side (because of the managerial importance attached to waiting times).

2. The study builds on two earlier studies at York that suggested that the expected demand and supply side responses do occur. That work was based on small area population data, and obtained robust results relating to demand for inpatient care. However, the supply models, although statistically satisfactory, were rather constrained by data limitations. The motivation behind this study was to strengthen our understanding of both the supply of and demand for elective care through the estimation of more complex supply models and through consideration of outpatient as well inpatient models.

3. The study therefore relies on data provided at the hospital level, rather than small area data. In particular, it focuses on the quarterly waiting list data provided by NHS Acute Trusts. These relate to both outpatients and inpatients, and cover waiting times, referral rates, and activity rates. For inpatients the waiting time data reveals how long those still awaiting treatment have been waiting. For outpatients they report (a) how long those patients seen have waited and (b) how long those still awaiting treatment have been waiting. The immediate objective of this study is to measure the influence on hospital activity of its waiting list and waiting time performance, as measured by these returns.

4. However, in doing so, we found it necessary to develop general models of hospital activity that are much more comprehensive than has previously been possible, incorporating many additional determinants of supply such as hospital workload, clinical quality, workforce characteristics, patient characteristics, and the local health care market. This resulted in numerous research findings on the productivity of hospitals that extend well beyond the immediate concern with waiting times. The study may therefore be of interest from a number of other policy perspectives.

Waiting list data

5. Hospital level data on waiting times for a first outpatient appointment have been available from 1995. Over the period from 1995 to 2002, the number of GP referrals increased 16%, whilst the number of referrals seen increased by only 8%. The proportion of GP referrals seen within 13 weeks declined from 85% to 80%. At the beginning of 2002, just under 2 million GP referrals were seen and just under 250,000 had been waiting over 13 weeks and were still awaiting to be seen. Chapter 4 gives a detailed analysis of national trends, including speciality level results.

6. Inpatient waiting list statistics have been collected since the beginning of the NHS. Additions to the list and the total numbers waiting increased sharply between 1995 and 1998, but since 1998 demand (in the form of quarterly additions to waiting lists) has declined by about 10%. Over the same period, supply (in the form of quarterly admissions from the waiting list) declined by about 15%. Chapter 5 gives a detailed analysis of national trends, including speciality level results for both inpatients and day cases.

Theoretical models

7. We deploy economic models that seek to explain both demand side and supply side behaviour. Our demand side model is based on the belief that a long perceived waiting time might encourage patients to seek (immediate) care in the private sector, or forego hospital care entirely, and might discourage GPs from referring patients. In addition to any measure of delay, the relative costs of reaching NHS or private facilities might affect the demand for NHS care. Thus our demand model includes such factors as the accessibility of private health care and the local availability of General Practitioners, as well as a measure of the morbidity of the local population.

8. On the supply side we employ a model where hospital managers care about the waiting times (or waiting lists) that they report. However, their actions are subject to numerous constraints. Moreover, although increased activity might initially lower waiting times, the model recognizes that demand might therefore be stimulated, leading to a heavier workload. So the net impact of waiting times on hospital activity could in theory be positive or negative.

9. Demand may be affected by aspects of quality other than waiting time. There are numerous measures now employed, both locally and centrally, as indicators of hospital performance. These include: death rates, re-admission rates, the length of stay in hospital, and the proportion of elective admissions that are treated as day cases. Some of these indicators may be interpreted as indicators of supply quality and therefore indirectly affect demand. And some may be proxies for hospital efficiency. Managers may care about them for either reason. Our supply model therefore includes waiting time measures and a batch of variables which can be interpreted as reflecting various aspects of hospital performance, efficiency or quality.

10. We apply these demand and supply models to both inpatient and outpatient care, resulting in a suite of four models. These are applied first to all specialities combined, and then to each of the following: routine surgery, orthopaedics, ear nose and throat, and urology. We also apply the models to outpatient and inpatient care combined, and explore a method of capturing interactions between the four models. Full details of the theoretical models are given in Chapter 6.

Data

11. Before estimation of the regression models commenced, a substantial data set was assembled. Compilation of this database was a major exercise in itself, requiring the assembly of information from diverse sources, and considerable data validation and correction activities. The waiting and activity data were derived from quarterly waiting time, referral, and activity returns from 1995 to 2002 for both outpatients and inpatients for each Trust. Numerous alternative measures of activity and waiting have been used. From the quarterly data, we constructed three measures of demand, two measures of supply, and

five measures of waiting time for the inpatient models. For outpatients four measures of demand, four measures of supply, and six measures of waiting time were constructed.

12. Before supply and demand models could be estimated, we needed to attach a catchment population to each Trust. To do this we employed a purchaser-provider matrix, which measures the flow of patients from each Health Authority to each hospital trust. This enabled us to construct a notional population and measures of population characteristics for each hospital.

13. To this hospital-based database we added a further batch of variables from a data set compiled by researchers at the Centre for Health Economics. This database comprises about 25 variables describing the hospital characteristics, such as: the bed occupancy rate, the average length of stay, an index of case mix complexity, the re-admission rate, the death rate, the day case percentage, and the number of beds per head of population. Full details of the hospital data are given in Chapter 7.

Model estimation

14. In order to estimate the models, we deployed appropriate econometric techniques, as described in Chapter 8. These are based on modern panel data methods, and tests of model specification were undertaken to ensure model assumptions were not violated. Specialist hospitals were deleted from the dataset as they were found to adversely affect model performance, resulting in the use of about 170 general acute hospitals.

15. For both inpatients and outpatients, the alternative measures of supply and demand were typically well correlated with each other, and the mean waiting time was highly correlated with most of the other waiting time measures. We therefore concluded that the models would be insensitive to which specific measures we used. The mean wait was negatively correlated with both the supply and demand measures, and the mean wait was highly correlated with its own lagged values (this correlation declined slowly as the lag increased). The results were broadly similar for each specialty grouping. They are described in detail in the opening sections of Chapters 9 and 10.

Results: inpatients

16. We found that waiting times had a significant negative effect on inpatient demand in all five specialty groupings and that this effect declined as the lag on the waiting time variable increased. We measure the impact of waiting time on demand using the concept of elasticity – the percentage change in demand brought about by a one percent change in waiting time. We detect demand elasticities of between -0.135 and -0.235, relatively modest figures that are consistent with earlier studies. These elasticities imply that a one percent reduction in average waiting time will lead to between a 0.135 percent and 0.235 percent increase in demand, and that a ten percent reduction in average waiting time will lead to between a 1.35 percent and 2.35 percent increase in demand. We also found that the local availability of private beds had a negative impact on the demand for NHS care for all surgery and three of the four specialty groupings (but not ENT).

17. We found that waiting times had a positive impact on the supply of inpatient care, and that the supply response to waiting times was best modelled with a four quarter lag. The elasticity of supply with respect to the mean wait was between 0.052 and 0.103. These elasticities imply that a one percent reduction in waiting time is associated with between a 0.052 per cent and 0.103 percent reduction in the supply of elective surgical activity. Thus

as waiting times fall there is a very small shift in resources away from elective surgery and into other areas of NHS activity (eg emergency, medical, and A&E services). We also found that a number of other variables (such as the number of beds and case mix complexity) were associated with the supply of elective care. With the exception of ENT and all specialties combined, the local availability of private beds was negatively associated with the supply of inpatient NHS care. Full details of the inpatient results are given in Chapter 9.

Results: outpatients

18. For each outpatient demand and supply model two equations were estimated: one based on GP referrals and the other based on all referrals (including referrals from other consultants as well as GP referrals). We found that waiting times, lagged one period, had a significant negative effect on demand and that this effect declined as the lag on the waiting time variable increased. For individual specialities, the elasticity of all referral demand with respect to the mean wait was between -0.034 and -0.059, while that for GP referral demand was between -0.055 and -0.173. There was some evidence that the local availability of private health care was negatively associated with the demand for NHS outpatient appointments.

19. With regard to the supply of outpatient appointments, we found it possible to develop good models only for all referrals (and not for GP referrals alone). Waiting times had a positive impact on supply and the supply response to waiting times was best modelled with an eight quarter lag. The elasticity of all referral supply with respect to the mean wait was between 0.027 and 0.070. We also found that a number of inpatient-related variables (such as the number of beds) also appeared to be associated with the supply of outpatient services. This effect is probably an indirect one reflecting the fact that more pressure on inpatient resources is likely to be associated with less outpatient capacity. We also found some evidence that the local availability of private care was negatively associated with the supply of NHS outpatient care. Full details of outpatient results are given in Chapter 10.

Results: outpatients and inpatients combined

20. We also estimated combined inpatient and outpatient supply and demand models where the impact of total (outpatient plus inpatient) waiting time affects total (outpatient plus inpatient) demand and total (outpatient plus inpatient) supply. Generally, the results we obtained were similar to those for inpatients alone but in some cases the inclusion of outpatients enabled us to obtain a better statistical model. We found that waiting times had a significant negative effect on demand and that this effect declined as the lag on the waiting time variable increased. The elasticity of total demand with respect to the mean wait was between -0.133 and -0.238 and there was some evidence that the local availability of private health care had a negative impact on the demand for NHS care. On the supply side, the elasticity of all referral supply with respect to the mean wait varied between 0.054 and 0.087. We again found that a number of inpatient-related variables (such as the number of beds and case mix complexity) were associated with the total supply of services. Full details are given in Chapter 13.

Further work

21. We found that, for a given service (inpatients or outpatients), there was a positive correlation between divergences from the demand and supply models. For example, if our statistical model underestimated demand, it also tended to underestimate supply. One interpretation of this is that there is some unobserved factor that boosts both demand and

supply but which has not been included in the model. We therefore experimented with the use of a seemingly unrelated regression (SUR) estimator, as reported in an Annex to the main report. This effectively seeks to correct for observed linkages between separate statistical models, of the sort we detected between demand and supply. Because the reason for the correlation between the demand and supply models cannot be established with any certainty, the SUR results are in an annex to the main report and should be viewed as a promising avenue for future research.

Systems dynamics simulations

22. Using some of the results from this study, we constructed a basic dynamic model of the demand for and supply of elective health care within a system dynamics framework. This model examined the dynamic consequences for waiting times and waiting lists of various scenarios (such as changes in funding levels). We also incorporated a consultant-held target waiting time into the model so that, when waiting times differ from the target level, consultants adjust their treatment thresholds in an attempt to bring waits back into line with the target wait. This part of the study is intended as a demonstration of how our statistical results could be used to explore future policy scenarios.

Conclusions

23. Our inpatient supply and demand results are broadly consistent with our previous findings. This is a reassuring result, and notable because this study used an entirely different data set, based on hospitals, to that used in our previous work. Moreover, the current results are based on the most recently available data (from 1995 to 2002) whereas our previous study covered an earlier period (from 1992 to 1997). Our results are also in line with the small number of other studies that have examined this topic, confirming that waiting times have a small but significant impact on both the demand for and supply of inpatient NHS care.

24. The study offers some important messages for policy. First it confirms that lower waiting times give only a relatively modest stimulus to demand for inpatient and outpatient surgery. It reinforces previous findings that, other things being equal, the dramatic reductions in waiting times in the NHS are unlikely to lead to major increases in demand.

25. On the supply side, longer waiting times appear to have only a marginal positive impact on NHS activity, both in aggregate and in the three specialities studied. The precise response of the NHS supply side as waiting times are reduced in the future will depend heavily on the incentives put in place to sustain the improvements. However, this study suggests that – over the years studied – NHS hospitals did not 'ease up' in any major fashion when waiting times fell.

26. We have demonstrated how the results of this study could be used to simulate dynamic responses to extra resources, and have demonstrated the implications of a consultant-held target. These simulations probably have limited predictive power, but they can help policy makers understand the components of the waiting time problem and the potentially complex dynamics of the health system.

27. Our study offers some evidence that better access to private healthcare provision may depress both the demand for NHS services as well as NHS supply. This result must be viewed in the light of the rudimentary measures of private supply we had available, but it does suggest that interactions with private sector provision may be quite subtle and require careful examination before drawing policy conclusions.

28. Using new analytic techniques (SUR), we have for the first time modelled simultaneously the links between inpatients and outpatients and demand and supply. This analysis is exploratory, but it does suggest that the impact of waiting times on system behaviour may if anything be less than we had previously suggested, reinforcing our confidence that the new targets will not in themselves have a major influence on demand or supply.

29. This study offers an advance on previous research in a number of ways. First, we have been able to estimate demand and supply models for both outpatients and inpatients and have demonstrated the usefulness of Trust returns as data source for modelling the demand for and supply of health care. Second, by combining these returns with a database of Trust characteristics we have been able to estimate more general models of hospital supply (based not just on waiting time). We have examined the impact of many factors on hospital supply and have applied these models to both groups of specialties and individual specialties. Third, we have obtained a reasonably stable set of results, based on a panel that runs from 1995 to 2002. Use of a panel has allowed us to explore the lag with which demand and supply respond to waiting times, suggesting that the supply response is rarely instantaneous. Fourth, the exploratory use of the seemingly unrelated regression technique is in our view a promising approach to modelling hospital behaviour, and merits further development as an analytic tool. And fifth, we have assembled an important dataset that could in principle answer a number of other research questions unrelated to our original intentions.

WAITING TIMES FOR ELECTIVE SURGERY:

A HOSPITAL-BASED APPROACH

1. INTRODUCTION

The NHS inherited a waiting list of just under 500,000 patients on its formation in 1948. Currently, the waiting list for inpatient treatment is about one million, having reached an all-time high of 1.3 million in 1998.[1] The very large number of people on this waiting list has meant that this issue has always attracted a good deal of political attention and there have many policy initiatives over the past 50 years designed to reduce numbers waiting or numbers waiting for a long time (NAO, 2001, pp30-31). Some initiatives have been very successful: for example, the number of long waits (patients waiting longer than 12 months for admission) was reduced from over 200,000 in 1990 to less than 5,000 in under six years. However, even where initiatives have been successful there is evidence that once such initiatives are relaxed previous gains can be quickly reversed. Thus the number of long waits bounced back from less than 5,000 in March 1996 to over 70,000 in June 1998. This reversal, which occurred around the time of the 1997 General Election, might suggest that if gains are to be maintained waiting lists must remain a high Ministerial priority.

Various reasons have been put forward for the persistence of NHS waiting lists. At a very basic level some waiting list is needed to regulate the flow of work for NHS surgeons (Street and Duckett, 1996). However, most would agree that this pool does not need to contain as many as one million waiting patients. Another common view is that - in the absence of a price mechanism - the waiting time for elective (non-emergency) health care acts as a rationing device, and that any reduction in waiting times merely stimulates demand until waiting times return to their previous level (Pope, 1992; Roland and Morris, 1988). However, recent research suggests that the responsiveness of demand to changes in waiting times is relatively small (Martin and Smith, 1999). Others have argued that long waiting lists are in the interests of NHS surgeons who reap large financial rewards as some patients avoid long waits by paying for their treatment in the private sector (Yates, 1995). One strand to this argument is that most NHS surgeons have contracts that permit them uncontrolled activity in the private sector and that such activity is at the expense of additional NHS activity (Yates, 2002). Alternatively, some argue that waiting lists are a symptom of the chronic under-funding of the NHS which all too often has a shortage of consultants, nursing staff, beds, and operating theatres. These commentators point to the fact that the UK spends a relatively small proportion of its GDP on health care and that spending must be increased if waiting lists are to be reduced. Finally, some note that the shortage of government funding for residential and nursing homes contributes to the maintenance of waiting lists. Without appropriate accommodation to go to, elderly inpatients cannot be discharged from hospital and occupy beds for long periods which would otherwise be used to treat other patients (Pascoe, 2001). Of course, these reasons are not mutually exclusive and it is perfectly possible that all these factors have contributed, to some extent, to the preservation and growth of NHS waiting lists.

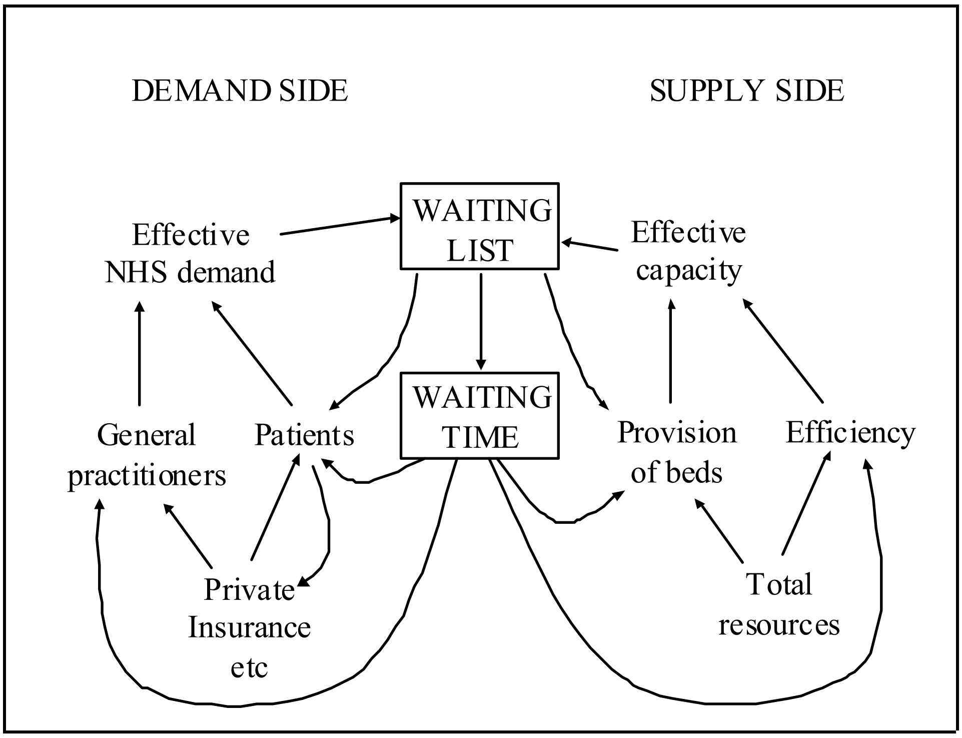
---

[1] This report was written between January and March 2003 and reflects the information available at that time. It was revised in July 2003 following comments from several referees.

The objective of this research is to explore in more detail the factors that influence the demand for and supply of NHS surgery, and to offer estimates of the size of their influence. This study builds on previous work which focussed on population behaviour, and employed the electoral ward as the unit of analysis (Martin, Rice, Siciliani and Smith, 2001). However, in contrast, this study employs NHS hospitals as the unit of analysis. The advantage of this is that it facilitates the exploitation of inpatient *and* outpatient waiting list data, which have hitherto received relatively little empirical attention, together with a database of provider characteristics.

Figure 1 illustrates the analytic framework that informs the study. The central feature of the framework is that the NHS waiting phenomenon (waiting times and/or waiting list size) influences both demand and supply. On the demand side, long waits and/or long lists might suppress demand, either by persuading patients to seek care outside the NHS, or to forgo any form of health care. On the supply side, the length of wait and/or lists might influence the level of resources that local services devote to elective surgery, and the efficiency with which those services are delivered. For example, given the national focus on elective waits, particularly long waits and/or lists might persuade a local hospital to switch resources into elective surgery in order to avoid possible sanctions.

Figure 1 Schematic representation of the influences of waiting on demand and supply



Of course there will be many other influences on local demand and supply. On the demand side examples might be the population's underlying needs, the characteristics of the primary care sector, and the strength of the local private sector. On the supply side, key external influences are likely to be the overall level of resources available and the nature of local contractual arrangements.

Employing this framework, Martin, Rice, Siciliani and Smith (2001) estimated both equilibrium and disequilibrium models using Hospital Episode Statistics data over the seven-year period 1991/92 -1997/98. The results suggest that waiting time has a small but distinct negative impact on demand with a larger positive impact on supply. Because the analysis was based on population behaviour, the results were more secure on the demand than the supply side. In particular, the only indicator of health care supply was the total number of NHS acute beds, and while this might be adequate for all specialties combined, it is clearly inadequate for modelling waiting times for individual specialties. Moreover, no attempt was made to incorporate any measure of the quality of supply (in the form, for example, of re-admission rates) because such data were not readily incorporated into the study methodology.

The other major limitation of previous studies by ourselves and others has been the emphasis on *inpatient* waiting time - that is, the period of time between the consultant's decision to admit and actual admission - rather than the entire waiting experience, including *outpatient* waiting. The reason for this is that these studies have been based on HES inpatient data, which only records the inpatient wait. The obvious difficulty with any model based solely on the inpatient wait is that it ignores the additional wait for an outpatient appointment, which might have a profound additional impact on both supply and demand side. To address these issues the present study abandons the use of the electoral ward as the unit of analysis and reliance on HES data. Instead, the NHS hospital becomes the unit of analysis with inpatient and outpatient waiting list/time data drawn from the quarterly returns made by the hospitals.

Waiting times currently have a high political profile so we begin, in section 2, by outlining the Government's current waiting time targets as presented in the NHS Plan and subsequent implementation programmes. In section 3 we consider the availability and coverage of nationally produced waiting times statistics. Sections 4 and 5 outline recent trends in outpatient and inpatient waiting times respectively. The discussion also considers whether the NHS is on course to meet the Government's targets and presents statistics on the level of hospital activity. Section 6 presents the economic models of waiting lists to be estimated. Section 7 describes the data used to estimate these models and section 8 discusses estimation issues. OLS regression results are presented in sections 9 - 13. In section 14 we undertake an exploratory study using system dynamics informed by some of our econometric results. In section 15 we summarise our results and compare them with those from other studies. In an annex to this report we present the results from an exploratory analysis employing the Seemingly Unrelated Regression (SUR) estimator rather than OLS estimator. The OLS estimator analyses supply and demand separately whereas the SUR estimator estimates supply and demand simultaneously.

Appendix 1 contains detailed information on recent trends in referral, activity, and waiting list data by individual specialty. To ensure that this study reflects the experience of those working in the NHS, three Trusts were visited and staff with knowledge of local waiting times, activity levels, and referral rate interviewed. Appendix 2 provides details of the questionnaire used as the basis for these semi-structured interviews together with an overview of some of the issues raised by participants.

2. CURRENT WAITING TIME TARGETS

Until very recently, the Department of Health neither calculated nor monitored the total time that patients wait from seeing their GP to being treated. With the establishment of targets for the total waiting time from referral to treatment for cancer patients, arrangements for monitoring total waiting time are being put in place (NAO, 2001). But for many patients the total waiting time between seeing a GP and being treated by the NHS will continue to go unmonitored.

The total waiting time comprises three main elements:

- **waiting for an initial outpatient appointment**: this is the period between seeing the GP and being seen by a consultant or other health professional at an outpatient clinic
- **waiting for second and subsequent outpatient appointments**: in some cases a consultant might require tests or diagnostic procedures to be carried out before determining what treatment, if any, is appropriate. Such tests might require further outpatient appointments.
- **waiting for inpatient treatment**: this is the time a patient waits from being placed on the inpatient waiting list for treatment until they are actually admitted to hospital.

In addition to the wait for an outpatient appointment and inpatient admission, access to other parts of the NHS can also involve a wait:

- to see a GP;
- for an emergency ambulance to hospital;
- to be seen in accident and emergency;
- to be allocated a bed in hospital from accident and emergency; and
- for discharge from hospital.

Public surveys reveal that people think that the NHS is too slow (DoH, 2000a, p137). Seven out of ten people think waiting lists and waiting times for operations are too long. More than six in ten think patients have to wait too long to be seen in casualty. Trolley waits are regarded as unacceptable and almost a third of patients would like to see GPs extend their opening hours in the evenings (DoH, 2000a, p137).

Published in July 2000 the NHS Plan set some ambitious targets, particularly with regard to cutting the wait for medical treatment (DoH, 2000a, pp101-105). These targets included:

- by 2004 patients will be able to see a GP within 48 hours;
- by 2001 the ambulance service should achieve a first response to 75% of Category A calls within 8 minutes;[2]
- by 2004 no-one should be waiting more than four hours in accident and emergency from arrival to admission, transfer or discharge, and average waiting times in accident and emergency will fall to 75 minutes;
- by the end of 2005 the maximum waiting time for a routine outpatient appointment will be halved from over six months (in mid-2000) to three months, and the average waiting time for an outpatient will fall to five weeks;

---

[2] The deadline for the achievement of this target has been revised to December 2002 (DoH, 2001a).

- by the end of 2005 the maximum wait for inpatient treatment will be cut from18 months (in mid-2000) to six months, and the average inpatient waiting time will fall from three months to seven weeks;
- by 2004 widespread bed blocking will end; and
- by the end of 2008 the maximum wait for any stage of treatment will be three months.

In addition, the NHS Cancer Plan has set targets for cutting waiting times for the diagnosis and treatment of cancer (DoH, 2000b).

Although the outpatient and inpatient waiting targets appear relatively well-defined in the sense that the NHS Plan is explicit about what is to be achieved and by when, the Plan is rather vague about intermediate goals and monitoring progress towards the targets. The Plan notes that:

> *We will progress towards our objectives on a staged basis - the pace of progress being linked to the growth in staff. The Plan will see a staged reduction of maximum inpatient waits from 18 months through 15, 12, 9 down to 6, and eventually 3 months (DoH, 2000a, p105).*

Details of initial goals and deadlines for their achievement can be found in the *Implementation Programme* for 2001-02 (DoH, 2000c). These included the following waiting time targets:

- for inpatients, reduce the number of over 12 month waiters and implement a maximum waiting time of 15 months by March 2002; and
- for outpatients, reduce the number of over 13 week waiters and implement a maximum waiting time of 26 weeks by March 2002.

In addition to the targets set out in the NHS Plan, one of New Labour's five promises made in its 1997 election manifesto was to reduce the number of patients on the waiting list by 100,000. This commitment - to cut waiting lists by 100,000 from the 1997 level over the lifetime of a Parliament - was also reiterated in the *NHS Plan Implementation Programme* for 2001-02 (DoH, 2000c).

The *Priorities and Planning Framework 2002/2003* establishes further intermediate targets (DoH, 2001a). For inpatients there is to be:

- a maximum wait of 12 months by March 2003;
- a reduction in the number of 9 month waiters by the end of the year; and
- a reduction in the overall list size by the end of the year.

For outpatients there is to be:

- a reduction in the number of those waiting more than 13 weeks by the end of the year; and
- a maximum wait of 5 months (21 weeks) by March 2003.

Further intermediate targets, to be achieved by March 2004, can be found in the *Priorities and Planning Framework 2003/2006* (DoH, 2002). For inpatients there is to be:

- a maximum wait of 9 months by March 2004;
- a reduction in the number of 6 month waiters by 40% by the end of the year; and
- a reduction in the overall list size by the end of the year.

For outpatients there is to be:

- a reduction in the number of those waiting more than 13 weeks by the end of the year; and
- a maximum wait of 4 months (17 weeks) by March 2004.

In the next section, we will consider the availability and coverage of nationally produced waiting times statistics that will be used to monitor the achievement of these targets. As we shall see, there is some debate as to whether these targets should be monitored using data reflecting either

- the waiting time of those that have been treated over a given time period (say, three months)

or

- how long those still awaiting treatment have waited at a given point in time (say, at end of the quarter).

3. NHS WAITING STATISTICS

Waiting statistics typically either refer to a list or time. Waiting time information might refer to how long someone - who has received treatment - had to wait for that treatment, or to how long they have waited to date when they are still awaiting treatment. Waiting lists are a count, at any one point in time, of the number of people still to be treated by the NHS. There are two quite separate waiting lists:

- the outpatient waiting list; and
- the inpatient waiting list.

About 80 per cent of the population in England visited their GP in 1998. Over one third of these patients (35 per cent) were referred by letter to a hospital consultant specialising in the relevant area. From the date the hospital receives the letter, the individual is added to the outpatient waiting list and remains on it until the patient is seen at an outpatient clinic.

About one in ten of all outpatients require inpatient treatment, sometimes after one or more diagnostic tests. Once the consultant concludes that an admission is necessary and the patient agrees, the patient is added to the inpatient waiting list and typically remains there until admitted into hospital for the proposed treatment, either as a day case or involving an overnight stay in hospital.[3]

There are two major sources of waiting list and waiting time data for patients treated in the NHS: Hospital Episode Statistics and the quarterly returns made by NHS hospitals and Health Authorities (now Commissioners).

3.1 Hospital Episode Statistics

The Hospital Episode Statistics (HES) database contains about 12 million records for each data year (1 April to 31 March) detailing inpatient treatment provided by NHS hospitals in England. There are no records for outpatients but day cases are included. HES records comprise approximately forty to sixty base fields that hold data collected directly by hospital providers. Included in each record are diagnoses and surgical procedure codes, various dates that permit the calculation of patient's length of stay in hospital and the inpatient waiting time, the location of treatment, and details relating to the patient. Each record details a continuous period of care (episode) administered within a particular consultant specialty at a single hospital provider. Therefore if, during a spell of treatment, a patient is transferred to another consultant and/or different provider, a new record is generated.

Unfortunately, no information is available from the HES database on the outpatient wait and, because of the size of the data set and the cleaning required, the full annual HES database tends to be available with a relatively long lag (although quarterly releases are now available). Consequently, information about waiting times for FCEs in any given financial year is only available at least six months or more after the end of the year covered by the data set. In addition, HES only provides information on waiting times for those patients who have completed a period of care. There is no information about how long those who are awaiting treatment have waited, nor

[3]Other possibilities are that the patient dies, moves away from the area, or decides against treatment.

about how many people are awaiting treatment. Nevertheless, because of the large amount of information available from HES, both about the individual and the treatment received, this database has proved a useful source of information for studies of the inpatient wait (see, for example, Martin and Smith: 1999, 2001).

3.2 Quarterly returns made by Trusts and Health Authorities

The HES database contains information about how long each individual patient had to wait for admission. Further, but much more aggregated, information about waiting times is available from the quarterly returns submitted by NHS Trusts (KH07, QM08) and, what were, Health Authorities, but are now Commissioners (QF01, QM08R). Two of the returns relate to inpatient admissions (KH07 and QF01) while the other two concern outpatient attendances (QM08 and QM08R).

3.2.1 Inpatients

Consider first the KH07 return submitted quarterly by providers of hospital services in NHS Trusts. In addition to emergency and maternity admissions, this return, and hence published statistics on the inpatient waiting list, excludes the following patients:

- patients who have been given a date, or an approximate date, for admission, usually as a planned sequence of clinical care (planned admissions);
- non consultant-led treatments (e.g., for physiotherapy; speech therapy, and counselling); and
- patients temporarily suspended from waiting lists for personal reasons or because they are not medically ready for treatment.

The KH07 return provides both waiting list and some waiting time information. No information is available on how long those admitted actually waited. However, figures are reported for the total number of patients awaiting inpatient admission as at the last day of the quarter together with a breakdown of how many of these patients have been waiting:

- less than three months;
- between three and six months;
- between six and nine months;
- between nine and twelve months;
- between 12 and 15 months;
- between 15 and 18 months;
- between 18 and 21 months;
- between 21 and 24 months; and
- over 24 months.

Figures are available by specialty, by NHS Region and by NHS Trust. A distinction is also drawn between ordinary and day case admissions. This data set is available electronically from the Department of Health. It also contains additional fields - drawn from other returns - that provide supplementary information about the evolution of the waiting list during the quarter including:

- the number of admissions from the waiting list
- the number of cases where a decision to admit has been made (additions to the waiting list)
- the number of patients who failed to attend for their inpatient admission
- the number of removals from the waiting list (e.g., because the patient was admitted as an emergency or died while on the waiting list)
- the number of self-deferrals (patients who have been offered an admission date but who are unable to attend for social reasons). These patients have their waiting time calculated from the most recent date they were offered an admission.
- the number of suspensions from the list (patients who are not medically ready for treatment).

This data set - excluding the supplementary list information - and with the waiting time fields condensed from the nine detailed above so that they report the number of patients that have been waiting:

- less than three months;
- between three and six months;
- between six and twelve months;
- between 12 and 18 months; and
- over 18 months

is available from the quarterly publication *Hospital Waiting List Statistics: England* and electronically from the Department of Health's website http://www.doh.gov.uk/waitingtimes/.[4] Again, figures are available by specialty, by NHS Region, by NHS Trust, and also distinguish between ordinary and day case admissions. Similar data sets, but ones based on Health Authorities (now Commissioners) and their local populations rather than NHS Trusts, are also available from the same sources.[5]

---

[4]With effect from 2002/03 Q3, the website contains the full waiting time and activity data set.

[5]There are fundamental differences in coverage between population based (resident or responsible population) and Trust based information. Population based returns exclude all patients living outside England and all privately funded patients waiting for treatment in NHS hospitals. However they do include NHS funded patients, living in England, who are waiting for treatment in Scotland, Wales, Northern Ireland, abroad and at private hospitals, which are not included in the corresponding Trust based returns.

3.2.2 Outpatients

In addition to this inpatient information, somewhat more extensive data on outpatient waiting times is available from the QM08 return submitted by NHS Trusts. This gathers data on:

- the number of written referrals received from GPs during the quarter;
- the number of other referral requests received (including those from A&E departments, a consultant in a department other than A&E, and a prosthetist);
- the number of GP written referrals seen who had waited:
  - less than 4 weeks
  - between 4 and less than 13 weeks
  - between 13 and less than 26 weeks[6]
  - more than 26 weeks
  - the number of patients with a written referral from a GP who had not yet attended for a first appointment and who had been waiting:
  - between 13 and 26 weeks;[7] and
  - over 26 weeks.

Figures are available by specialty, by NHS Region and by NHS Trust. Again, this data set is available electronically from the Department of Health and includes two additional data fields:

- the number of patients who did not attend and who gave no advance warning of their non-attendance
- the total number of referrals seen (from GP and other sources).

These additional fields are not included in the data sets downloadable from the Department of Health's website *http://www.doh.gov.uk/waitingtimes/*. Two similar data sets, but based on Health Authorities (now Commissioners) and their local populations rather than NHS Trusts, are also available from the Department and its website.

This outpatient waiting time data is more extensive than that available for inpatients in that data is available for both those that have been treated and those awaiting treatment. As we shall see in section 4.3, the 'awaiting treatment' measure records an apparently lower waiting time so that the use of this measure makes the achievement of NHS Plan targets easier.

---

[6]Since 2002:Q1 the 13-26 weeks category has been split into three divisions: 13 - 17 weeks, 17-21 weeks, and 21-26 weeks.

[7]Since 2002:Q1 the 13-26 weeks category has been split into three divisions: 13 - 17 weeks, 17-21 weeks, and 21-26 weeks.

4. RECENT TRENDS IN OUTPATIENT WAITING LISTS/TIMES

Data first began to be collected nationally on the time patients waited for an outpatient appointment in 1995. As has been noted above, this data only relates to people attending their first outpatient appointment following a written referral from their GP. It excludes individuals waiting for anything other than their first appointment, and patients referred for their first appointment by anybody other than a GP. Patients referred by consultants and other health professionals (for example, from A&E) would thus be excluded.

The significance of these exclusions is unclear. If these exclusions reflected a relatively small proportion of all outpatient appointments then their omission from the waiting list statistics might be deemed unimportant. However, a substantial majority of all outpatient attendances are not first attendances following a GP referral: in 1999-2000, GPs made 9.3 million referrals and outpatient clinics saw 43.0 million patients (DoH, 2000d, p1). Thus outpatient waiting list statistics relate to less than one quarter of all outpatient activity.

Although the NHS Plan talks of a maximum wait of three months for a 'routine outpatient appointment' what this means in practice is a maximum wait of three months for a first outpatient appointment following a GP referral. The Plan makes no mention of targets for any other type of appointment. By having targets for one particular type of appointment and not others, there may be pressure to prioritise some patients (who are covered by the target) over others (who are not covered by the target). It is not inconceivable that although the waiting time for first outpatient appointments following GP referral might fall, the waiting time for other referrals and all second and subsequent appointments might rise. With no nationally collected statistics on the wait for appointments not covered by the NHS Plan, it will be difficult to ascertain whether and to what extent this occurs.

Alternatively, it can be argued that it is the waiting time for the *first* outpatient appointment that is the most important wait as it is at the patient's first appointment that the consultant will determine the urgency of the case. Moreover, it might be that a non-trivial proportion of second and subsequent appointments are part of a programme of planned care (e.g., annual check ups) and therefore the exclusion of these appointments from the waiting time target is appropriate as there will be no 'waiting time' associated with them.

4.1 All specialties

Outpatient waiting time data are collected quarterly and Table 1 presents figures for the first quarter of each year from 1995 to 2002.[8] The third column of Table 1 shows that the number of GP referrals seen increased from 1.786 million in the first quarter of 1995 to 1.926 million in 2002, an increase of almost 8% over the seven-year period. Table 1 also details how long these referrals had to wait before they were seen at an outpatient clinic. Patients are divided into four groups according to how long they waited: whether less than 4 weeks, between 4 and 12 weeks, between 13 and 26 weeks, or more than 26 weeks. In 1995:Q1, 40 per cent of GP referrals had their first outpatient appointment within 4 weeks. By 2002:Q1, this proportion had declined to less than 35 per cent. Similarly, the proportion of patients seen within 13 weeks declined from 85 per cent in 1995 to 80 per cent seven years later.

---

[8]It is important to compare figures from the same quarter as there are marked seasonal fluctuations in activity levels.

Table 1 Outpatient waiting times, Q1, 1995-2002, all specialties

Position as at the end of:		Number of GP referrals seen (000s)	Of those GP referrals seen, the number who waited (thousands)				Of those referrals not yet seen, the number waiting (thousands)	
			0 - <4 weeks	4 - <13 weeks	13 - <26 weeks	26 + weeks	13-<26 weeks	26 + weeks
1995	Q1	1786	715	803	213	56	212	87
1996	Q1	1870	733	854	234	50	169	52
1997	Q1	1905	743	867	234	61	210	85
1998	Q1	1827	690	809	256	72	269	109
1999	Q1	1838	647	792	294	105	339	146
2000	Q1	1885	658	823	293	111	314	130
2001	Q1	1895	675	850	289	81	274	85
2002	Q1	1926	666	881	348	31	244	1

Data are also collected on the number of GP referrals who have been waiting 13 weeks or more and who have not yet been seen (as at the end of the quarter). No information is available about how many have been waiting less than 13 weeks so we do not know how many are waiting in total. As at the end of 1995:Q1, there were 299,000 GP referrals that had been waiting at least 13 weeks. One year later this total had declined by almost 80,000 but then proceeded to rise by about 90,000 per year for the next three years so that at the end of 1999:Q1 some 485,000 GP referrals had been waiting at least 13 weeks and had not been seen. Since then, the number of long (over 13 week) waits has halved and at the end of 2002:Q1 only 1,000 referrals had been waiting longer than 26 weeks. Nevertheless, the number of long wait referrals in 2002:Q1 (244,000) exceeded that recorded in 1996:Q1 (221,000).

To help understand recent trends in outpatient waiting times, Table 2 outlines recent trends in total outpatient referral and activity rates. Between 1995 and 2000, the number of GP referrals increased by 13 per cent but other referrals increased by 72 per cent so that, overall, total referrals increased by 25 per cent. Over the same time period, the number of referrals seen increased by 17 per cent and the number of patients who failed to attend their appointment increased by 20 per cent. By combining the number of referrals seen (appointments kept) with the number of appointments missed, we obtain the total number of appointments offered. This grew by 17 per cent (less than the growth rate for number of referrals received). With the exception of 1996, the quarterly number of appointments offered is about 100,000 less than the number of referrals received. Thus it is not surprising that GP referred outpatient waiting lists/times increased over this particular period.

For 2001 and 2002 no data are available on other (non-GP) referrals seen although it is this very category of referral that has seen the most rapid growth (more than doubling between 1995 and

2002 while GP referrals increased by only 16%). Our interviews with Trust staff revealed one reason for this growth. There is a tendency for consultants - particularly the more recently trained - to specialise within the standard specialties so that although a GP might refer a patient to an ENT specialist this consultant might refer the patient on to another ENT consultant who has the appropriate specialism within ENT.

Table 2 Outpatient referral and activity levels, Q1, 1995-2002
All specialties

Position as at the end of Q1:	Number of referrals received (000s):			Number of referrals seen (000s):			DNAs (000s)	Total number of appoint-ments (000s)
	GPs	Others	Total	GP	Others	Total		
1995	2077	529	2606	1786	606	2392	291	2683
1996	2211	671	2882	1870	707	2577	310	2883
1997	2328	825	3153	1905	785	2690	327	3017
1998	2301	848	3149	1827	834	2661	327	2988
1999	2317	863	3180	1838	877	2714	342	3056
2000	2357	908	3265	1885	911	2796	349	3145
2001	2385	990	3375	1895	n/a	n/a	n/a	n/a
2002	2416	1060	3476	1926	n/a	n/a	n/a	n/a
Growth:								
1995-00	13%	72%	25%	6%	50%	17%	20%	17%
1995-02	16%	100%	33%	8%	n/a	n/a	n/a	n/a

In summary the evidence from outpatient referral and activity data suggests that between 1995 and 2002:

- the growth in demand (referrals) outstripped the growth in supply (referrals seen)
- the number of long wait referrals (over 13 weeks) at first increased (to 1999) but then declined with very long waits (over 26 weeks) all but eliminated by 2002
- the elimination of very long waits has coincided with a reduction in the proportion of patients seen quickly (within 4 weeks)
- the absence of any information about waiting times for second and subsequent outpatient appointments (which constitute over three-quarters of all appointments) makes it difficult to assess the full impact of the outpatient waiting time targets although it can be argued that it is the waiting time for the *first* outpatient appointment that is the most important and that many second and subsequent appointments are part of a programme of planned care

4.2 By individual specialty

The above discussion relates to outpatient waiting times for all specialties combined. However, waiting lists are dominated by a small number of surgical specialties and it might be useful to consider recent trends in activity rates and waiting lists/times for these routine surgical specialties as a whole and for them as individual specialties.

Table 3 reports figures for seven routine surgical specialties (general surgery, urology, orthopaedics, ENT, ophthalmology, oral surgery and gynaecology) combined.[9] In both 1995 and 2002, the routine surgical specialties accounted for 58 per cent of all GP referrals seen. As was the case for all specialties, the number of GP referrals seen increased by 8 per cent but the proportion of GP referrals seen within 13 weeks declined, falling from 83 per cent in 1995 to 79 per cent to 2002. Routine surgery also saw an initial increase in the length of the GP outpatient (long wait) waiting list, with an increase from 190,000 patients in 1995 to 312,000 patients in 1999. Since then, however, the number waiting over 13 weeks and not yet seen has fallen to 152,000 and the very long waits (over 26 weeks) have been all but eliminated.

[9] For want of a better term we label these specialties the 'routine surgical specialties' although we recognise that there may be non-routine procedures contained within these broad specialty headings.

Table 3 Outpatient waiting times for first outpatient appointment following written GP referral (thousands), Q1, 1995-2002, routine surgery

Position as at the end of:		Number of GP referrals seen (000s)	Of those GP referrals seen, the number who waited (thousands)				Of those referrals not yet seen, the number waiting (thousands)	
			0 - <4 weeks	4 - <13 weeks	13 - <26 weeks	26 + weeks	13-<26 weeks	26 + weeks
1995	Q1	1044	391	476	141	37	137	53
1996	Q1	1081	399	502	150	31	104	32
1997	Q1	1085	397	502	148	38	130	49
1998	Q1	1049	373	465	167	45	171	65
1999	Q1	1067	355	455	186	70	220	92
2000	Q1	1094	361	472	186	75	203	84
2001	Q1	1098	373	494	181	51	168	50
2002	Q1	1128	370	523	217	18	151	1

Consider next similar figures for six individual routine surgical specialties which account for over 50 per cent of all GP referrals. As Table 4 shows, there are considerable differences between specialties, both at a given point in time and over a set period of time. Thus in 1995 the proportion of referrals seen within three months (13 weeks) varied between 76 per cent in orthopaedics and 91 per cent in general surgery. By 2002, this difference had increased further with 70 per cent of orthopaedic patients and 89 per cent of general surgery patients being seen within three months.

Between 1995 and 2002 the number of GP referrals increased in all specialties but this increase varied markedly between specialties with a 4 per cent increase for ENT and a 28 per cent increase for both urology and ophthalmology.

There were even greater differences in the growth of the number of GP referrals seen between specialties. With GP referrals up by 29 per cent in ophthalmology, the number of GP patients seen increased by 23 per cent and the number of GP patients seen within 3 months declined only marginally from 77 to 74 per cent. In marked contrast, the number of GP referrals grew more modestly in orthopaedics (an increase of 18 per cent) but the number of GP referrals seen actually *declined* (by 2 per cent). There was thus a 20 percentage point difference between the growth in GP referrals and the growth in the number of GP patients seen. Consequently, the 6 percentage point decline in the number of orthopaedic GP referrals seen within three months was to be expected.

Table 4 Outpatient referrals, activity levels and waiting times by specialty, 1995:Q1 and 2002:Q1

Specialty	Year	Number of GP referrals received (000s)	Number of GP referrals seen (000s)	Of those GP referrals seen, the percentage who had waited			Of those referrals not yet seen, the number (000s) who have waited		Total number of referrals seen (000s)
				< 4 weeks	4 - < 13 weeks	13 - < 26 weeks	13 - < 26 weeks	26 plus weeks	
General surgery	1995	290	245	49	42	7	15	7	272
	2002	319 +10%	265 +8%	46	43	11	18	0	308* +13%
Urology	1995	80	69	29	49	16	11	4	80
	2002	102 +28%	80 +16%	33	45	20	13	0	93* +16%
Ortho-paedics	1995	209	194	35	41	18	39	19	352
	2002	246 +18%	190 -2%	23	47	28	39	0	411* +17%
ENT	1995	198	170	28	52	17	28	6	197
	2002	205 +4%	168 -1%	25	48	15	28	0	207* +5%
Ophthal-mology	1995	164	139	31	46	18	26	9	187
	2002	212 +29%	171 +23%	25	49	23	27	0	251* +34%
Gynae-cology	1995	194	164	42	48	10	11	5	184
	2002	224 +15%	182 +11%	40	46	13	14	0	219* +19%

Note: * denotes that the total number of referrals seen data is for 2000:Q1 (more recent data are not available)

It is tempting to speculate on the reasons for these differences. Are they, for example, attributable to differences in the rate of growth of staff numbers? Has, for example, the number of orthopaedic consultants declined relative to the number of consultants in ophthalmology? As Table 5 shows, this is not the case with the number of whole-time equivalent orthopaedic consultants increasing as fast as any other group of consultants between 1995 and 2001.

Table 5 NHS Hospital medical staff, by specialty, as at 30 September 1995 and 2001

Specialty	Consultant numbers (wte)			Other medical staff numbers (wte)		
	1995	2001	% growth	1995	2001	% growth
General surgery	1 035	1 275	23	2 879	3 437	19
Urology	300	398	33	430	642	49
Orthopaedics	906	1 189	31	1 932	2 413	25
ENT	384	419	9	707	761	8
Ophthalmology	491	613	25	915	1 144	25
Gynaecology	879	1 105	26	2 527	2 591	3
Surgical group	3 542	4 490	27	7 786	9 593	23
Medical group	3 719	4 896	32	8 189	10 342	26
All specialties	16 928	21 954	30	30 944	37 966	23

Source: Annual census of HCHS medical and dental staff in England.
See *http://www.doh.gov.uk/stats/d_results.htm*.

There are at least three obvious reasons why the growth in the number of GP referrals seen might fall short of the growth in consultant numbers. There might have been:

- an increase in the number of second and subsequent outpatient appointments required per initial referral;
- an increase in the number of non-GP referrals; and/or
- an increase in other demands on consultants' time.

Far from increasing, the number of second and subsequent outpatient attendances per initial attendance actually declined from 2.70 in 1995-96 to 2.50 in 2000-01 (DoH, 2000d, p183). The possibility that an increase in the number of non-GP referrals seen might have affected the number of GP referrals seen is more promising. We know from Table 1 that over the period 1995-2002, the growth in the number of non-GP referrals (100 per cent) far outstripped the growth in GP referrals (16 per cent). Thus it seems plausible that different rates of growth in non-GP referrals seen could have contributed to the different rates of growth in GP referrals seen at the individual specialty level.

The final column of Table 4 provides the relevant information. It shows the rate of growth in the number of all referrals seen and this can be compared with the rate of growth in GP referrals seen. Unfortunately, the most recent Q1 figures available for total referrals seen are for 2000 and, although two years out-of-date, they are useful. They reveal that although the number of orthopaedic GP referrals seen *declined* by 7 per cent between 1995 and 2000, the number of all referrals seen *increased* by 17 per cent. This implies that the number of non-GP referrals seen *increased* by 46 per cent.

This pattern - with a much larger growth rate in non-GP than GP referrals - occurs in all of the other specialties identified, particularly ophthalmology. In this specialty, the number of GP referrals seen increased by 19 per cent but the number of all referrals seen increased by 34 per cent, implying a growth rate of 77 per cent in the number of non-GP referrals seen.

This rapid growth in the number of non-GP referrals has at least two implications. First, it confirms the very limited nature of the outpatient waiting time target. Although the target is described as relating to a 'routine outpatient appointment' (DoH, 2000a, p105) what it in fact relates to is a first appointment following a GP referral. It does not relate to second and subsequent appointments which account for over 70 per cent of all appointments, and it does not relate to non-GP referrals which already account for 30 per cent of first referrals (and which, if recent growth rates persist, will account for almost 40 per cent of first referrals in 2005). Thus the outpatient waiting time target is likely to apply to less than one in five of all outpatient appointments.

Second, the achievement of the outpatient waiting time target is subject to the caveat that '...GP referrals remain broadly in line with the current trend in the growth of referrals...' (DoH, 2000a, p105). However, with non-GP referrals growing at more than four times the rate of GP referrals, it would seem prudent to examine the reasons for this. An outpatient slot can only be allocated to one patient so that an increase in non-GP referrals will be just as damaging to the achievement of the waiting time target as an increase in GP referrals.

In addition to outpatient waiting times varying considerably between specialties, they also vary geographically. Tables 6a - 6f report the percentage of GP written referrals seen in the third quarter of 2001-02 that had waited:

- less than 4 weeks;
- less than 13 weeks; and
- less than 26 weeks.

For all specialties combined (Table 6a), there is slightly less variation across the Regions than for individual specialties. Thus for all specialties combined, 39 per cent of GP referrals seen in the third quarter of 2001 received an appointment within 4 weeks of referral in the best performing region (the South West) with the comparable proportion in the worst performing region being 33 per cent. In general surgery, a relatively high proportion of GP referrals were seen quickly: between 41 per cent in the North West and 51 per cent in the South West. In ophthalmology, however, a relatively small proportion of GP referrals were seen within 4 weeks although, again, there is much geographical variation: from 18 per cent of GP referrals in the West Midlands and Trent to 30 per cent in the South East.

Another indicator of waiting time is presented in the final column of Table 6a. This is calculated as the number of GP referrals waiting to be seen (as at the end of December 2001) that had been waiting for 13 weeks or more, divided by the number of GP referrals seen in that quarter. It is an indicator of how long it would take to clear the backlog of long waits. Thus in the South West there are 31,000 outstanding GP referrals that have been waiting 13 weeks or more for an appointment. In this region, 218,000 GP referrals were seen this quarter so the backlog represents about 14 per cent of the workload for the quarter (this is just under two weeks' work). In London, however, the backlog - of 71,000 referrals - would take longer to clear. With 317,000 referrals seen per quarter the backlog represents about 22 per cent of the workload for the quarter (this is just under three weeks' work).

Table 6 Outpatient waiting times, Q3, 2001-2002, by NHS Region

(a)All specialties

NHS Region	Number of GP referrals seen (000s)	Of those GP referrals seen, the percentage that had waited:			Of those referrals not yet seen, the number waiting (thousands)		Long waits as a % of GP referrals seen, i.e., (e+f)/a (%)
		< 4 weeks	< 13 weeks	< 26 weeks	13 - < 26 weeks	26 + weeks	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)
Northern	267	37	79	96	31	10	15
Trent	207	37	77	95	27	8	17
Midlands	219	33	75	96	27	6	15
N West	294	35	75	95	40	10	17
Eastern	208	33	73	94	33	12	22
London	317	35	76	95	55	16	22
S East	318	33	75	95	43	13	18
S West	218	39	80	95	22	9	14

(b)General surgery

NHS Region	Number of GP referrals seen (000s)	Of those GP referrals seen, the percentage that had waited:			Of those referrals not yet seen, the number waiting (thousands)		Long waits as a % of GP referrals seen, i.e., (e+f)/a (%)
		< 4 weeks	< 13 weeks	< 26 weeks	13 - < 26 weeks	26 + weeks	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)
Northern	40	50	87	99	2	0	6
Trent	27	46	85	98	3	0	11
Midlands	30	47	87	98	2	1	10
N West	42	41	81	96	5	1	13
Eastern	28	43	82	97	3	1	13
London	42	43	83	97	4	1	11
S East	45	42	84	97	4	1	9
S West	30	51	88	98	2	0	7

(c) Urology

NHS Region	Number of GP referrals seen (000s)	Of those GP referrals seen, the percentage that had waited:			Of those referrals not yet seen, the number waiting (thousands)		Long waits as a % of GP referrals seen, i.e., (e+f)/a (%)
		< 4 weeks	< 13 weeks	< 26 weeks	13 - < 26 weeks	26 + weeks	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)
Northern	11	35	79	97	1	0	16
Trent	8	38	75	92	1	0	17
Midlands	9	30	79	97	1	0	13
N West	13	31	72	93	2	1	22
Eastern	8	32	73	93	2	1	30
London	13	31	70	93	3	1	28
S East	14	34	75	95	2	1	20
S West	10	40	86	97	1	0	11

(d) Orthopaedics

NHS Region	Number of GP referrals seen (000s)	Of those GP referrals seen, the percentage that had waited:			Of those referrals not yet seen, the number waiting (thousands)		Long waits as a % of GP referrals seen, i.e., (e+f)/a (%)
		< 4 weeks	< 13 weeks	< 26 weeks	13 - < 26 weeks	26 + weeks	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)
Northern	22	20	62	90	6	3	41
Trent	22	21	65	93	4	1	24
Midlands	27	24	61	92	5	1	24
N West	31	21	61	89	7	2	29
Eastern	20	16	55	84	6	4	49
London	25	22	58	90	9	3	48
S East	35	20	60	89	8	3	33
S West	24	26	68	90	5	4	36

(e) ENT

NHS Region	Number of GP referrals seen (000s)	Of those GP referrals seen, the percentage that had waited:			Of those referrals not yet seen, the number waiting (thousands)		Long waits as a % of GP referrals seen, i.e., (e+f)/a (%)
		< 4 weeks	< 13 weeks	< 26 weeks	13 - < 26 weeks	26 + weeks	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)
Northern	25	26	70	95	3	1	16
Trent	18	29	73	96	2	0	14
Midlands	19	23	69	95	3	0	17
N West	27	30	72	95	4	0	15
Eastern	19	25	69	95	4	1	23
London	25	23	63	90	6	2	32
S East	28	24	68	93	4	1	19
S West	18	30	72	96	2	1	18

(f) Ophthalmology

NHS Region	Number of GP referrals seen (000s)	Of those GP referrals seen, the percentage that had waited:			Of those referrals not yet seen, the number waiting (thousands)		Long waits as a % of GP referrals seen, i.e., (e+f)/a (%)
		< 4 weeks	< 13 weeks	< 26 weeks	13 - < 26 weeks	26 + weeks	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)
Northern	22	24	72	96	3	0	13
Trent	18	27	71	94	3	0	17
Midlands	18	22	63	93	4	1	30
N West	26	30	71	94	3	0	14
Eastern	21	28	72	96	2	1	15
London	26	26	74	93	5	2	25
S East	30	21	67	93	5	1	19
S West	21	31	71	94	3	0	14

Greater differences - in terms of time to clear the long wait backlog - across the country are evident for individual specialties (see Tables 6b - 6f above). In orthopaedics (Table 6d), the backlog of 6,000 long wait cases in the Midlands represents about 24 per cent of the number of GP referrals seen in the third quarter. This would take just over three weeks to clear. In Eastern region, however, the backlog of 10,000 long wait cases needs to be set against a quarterly capacity of 20,000 cases. In other words, the backlog represents about 49 per cent of treatment capacity. Here, the backlog would take over six weeks to clear.

Similar differences in queue length can be found in other specialties. In ENT, for example, the backlog of long wait referrals represents only 14 per cent of treatment capacity in Trent but 32 per cent of capacity in London. In ophthalmology the backlog of long wait referrals represents only 13 per cent of treatment capacity in Northern but 30 per cent of capacity in West Midlands. Overall, Tables 6a - 6f confirm picture that there is much variation in outpatient waiting times both across specialties and within a given specialty across the country.

4.3 Meeting waiting targets

Before moving on to consider recent trends in the inpatient waiting list, let us examine whether the NHS is on course to meet its outpatient waiting time targets. Recall that:

- by the end of 2005 the maximum waiting time for a routine outpatient appointment will be three months

and that for 2001-02 the target is to

- reduce the number of over 13 week waiters and implement a maximum waiting time of 26 weeks by March 2002

with the following targets for 2002-03

- a reduction in the number of those waiting more than 13 weeks by the end of the year; and
- a maximum wait of 5 months (21 weeks) by March 2003.

The evidence on whether the targets for March 2002 - to reduce the number of over 13 week waiters and implement a maximum waiting time of 26 weeks - have been met is a little mixed and depends on whether one considers those that have been treated or those that are awaiting treatment (see Table 7). As at the end of March 2002 there were less than 1,000 patients who were waiting to be seen and had been waiting over 26 weeks. However, in the first quarter of 2002, 31,000 patients waited longer than 26 weeks to be seen and in the next quarter 18,000 patients waited longer than 26 weeks. It is clear that the maximum waiting time of 26 weeks is being breached albeit by a very small proportion of GP referrals. The target for March 2003 - a maximum wait of 5 months (21 weeks) - will be challenging: in 2002:Q1 113,000 patients waited longer than this and in the second quarter 125,000 patients waited longer than this.

Whether the March 2002 target to reduce the number of over 13 week waiters was met again depends on whether one looks at those that have been treated or those that are awaiting treatment. The number of over 13 week waiters still awaiting treatment fell from 284,000 in March 2001 (2000:Q4) to 194,000 in March 2002 (2001:Q4). However, of those actually treated in the last quarter, 505,000 waited over 13 weeks in 2001 whereas 534,000 waited over 13 weeks in 2002.

Applying the target waiting times to those still waiting to be seen effectively relaxes the target. The maximum 26 week wait applied to those not yet seen converts to a maximum 38 week wait to those that have been seen. Someone to be seen who had waited 25 weeks as at the end of the quarter would not breach the target and could wait a further 13 weeks before doing so. However, it is difficult to defend the application of the waiting time targets to those not yet seen because, by definition, we do not know their waiting time (they are still waiting to be seen). To calculate a waiting time requires a beginning and end point but there is, as yet, no end point for those who are still waiting to be seen. The application of the waiting time targets to this group is curious, particularly when we have excellent outpatient waiting time data for those that have been seen.

Thus in a recent press release it was noted that, as at the end of September 2002, the outpatient waiting figures revealed that:

> 'There were 31,600 patients waiting over 21 weeks for an initial outpatient appointment...' (DoH, 2002).

whereas in fact the figures showed that, as at the end of September 2002, 31,600 patients were waiting to be seen *and* had already waited longer than 21 weeks. Over the entire quarter, from July to September, 125,000 patients had been seen *and* had waited longer than 21 weeks for treatment.

Table 7 Patients waiting for first outpatient appointment following written GP referral (thousands), quarterly, 1995-2002, all specialties

Position as at the end of:		Number of GP referrals seen (000s)	Of those GP referrals seen, the number who waited (thousands)				Of those referrals not yet seen, the number waiting (thousands)	
			0 - <4 weeks	4 - <13 weeks	13 - <26 weeks	26 + weeks	13-<26 weeks	26 + weeks
1995	Q1	1786	715	803	213	56	212	87
	Q2	1840	710	814	261	55	217	72
	Q3	1897	763	808	269	57	185	60
	Q4	2003	809	858	277	59	157	58
1996	Q1	1870	733	854	234	50	169	52
	Q2	1894	742	845	265	42	202	62
	Q3	1921	773	823	273	53	188	68
	Q4	1880	757	806	262	55	177	71
1997	Q1	1905	743	867	234	61	210	85
	Q2	1900	727	842	273	55	253	90
	Q3	1889	747	790	284	67	249	107
	Q4	1919	758	800	284	78	222	112
1998	Q1	1827	690	809	256	72	269	109
	Q2	1882	687	817	304	75	311	126
	Q3	1894	696	780	329	89	323	144
	Q4	1930	704	787	333	106	303	153
1999	Q1	1838	647	792	294	105	339	146
	Q2	1908	664	788	347	109	363	149
	Q3	1936	687	763	360	126	336	159
	Q4	2028	693	807	381	147	269	132
2000	Q1	1885	658	823	293	111	314	130
	Q2	1949	660	822	358	110	310	126
	Q3	2006	695	818	372	120	286	114
	Q4	2100	721	873	382	123	202	82
2001	Q1	1895	675	850	289	81	274	85
	Q2	1962	678	850	348	85	307	93
	Q3	2047	718	840	385	104	277	84
	Q4	2112	712	865	407	127	193	1
2002	Q1	1925	666	881	348	31	244	1
	Q2	2018	708	858	434	18	256	1

5. RECENT TRENDS IN INPATIENT WAITING LISTS/TIMES

5.1 All specialties

Inpatient waiting list statistics have been collected since the inception of the NHS. Elective admissions can be divided between overnight admissions and day cases. Until 1987, however, the NHS did not count patients waiting for day case treatment. However, until 1980 day cases accounted for less than 10 per cent of all admissions. Therefore, until that time, their omission from the total is unlikely to affect the identification of trends from a study of overnight admissions alone.

The second column of Table 8 reports the number of patients awaiting overnight admission to hospital as at 31 December from 1949 to 2002. Although there is considerable year-on-year variation in list length, a number of phases can be distinguished. First, from 1949 through to 1963, the list seems to fluctuate at around 450,000 patients. Within this period there is evidence of a fall from 492,000 in 1953 through to 404,000 in 1956 but thereafter the list starts to grow again. In 1964 and 1965 the list grows by about 40,000 and by 1966 seems to have reached a new plateau at about 500,000 patients. The waiting list, with some ups and downs, remains on this plateau until 1975. In this year the list grows by 70,000 and remains at around 600,000 until 1979 when it jumps to almost 700,000. In 1980 the list declines markedly and remains at its 1978 level in 1981.

At this point it becomes difficult to talk about movements in the inpatient waiting list by referring solely to those awaiting overnight admission because of the increasing prevalence of day cases. The increasing use of day case admissions may lead us to over- or under-estimate the growth in the total waiting list if we focus on only one component of it (overnight admissions).

Figures for the number of patients awaiting day case admission were first collected in 1987. As Table 8 shows, the number of day cases awaiting admission has grown rapidly, rising from 150,000 in 1987 to 300,000 five years later, and then doubling again over the next five years. The number of day cases awaiting admission prior to 1987 can be estimated in a number of ways. One way is to estimate a regression that relates the logarithm of the number of such cases to a constant and time trend. This relationship explains over 85 per cent of the variation in the number of day cases between 1987 and 1997 and can be used to predict the annual number of day cases before 1987. However, although this generates plausible values for the number of day cases in the 1980s, the implied number of day cases falls rapidly so that, by 1972, it implies that day cases added 3.2% to the waiting list. However, inpatient activity statistics reveal that day cases added more than double this amount (7.2%) to overnight admissions (DHSS, 1978).

Alternatively, activity statistics can be used to estimate the number of day cases by assuming that the waiting list ratio of day cases to overnight cases is the same as the ratio of day case admissions to overnight admissions.[10] Even this assumption requires some extrapolation as day case activity figures are only available back to 1972. Between 1972 and 1984 the ratio of day cases to overnight activity doubled so we assumed that it also doubled between 1948 and 1960, and then doubled again between 1960 and 1972. On these assumptions we derived an estimate of the number of day cases awaiting admission for 1949 - 1986 shown in the third column of Table 8.

[10] We are indebted to a referee for pointing us in this direction.

Table 8 The number waiting for admission to hospital, as at 31 December, with estimates for day case numbers prior to 1987

Year	Overnight admissions	Day cases	Total waiting
1949	467069	9108	476177
1950	500148	10503	510651
1951	464995	10462	475457
1952	467622	11223	478845
1953	492494	12559	505053
1954	446032	12043	458075
1955	426967	12169	439136
1956	404176	12125	416301
1957	415168	13078	428246
1958	420548	13878	434426
1959	447469	15438	462907
1960	442995	15948	458943
1961	450681	17577	468258
1962	446842	18767	465609
1963	454193	20439	474632
1964	476403	22867	499270
1965	492129	25099	517228
1966	510422	27563	537985
1967	509537	29044	538581
1968	505107	30306	535413
1969	532370	33539	565909
1970	525926	34711	560637
1971	493731	34067	527798
1972	479199	34497	513693
1973	508617	40436	549053
1974	517424	45019	562443
1975	588483	49907	638390
1976	588264	53743	642007
1977	591096	59275	650371
1978	628361	65761	694122
1979	695726	76272	771998
1980	635881	75251	711132
1981	619393	76779	696172
1982	725865	89591	815456
1983	703755	95058	798813
1984	682599	99771	782370
1985	661249	100217	761466
1986	681901	111630	793531
1987	718216	154914	873130
1988	757673	173822	931495
1989	761240	210605	971845
1990	748375	217145	965520
1991	703450	246648	950098
1992	671817	305372	977189
1993	675602	390180	1065782
1994	618218	452274	1070492
1995	558144	496804	1054948
1996	550109	554874	1104983
1997	593115	668800	1261915
1998	541310	632288	1173598
1999	514224	593782	1108006
2000	497673	536708	1034381
2001	507749	542472	1050221

Notes:
1 Before 1987, figures for the number awaiting day case admission were not collected. The figures presented are estimates, based on the number of day case admissions as a proportion of ordinary (overnight) admissions.
2 Between 1976 and 1986 the figures relate to the position as at 30 September (December figures are not available).

In 1982 the (overnight and day case) waiting list increases by more than 100,000 and remains at about 800,000 for five years. In 1987 the list increases by about 70,000 and does so again in 1988. Another temporary plateau is reached by the end of 1989 with 970,000 awaiting inpatient admission. The waiting list remains at about this level until 1993 during which year it rises by another 100,000. Again, this seems to be another plateau and the list remains at this level through 1996. By the end of 1997, however, the list had increased by a further 150,000 to reach a new all-time high with 1.25 million patients awaiting admission. Since then the total waiting has fallen back to just over 1 million.

5.2 Waiting list/time targets

One of the five promises that New Labour made in its 1997 election manifesto was to reduce the number of patients on the waiting list by 100,000. This commitment - to keep waiting lists at least 100,000 below the level inherited from the Conservatives - was also reiterated in the *NHS Plan Implementation Programme* for 2001-02 (DoH, 2000c). Table 9 reports the number of patients on the inpatient waiting list at the end of each quarter since March 1995 for all specialties combined.[11] The last figure produced under the previous Conservative administration was for March 1997 which recorded 1.158 million on the waiting list. The number waiting fell below this figure by more than 100,000 in March 2000 and has remained below 1.058 million since then. The latest (September 2002) number waiting for admission is 1.048 million.

---

[11] A breakdown by specialty is available in Tables A10-A18 in the appendix. Further breakdowns are available for overnight admissions (Tables A19-A27) and for day cases (Tables A28-A36).

Table 9 The number waiting for admission to hospital, quarterly, 1995-2002

Year	Quarter	Overnight admissions	Day cases	Total waiting
1995	March	582642	461409	1044051
1995	June	571849	481109	1052958
1995	September	556233	483919	1040152
1995	December	558144	496804	1054948
1996	March	540037	507992	1048029
1996	June	532239	523883	1056122
1996	September	532045	529512	1061557
1996	December	550109	554874	1104983
1997	March	566588	591416	1158004
1997	June	574135	615827	1189962
1997	September	571561	635954	1207515
1997	December	593115	668800	1261915
1998	March	593042	704620	1297662
1998	June	581451	706092	1287543
1998	September	550813	663026	1213839
1998	December	541310	632288	1173598
1999	March	508657	564203	1072860
1999	June	507346	586905	1094251
1999	September	499933	584224	1084157
1999	December	514224	593782	1108006
2000	March	502174	534892	1037066
2000	June	501958	545932	1047890
2000	September	491521	540303	1031824
2000	December	497673	536708	1034381
2001	March	494334	512393	1006727
2001	June	508743	529132	1037875
2001	September	505611	529691	1035302
2001	December	507749	542472	1050221
2002	March	499285	535434	1034719
2002	June	500257	554482	1054739
2002	September	490993	557096	1048089

It has been argued that how long patients wait for treatment is more important than the number of patients waiting; after all, one million patients all waiting three months is probably preferable to half a million patients waiting twelve months. Reflecting this concern for the length of wait, the NHS Plan aims for a maximum six month wait for inpatient treatment by the end of 2005 with the following intermediate target for 2001/02:

- to reduce the number of over 12 month waiters and implement a maximum waiting time of 15 months by March 2002 (DoH, 2000c);

and the following targets for 2002/03:

- to reduce the number of over 9 month waiters and implement a maximum waiting time of 12 months by March 2003 (DoH, 2001a); and
- to reduce the overall list size by the end of the year.

The difficulty with investigating whether these targets have been met is that the available data do not permit a proper evaluation. As was the case for outpatients, the targets refer to ‘waiting times’.

However, the data used to evaluate whether the targets have been met refer to patients still awaiting treatment and how long they have waited to date. Quarterly Trust-based data on actual waiting times, rather than waiting time to date, is neither gathered nor used to evaluate these targets. The effect of this is, as we have seen, to relax the target for some patients and effectively adds up to a maximum of 3 months to any specified target. Because of the way in which the data are collected, the longest someone could actually wait and not break a maximum waiting time of, say, 12 months, is 15 months. This would be so if, on the last day of the quarter, they had waited a day under 12 months, and were ultimately admitted 3 months later so that they just missed inclusion in the next quarter's waiting time figures.

Putting this issue to one side, let us consider the extent to which the waiting time targets have been met using the data collected from Trusts. Consider first the target to have a maximum waiting time of 15 months by March 2002. Table 10 reports the number of patients that have been waiting longer than 15 months for admission, as at the last day of each quarter, 1995-2002. It reveals that the incoming Labour Government inherited a waiting list of between 6,000 (March) and 11,000 (June) in May 1997. Since then, the list has fluctuated at around 10,000 to 15,000. In December 2001 it fell below its March 1997 level (to just over 4,000). At the end of March 2002, 224 patients had been waiting longer than 15 months for admission and this figure fell to 61 by September 2002.

Table 10 Patients waiting for admission to hospital who have been waiting longer than 15 months, as at the end of the quarter, 1995-2002

Year	Quarter	Overnight admissions	Day cases	Total waiting
1995	June	5,540	2,767	8,307
1995	September	5,019	1,804	6,823
1995	December	3,683	1,219	4,902
1996	March	860	161	1,021
1996	June	953	219	1,172
1996	September	2,202	598	2,800
1996	December	3,074	1,033	4,107
1997	March	4,242	1,656	5,898
1997	June	7,213	3,936	11,149
1997	September	9,835	5,354	15,189
1997	December	11,493	6,720	18,213
1998	March	10,474	6,340	16,814
1998	June	10,710	7,091	17,801
1998	September	9,507	5,762	15,269
1998	December	9,228	4,741	13,969
1999	March	7,398	2,989	10,387
1999	June	8,440	3,394	11,834
1999	September	8,859	3,418	12,277
1999	December	9,404	3,687	13,091
2000	March	8,838	3,117	11,955
2000	June	10,049	3,373	13,422
2000	September	9,886	3,289	13,175
2000	December	10,053	3,240	13,293
2001	March	8,269	2,231	10,500
2001	June	9,566	2,753	12,319
2001	September	8,067	2,256	10,323
2001	December	3,455	767	4,222
2002	March	224	0	224
2002	June	87	18	105
2002	September	52	9	61

With the virtual elimination of the over 15 month waits, what of the objective to reduce the number of over 12 month waiters by March 2002 and completely by March 2003? Table 11 reports the number of patients falling into this category, as at the end of each quarter, 1988-2002. Certainly the number waiting over 12 months fell from 42,000 in March 2001 to 22,000 in March 2002 but what of the target to eliminate these long waits entirely by March 2003?

Looking at the figures back to 1988 illustrates how rapidly the size of this particular queue can change. From September 1987 to September 1990 the queue fluctuates at around 210,000 patients. For the next five years the queue declined almost continuously so that by March 1996 it had been almost eliminated. From this low point, however, it then proceeded to rise almost as rapidly as it had fallen so that two years later (June 1998) there were over 70,000 patients in this queue, a position almost identical to that witnessed just over four years previously (December 1993). This suggests that the elimination of this queue by March 2003 should not be that difficult - after all, it was virtually eliminated in 1996 - but that this time the presence of the likely target for March 2004 - to eliminate over nine month waits - should keep the pressure on and thus prevent the re-emergence of patients waiting more than 12 months.

The achievement of the March 2004 target - to eliminate over nine month waits - will be more challenging. At the end of September 2002 there were 95,000 people awaiting admission who had been waiting longer than nine months. This queue represents just under 3 per cent of the annual number of inpatient admissions.

Table 11 Patients waiting for admission to hospital who have been waiting longer than 12 months, as at the end of each quarter, 1988-2002

Year	Quarter	Overnight admissions	Day cases	Total waiting
1988	March	182,161	25,764	207,925
1988	June	186,578	25,623	212,201
1988	September	192,591	27,338	219,929
1988	December	195,411	28,232	223,643
1989	March	193,952	29,359	223,311
1989	June	187,474	30,456	217,930
1989	September	187,528	30,588	218,116
1989	December	186,112	32,831	218,943
1990	March	175,777	32,083	207,860
1990	June	174,505	31,955	206,460
1990	September	172,025	30,715	202,740
1990	December	158,567	29,248	187,815
1991	March	145,109	24,652	169,761
1991	June	145,891	25,866	171,757
1991	September	134,661	23,860	158,521
1991	December	110,049	20,520	130,569
1992	March	69,000	11,585	80,585
1992	June	70,675	14,241	84,916
1992	September	66,821	13,760	80,581
1992	December	59,450	13,428	72,878
1993	March	45,195	11,682	56,877
1993	June	51,671	14,161	65,832
1993	September	54,317	16,705	71,022
1993	December	55,955	19,152	75,107
1994	March	46,404	18,104	64,508
1994	June	47,532	17,948	65,480
1994	September	44,858	17,483	62,341
1994	December	38,956	15,878	54,834
1995	March	21,750	10,444	32,194
1995	June	22,214	10,545	32,759
1995	September	19,815	8,123	27,938
1995	December	14,647	5,839	20,486
1996	March	3,686	890	4,576
1996	June	7,620	2,779	10,399
1996	September	10,733	4,260	14,993
1996	December	15,337	6,824	22,161
1997	March	20,732	10,476	31,208
1997	June	29,539	17,145	46,684
1997	September	35,583	22,083	57,666
1997	December	41,922	26,410	68,332
1998	March	40,170	27,853	68,023
1998	June	42,416	30,330	72,746
1998	September	37,760	25,720	63,480
1998	December	35,361	20,733	56,094
1999	March	32,110	15,194	47,304
1999	June	33,309	16,133	49,442
1999	September	34,091	16,710	50,801
1999	December	35,262	16,885	52,147
2000	March	34,462	14,584	49,046
2000	June	36,277	15,104	51,381
2000	September	36,360	14,755	51,115
2000	December	35,513	13,702	49,215
2001	March	31,413	10,745	42,158
2001	June	34,522	12,167	46,689
2001	September	32,308	12,362	44,670
2001	December	23,068	8,701	31,769
2002	March	15,575	6,607	22,195
2002	June	14,735	6,233	20,968
2002	September	11,776	5,335	17,111

The number of patients awaiting admission at the end of any quarter will depend on four major factors:

- the number of patients awaiting admission at the beginning of the quarter
- the number of additions to the list during the quarter
- the number of admissions to hospital during the quarter
- the number of removals from the list during the quarter.

Trends in referral and activity rates will impact upon list size so that to understand the time path taken by waiting lists we need to understand trends in referral and activity rates. Tables 12-14 provide quarterly figures for waiting lists, referral, and activity rates for all specialties from 1995 to 2002 for overnight admissions (Table 12), for day cases (Table 13), and for both types of admission combined (Table 14).[12] [13] Broadly speaking the all admission data in Table 14 suggests that:

- the number waiting remains at about 1.050 million through 1995 and 1996. In 1997, the list starts to increase, it peaks at 1.298 million in mid-1998 and then declines, returning to about 1.040 million by mid-2000 at which level it remains. The decline from the quarter ending June 1998 to the quarter ending June 2000 is a dramatic one with a 20 per cent reduction in total list size over a two year period.[14]

- additions to the waiting list (demand) exhibit a slightly different pattern. There is less volatility in the series with a seasonal boost in March. From March 1996 to March 2000, the number of additions fluctuated at about 1.050 million. In June 2000 additions fell to 0.990 million with a further decline to 0.930 million in June 2001

- the number of admissions follows a similar pattern to demand but demonstrates greater fluctuations, particularly from one quarter to the next. The number of admissions fell by almost 100,000 (10 per cent) between March and June 1999 and by a similar amount between the same quarters in 2001. The figures for June and September 2001 suggest that elective activity levels are at their lowest level for six years with admissions in June 2001 about 20 per cent the level recorded in September 1998 or March 1999.

- removals from the list (for emergency admission or because the patient has died) seem fairly constant at about 140,000 per quarter with evidence of a temporary increase in late 1998. There is also evidence of a final quarter effect (March) for 1999, 2000, 2001, and 2002. This might reflect an annual effort to verify the list’s accuracy.

---

[12]A breakdown by specialty is available in Tables A37-A63 in the appendix.

[13]The waiting time and activity data in Tables 12 - 14 and throughout this study exclude planned admissions (in other words the focus is on booked and unbooked admissions from the waiting list).

[14]To avoid repetition of ‘the quarter ending’ followed by a month and year, we will simply use the month and year to denote that quarter. Thus ‘the quarter ending June 1995' becomes ‘June 1995'.

A priori, one might have anticipated that changes in the size of the waiting list are driven largely by supply changes with demand - or the growth in demand - fairly constant. An examination of the figures in Table 14 shows that this is not the whole case. Thus in both June and September 2001 demand was about 7 per cent below that recorded in March 2001 and it might have been anticipated that the waiting list would fall. However, supply fell by a similar amount in both quarters so that the list size did not decline.

Table 14 refers to all admissions combined whereas Tables 12 and 13 refer to overnight and day cases respectively. For overnight admissions, the waiting list is down by about 10 per cent. How has this been achieved? Demand fell by 15 per cent between September 1995 and September 2001 but admissions fell by even more (20 per cent) so that the decline in the list has relied on the removals from the list which have remained broadly constant over the period.

For day cases, the change in the size of the waiting list have been even more dramatic. Between September 1995 and September 1998 the number waiting increased by 47 per cent with demand and supply both increasing by about 25 per cent. In the two years following September 1998, the queue fell by 25 per cent but not because of an increase in activity. Admissions fell from 624,000 in September 1998 to 504,00 in September 2001 but fortunately for the queue, additions to the list also fell (from 673,00 to 578,000) and removals were at a higher level over this period than over the previous three years.

Table 12 The number waiting for admission, and additions to and deletions from the waiting list, quarterly, 1995-2002, (thousands).
Ordinary admissions only
All specialties

Year	Quarter ending	Number waiting at start of the quarter	Additions to the waiting list	Number of admissions	Number of removals from the list	Implied number waiting at end of quarter	Discrep-ancy	Actual number waiting at end of the quarter
1995	June	n/a	421	376	62	n/a	n/a	571
1995	September	571	421	385	66	541	14	555
1995	December	555	434	374	67	547	10	557
1996	March	557	440	391	73	533	6	539
1996	June	539	431	380	69	520	12	532
1996	September	532	427	382	64	514	18	532
1996	December	532	418	352	59	538	12	550
1997	March	550	397	331	58	558	8	567
1997	June	567	n/a	n/a	n/a	n/a	n/a	574
1997	September	574	n/a	n/a	n/a	n/a	n/a	572
1997	December	572	n/a	n/a	n/a	n/a	n/a	593
1998	March	593	n/a	n/a	n/a	n/a	n/a	593
1998	June	593	372	329	64	573	9	581
1998	September	581	391	358	71	543	8	551
1998	December	551	382	336	65	533	9	541
1999	March	541	373	346	72	496	12	509
1999	June	509	374	328	60	495	13	507
1999	September	507	374	335	60	487	13	500
1999	December	500	370	311	60	499	16	514
2000	March	514	371	317	71	497	6	502
2000	June	502	356	313	59	486	16	502
2000	September	502	357	320	61	478	13	492
2000	December	492	356	305	62	481	16	498
2001	March	498	362	303	72	484	11	494
2001	June	494	345	290	59	491	18	509
2001	September	509	351	308	63	489	16	505
2001	December	505	357	304	65	493	15	507
2002	March	507	359	307	71	488	11	499

Table 13 The number waiting for admission, and additions to and deletions from the waiting list, quarterly, 1995-2002, (thousands).
Day case admissions only
All specialties

Year	Quarter ending	Number waiting at start of the quarter	Additions to the waiting list	Number of admissions	Number of removals from the list	Implied number waiting at end of quarter	Discrep-ancy	Actual number waiting at end of the quarter
1995	June	n/a	521	458	62	n/a	n/a	480
1995	September	480	544	483	70	471	12	483
1995	December	483	569	493	70	489	7	496
1996	March	496	610	530	77	499	9	507
1996	June	507	601	521	78	509	15	524
1996	September	524	607	535	77	518	11	530
1996	December	530	615	530	74	541	14	555
1997	March	555	615	518	73	579	12	591
1997	June	591	n/a	n/a	n/a	n/a	n/a	616
1997	September	616	n/a	n/a	n/a	n/a	n/a	636
1997	December	636	n/a	n/a	n/a	n/a	n/a	669
1998	March	669	n/a	n/a	n/a	n/a	n/a	705
1998	June	705	647	565	90	696	10	706
1998	September	706	673	624	104	650	13	663
1998	December	663	672	616	97	622	10	632
1999	March	632	679	652	109	550	14	564
1999	June	564	659	575	87	562	25	587
1999	September	587	668	600	88	567	18	584
1999	December	584	666	585	89	576	17	594
2000	March	594	677	632	107	532	3	535
2000	June	535	633	557	85	525	20	546
2000	September	546	625	556	88	528	13	540
2000	December	540	616	545	87	524	12	537
2001	March	537	631	568	101	499	14	512
2001	June	512	579	498	80	513	14	528
2001	September	528	578	504	84	518	9	528
2001	December	528	599	515	81	530	11	540
2002	March	540	598	526	90	523	10	533

Table 14 The number waiting for admission, and additions to and deletions from the waiting list, quarterly, 1995-2002, (thousands).
All admissions
All specialties

Year	Quarter ending	Number waiting at start of the quarter	Additions to the waiting list	Number of admissions	Number of removals from the list	Implied number waiting at end of quarter	Discrep-ancy	Actual number waiting at end of the quarter
1995	June	n/a	942	834	124	n/a	n/a	1051
1995	September	1051	965	868	136	1012	26	1038
1995	December	1038	1003	867	137	1036	17	1053
1996	March	1053	1050	921	150	1032	15	1046
1996	June	1046	1032	901	147	1029	27	1056
1996	September	1056	1034	917	141	1032	29	1062
1996	December	1062	1033	882	133	1079	26	1105
1997	March	1105	1012	849	131	1137	20	1158
1997	June	1158	n/a	n/a	n/a	n/a	n/a	1190
1997	September	1190	n/a	n/a	n/a	n/a	n/a	1208
1997	December	1208	n/a	n/a	n/a	n/a	n/a	1262
1998	March	1262	n/a	n/a	n/a	n/a	n/a	1298
1998	June	1298	1019	894	154	1269	19	1287
1998	September	1287	1064	982	175	1193	21	1214
1998	December	1214	1054	952	162	1155	19	1173
1999	March	1173	1052	998	181	1046	26	1073
1999	June	1073	1033	903	147	1057	38	1094
1999	September	1094	1042	935	148	1054	31	1084
1999	December	1084	1036	896	149	1075	33	1108
2000	March	1108	1048	949	178	1029	9	1037
2000	June	1037	989	870	144	1011	36	1048
2000	September	1048	982	876	149	1006	26	1032
2000	December	1032	972	850	149	1005	28	1035
2001	March	1035	993	871	173	983	25	1006
2001	June	1006	924	788	139	1004	32	1037
2001	September	1037	929	812	147	1007	25	1033
2001	December	1033	956	819	146	1023	26	1047
2002	March	1047	957	833	161	1011	21	1032

5.3 Individual specialties

The broad trends identified for all specialties combined (Tables 12 - 14) can also be found in the data for all routine surgery (Tables A40 - A42 in the appendix) but there are some differences at the individual specialty level (Tables A43 - A63 in the appendix). Some of theses difference are quite modest:

- in general surgery, for example, the decline in the day case waiting list between September 1998 and September 2001 is about seven percentage points larger than that for all specialties combined and this, in turn, reflects what has been happening to day case admissions in this specialty with smaller growth (1995-98) followed by a larger decline (1998-2001).

- there is virtually no growth in the urology waiting list (Tables A46 - A48) between 1995 and 1998 whereas for all specialties combined the growth rate is over 20 per cent

In other specialties the differences are more marked:

- in orthopaedics (Tables A49 - A51) the waiting list declines by 4 per cent between September 1998 and September 2001 whereas for all specialties the fall is 20 per cent. Related to this, there is no decline in demand (as reflected in additions to the list) and no decline in supply (admissions) both of which fall by about 15 per cent for all specialties.

- in ENT (Tables A52 - A54) the growth in the queue over the early period (September 1995 - September 1998) is much smaller than that for all specialties combined and this reflects a smaller growth in demand and supply

- in ophthalmology (Tables A55 - A57) there has been a marked shift away from overnight admissions and towards day cases. Thus the proportion of overnight admissions fell from 45 per cent in September 1995 to 12 per cent in September 2001 (for all specialties the fall was much more modest, from 45 per cent in 1995 to 38 per cent in 2001). Despite this shift to shorter stays in hospital, however, the waiting list has not responded well. Over the period 1995-2002, the list first grew faster than, and then shrunk slower than, the all specialty list so that over the period as a whole the list grew by 25% whereas for all specialties combined it declined marginally. Additions to the list since September 1998 have not declined as they have for all specialties and demand in September 2001 is 16 per cent above that in September 1995 (for all specialties demand declines by 4 per cent). At the same time, however, supply has increased by 20 per cent whereas the number of all specialty admissions in September 2001 was 7 per cent down on the comparable figure for 1995

- the queue for oral surgery has halved between September 1995 and September 2001 (see Table A60) with demand showing a slightly greater fall than supply between September 1995 and September 2001

- between September 1995 and September 1998, the growth in the gynaecology waiting list (Table A63) is much smaller than that for all specialties combined and between 1998 and 2001 the decline much greater so that although the all specialties queue only declines marginally between 1995 and 2001, the gynaecology waiting list shrinks by 25 per cent.

6 DEMAND AND SUPPLY MODELS

6.1 The demand for care

Our demand model is similar to that employed in previous studies and represents a synthesis of the work of Lindsay and Feigenbaum (1984), Cullis and Jones (1986), and Goddard, Malek and Tavakoli (1995). Apart from those admitted through accident and emergency, all patients referred to an NHS hospital specialist must be referred by a GP. If their GP recommends hospital treatment, the patient has three choices: to seek NHS care; to seek private hospital care; or to seek no care. The option chosen by the patient will reflect the balance of costs and benefits associated with each of these three options.

Hospital treatment will yield a benefit to the patient. The present value of this treatment declines the longer treatment is delayed. Seeking care, whether NHS or private, is not costless. In addition, private care which offers immediate treatment incurs a financial cost whereas NHS care is free at the point of consumption. Thus although the health benefit from NHS treatment is lower than that from private treatment (because it is delayed), the financial costs associated with private treatment are greater than those associated with NHS treatment.

The demand, D_t, for elective NHS care in period t will depend on:

- the expected waiting time for NHS treatment; and
- various demand shifters such as population morbidity, the cost of seeking care, the cost of private treatment, and the perceived quality and convenience of NHS care.

The cost of seeking care will include the initial costs of examination by a GP, diagnostic tests, and attendance at an outpatient clinic. Some of these costs will be related to the ease of access to a GP and we therefore derived a measure of the local availability of GPs. At the same time, however, GPs may undertake some minor procedures locally and may therefore act as a substitute for hospital admission. For this reason, the theoretical impact of GP provision on the demand for NHS acute care is ambiguous.

The financial cost of private care does not vary greatly across the country. However, the physical accessibility of private facilities does vary substantially and we therefore derived a measure of the local availability of acute private hospital beds as a proxy for the ease of access to private health care. It is anticipated that the existence of local private health care will have a negative effect on NHS demand.

The perceived quality and convenience of NHS care is expected to have a positive impact on NHS demand and, although these characteristics are inherently difficult to measure, the proportion of elective admissions that are treated as day cases can be employed as a proxy measure.

An increase in the expected waiting time for NHS treatment will reduce the demand for NHS care in each period because it reduces the expected benefit from treatment. Some assumption has to be made about the information used by patients and GPs to estimate the expected waiting time. With an average waiting time for inpatient admission of about 100 days relatively few patients will be added to the waiting list and treated within the same quarter. Typically, a patient will be added to the list in the current quarter and admitted in the following or subsequent quarter. Given the uncertainty about the information available to patients and GPs, let us assume that the expected waiting time for those patients added to the NHS waiting list in the current quarter for admission in the following quarter (or thereafter) is based upon the waiting time of either:

(a) those admitted in the current quarter; or
(b) those admitted in the previous quarter.[15]

Thus our demand equation is:

$$D_t = D(w^p{}_t, z^d{}_t) \qquad (1)$$

where $w^p{}_t$ is patients' expected waiting time for those added to the NHS list in period *t* and $z^d{}_t$ comprises a number of demand shifters such as population morbidity and GP accessibility. As relatively few patients are added to the list and treated in the same quarter we do not need to worry about the issue of simultaneity between waiting times and demand when current period waiting times are used as a proxy for expected waiting times. Additions to the list in the current quarter will have little affect on the waiting time of those admitted this quarter. Of course, if most patients were added to the list and admitted in the same quarter, or if annual data were used, then the simultaneity issue would be a more serious one.

6.2 The supply of care

The model of supply is based upon that presented by Gravelle, Smith and Xavier (2003). In this model supply decisions are assumed to be taken by a hospital manager who has a period *t* utility function

$$u_t = u(S_t, w^m{}_t; w^m{}_{t-1}, z^s{}_t) \qquad (2)$$

where S_t is the supply of care in period *t*, $w^m{}_t$ is the manager's perception of the period *t* waiting time or list performance measure, and $z^s{}_t$ are exogenous factors affecting the manager's utility. The possibility that the manager's utility may depend not just on current performance but also on the change in performance is captured via the presence of $w^m{}_{t-1}$.

The perceived performance measure $w^m{}_t$ depends on the performance indicators in place and the manager's beliefs about how they are affected by supply decisions. The assumption is that the manager is concerned about the performance measure at the end of the period *t* and believes that it is best forecast as some function of the numbers waiting at the beginning of the period (L_{t-1}), the numbers added to the list in the current period (D_t), and supply (S_t)

$$w^m{}_t = f(S_t; L_{t-1}, D_t(w^p{}_t, z^d{}_t)) \qquad (3)$$

For example, the manager may care about the time to clear the list at the end of the period given current admissions so that $w^m{}_t = L_t/S_t = (L_{t-1} + D_t - S_t)/S_t$. The assumption is that the waiting list evolves as

$$L_t = L_{t-1} + D_t - S_t \qquad (4)$$

[15] Other alternatives are considered in the empirical work.

where L_t is the number on the list at the end of the period. The possibility that patients leave the waiting list because they change their minds about the benefit from treatment, die, or leave the area is ignored.

Since the utility of the manager in period *t* is affected by the list inherited from the previous period and possibly by the previous period's performance indicator, her behaviour in a period will in general depend on her willingness to trade period *t* utility for future utility. A manager who takes account of the future consequences of current supply decisions chooses S_t to maximise

$$u(S_t , w^m_t ; w^m_{t-1}, z^s_t) + \delta_t V(L_t + D_{t+1,} w^m_t , z^s_t) \qquad (5)$$

subject to the perceived performance function, $w^m_t = f(S_t ; L_{t-1} , D_t (w^p_t , z^d_t))$, where δ_t is the manager's one period ahead discount factor and V is the maximised value of discounted utility at the end of period *t+1*. Optimal supply in period *t* is

$$S^*_t = S(L_{t-1} , w^m_{t-1} , D_t, z^s_t, \delta_t) = S^*_t(L_{t-1} , w^m_{t-1} , w^p_t, z^s_t, z^d_t, \delta_t) \qquad (6)$$

and this is the relationship to be estimated. Managers will have different discount factors (δ) and these will be influenced by, amongst other things, how long a manager expects to remain in their present post. We have no information on these discount factors.

In general, predictions about the effect of waiting times and list on supply are ambiguous not least because any reduction in waiting time or list might stimulate next period demand thus adversely affecting the probability of achieving future waiting targets (Gravelle, Smith and Xavier, 2003).

In our empirical work we will examine the impact of various waiting time and list measures on supply. As we shall see, we find that the supply effect dominates with a positive coefficient on lagged waiting times and that this lag is typically four quarters. Although the model suggests that this effect might exhibit a shorter lag, any managerial response will be severely constrained by the annual budget setting process and that, as a consequence, any within year response might be severely constrained.

In addition to waiting times and lists there are a whole raft of measures that are now employed, both locally and centrally, as indicators of Trust performance. These might include: death rates, re-admission rates, the length of stay in hospital, bed occupancy rates, and the proportion of elective admissions that are treated as day cases. These too may enter the managerial utility function and some may be proxies for hospital efficiency. We have indicators of these variables and these will be included in our supply equation.

At the same time some of these variables, such the day case rate and death rate, may be interpreted as indicators of supply quality and act as demand shifters (z^d_t). The hypothesised effect of these would be to increase demand and then supply as managers seek to offset the impact of increased demand on the achievement of their waiting time goals.

In addition, there will be other demand shifters that do not impact as indicators of supply quality but act as direct measures of population morbidity. We have various measures of case mix such as the HRG index and average length of stay. Our model of supply is based on the number of admissions and therefore these resource intensity measures will be effectively controlling for differences in case mix across Trusts.

Our supply model therefore includes waiting time and a batch of variables that can be interpreted in a number of ways. These might be viewed as:

- measures of managerial and Trust performance
- indicators of supply quality
- indicators of demand

with some variables having more than one interpretation. Thus the day case rate might be both a measure of managerial performance and an indicator of supply quality.

6.3 Application of models to outpatient care

Both the demand and supply models presented above have been applied to inpatient care but we also propose to apply them to outpatient care. With regard to the demand for outpatient care, all of the factors influencing the demand for inpatient care can also be applied to outpatient care. Perceived waiting time, population morbidity, GP accessibility, the accessibility of private care, and the perceived quality of NHS care are also likely to affect the outpatient demand.

One difference with regard to the demand for outpatient care might be the relevant waiting time. Patients deciding whether to seek NHS or private outpatient treatment might consider the total (inpatient plus outpatient) wait rather than just the outpatient wait and we examined this hypothesis. However, we found no evidence of a significant effect for total (inpatient plus outpatient) waiting time on outpatient demand in any of the five specialties we studied.

7 DATA

To examine empirically the determinants of the demand for and supply of elective surgery we employed a panel of data for over 300 NHS hospitals for 32 quarters from the first quarter of the financial year 1995-96 to the last quarter of 2001-02.

7.1 Waiting list and activity (demand and supply) data

The waiting list data is extracted from the QM08 return for outpatients and the KH07 return for inpatients. The inpatient activity data is from the KH06 and KH07A returns, and the QM08 return includes activity data for outpatients. All these returns are made by Trusts and this Trust-based database has not previously been used for this type of analysis.[16]

The raw data are at Trust level and may therefore refer to hospitals at one or more sites. Each Trust is identified by a unique three digit identifier. Over the study period there were various Trust mergers. Following a merger, the resulting Trust is given a new identifier and is treated as a wholly new Trust.

In the models to be estimated, there are various ways in which demand, supply, and waiting time can be measured, and these also vary between the inpatient and outpatient models.

7.1.1 Inpatients: demand measures

Consider first the inpatient models. Three alternative demand measures were constructed:

(a) **addproxy** - the number of patients who had been waiting three months or less at the end of the quarter, divided by the population served by the Trust (the derivation of the population measure is outlined below)

(b) **additions** - the number of decisions to admit made during the quarter, divided by the population served by the Trust

(c) **addstand** - the number of decisions to admit made during the quarter, divided by the expected number of actual admissions (the derivation of the expected number of actual admissions is explained below)

The first measure (**addproxy**) does not directly measure the number of additions to the waiting list but has been used as a proxy for this in a previous study that applied the same model but to Health Authority rather than to Trust data (Gravelle, Smith and Xavier, 2003). This variable will understate the numbers actually added to the list in a quarter whenever there are any patients who have been added to the list and treated within the same quarter.

For this study we have a record of the number of patients actually added to the waiting list in each quarter and we have divided this figure by the population served by the Trust to obtain our second inpatient demand measure (**additions**).

---

[16] When we use the term 'NHS Trust' we are referring to NHS hospitals and not Primary Care Trusts or Ambulance Trusts.

Our third measure of inpatient demand **(addstand)** again uses the number of patients actually added to the waiting list in each quarter but this is divided by the expected number of *admissions* rather than the population. By using this denominator we were attempting to control for the age and sex profile of the Trust's population. Ideally, we would employ the expected number of *additions* to the waiting list but national rates for *additions* to the waiting list, by age and sex, are not available and so, as a proxy for these, we used national *admission* rates, by age and sex. Further details of this standardisation process can be found in section 7.3.

7.1.2 Inpatients: supply measures

For the inpatient supply models, two alternative supply measures were constructed:

(a) **admissions** - the number of admissions divided by the population served by the Trust
(b) **admissstand** - the number of admissions divided by the expected number of admissions

The first inpatient supply measure (**admissions**) divides the actual number of admissions by the Trust's population. This yields a measure of supply per head of population. Rather than divide by the population, the second measure of inpatient supply (**admissstand**) divides the actual number of admissions by the expected number of admissions where the latter has been generated by applying national admission rates by age and sex to the demographic profile of the population served by the Trust.

7.1.3 Inpatients: waiting time measures

Five alternative waiting time measures were constructed for the inpatient models:

(a) **meanwait** - the average time that those on the waiting list at the end of the quarter have been waiting
(b) **3monthwait** - of those on the list at the end of the quarter, the proportion that have been waiting more than 3 months
(c) **12monthwait** - of those on the list at the end of the quarter, the proportion that have been waiting more than 12 months
(d) **timetoclear** - the time to clear the waiting list (this was defined as the ratio of the number waiting at the end of the quarter divided by the number of admissions in that quarter)
(e) **listlength** - the number of patients on the waiting list divided by the Trust population

The waiting list data from Trust returns is divided in to a number of time bands (those having waited less than 3 months, those having waited between 3 and 6 months, etc) and records the number of patients on the list at the end of each quarter in each time band. To obtain the **meanwait** variable we calculated a weighted average of the time bands using the mid-points of each time band and the number of patients in each band as the weight for that band. The construction of the other inpatient waiting time measures (b - e) should be self-explanatory given the descriptions above.[17]

7.1.4 Outpatients: demand measures

Four alternative demand measures for the outpatient models were constructed:

(a)	**GPreferrals** -	the number of GP referrals received, divided by the population served by the Trust
(b)	**GPreferralsstand** -	the number of GP referrals received, divided by the expected number of inpatient admissions
(c)	**allreferrals** -	the number of all referrals received, divided by the population served by the Trust
(d)	**allreferralsstand** -	the number of all referrals received, divided by the expected number of inpatient admissions

The first measure of outpatient demand (**GPreferrals**) is calculated as the number of GP referrals received divided by the population served by the Trust. Rather than divide by the population, the second measure (**GPreferralsstand**) divides the number of referrals received by the expected number of inpatient admissions. This is an attempt to control for the age and sex profile of the population served by the Trust. Of course, we would prefer to divide by the expected number of GP referrals but we did not have access to national GP referral rates, by age and sex.[18] The third and fourth measures (**allreferrals** and **allreferralsstand** respectively) are similar to the first two measures except that they replace the number of GP referrals received with the number of referrals received from all sources.

[17]A referee noted that although we use a variety of waiting time measures the key measure for current targets is maximum waiting time and that there is not necessarily a clear relationship between mean and maximum waiting times. The coarse (three monthly) intervals used to collect the inpatient waiting time data make it infeasible to use a maximum waiting time variable in this study and we feel that the proportion of those on the list having waited over 12 months will be a good proxy for the maximum waiting time. As we shall see, the empirical results support the relevance of this waiting time variable.

[18]For further discussion of this standardisation procedure, see sections 7.1.1 and 7.3.

7.1.5 Outpatients: supply measures

Four alternative outpatient supply measures were constructed:

(a)	**GPreferseen** -	the number of GP referrals seen, divided by the population served by the Trust
(b)	**GPreferseenstand** -	the number of GP referrals seen, divided by the expected number of inpatient admissions
(c)	**allreferseen** -	the number of all referrals seen, divided by the population served by the Trust
(d)	**allreferseenstand** -	the number of all referrals seen, divided by the expected number of inpatient admissions

These four supply measures mirror the four demand measures except that they replace the number of referrals received with the number of referrals seen. Again there are different measures for GP referrals seen and all referrals seen, and different measures for whether or not the Trust's population is adjusted by a proxy for its age and sex profile.

7.1.6 Outpatients: waiting time measures

The available waiting time data for outpatients relates to those GP referrals seen during the preceding quarter and six alternative waiting time measures were constructed using this data:

(a)	**meanwait** -	of those GP referrals seen, the average time that these patients had been waiting
(b)	**<4weekwait** -	of those GP referrals seen, the proportion that had been waiting less than 4 weeks
(c)	**4-13weekwait** -	of those GP referrals seen, the proportion that had been waiting between 4 and 13 weeks
(d)	**13-26weekwait**-	of those GP referrals seen, the proportion that had been waiting between 13 and 26 weeks
(e)	**26+weekwait** -	of those GP referrals seen, the proportion that had been waiting more than 26 weeks
(f)	**<13weekwait** -	of those GP referrals seen, the proportion that had been waiting less than 13 weeks

The outpatient waiting time data records the number of patients seen in each quarter according to their length of wait. There are a number of time bands (e.g., less than 4 weeks, between 4 and less than 13 weeks, etc) and, to obtain the **meanwait** variable, we calculated a weighted average of the time bands using the mid-point of each time band and the number of patients in each band as the weight for that band. The construction of the other inpatient waiting time measures (b - f) should be self-explanatory given the descriptions above.[19]

7.2 Population data and the 'need' for acute care

In our models of the demand for elective surgery, two relevant explanatory variables will be:

a) the age and sex profile of the local population; and
b) the 'need' for acute care in the local population given its demographic profile.

Both of these require us to attach a population to each Trust. To do this we used a purchaser-provider matrix. Each row of this matrix relates to a different Trust and each column relates to a different Health Authority. Each cell in the matrix shows the cost, at national average prices, of all inpatient episodes of care (elective and emergency) purchased by a given HA from a given Trust.

The actual matrix used is the most recent available and is based on HES data for 1999/00 for all acute episodes of care excluding healthy live infants. Episodes of care in the geriatric, mental handicap, and mental illness programmes have been excluded. A cost is attached to each episode of care in the database. The cost of each episode is based on specialty specific daily hotel and fixed treatment costs (NHSE, 1998). These costs are aggregated across all episodes for each Trust and Health Authority pairing to obtain an estimate of the cost of all episodes purchased by a given HA from a given Trust.

An example of a purchaser provider matrix is shown in Figure 2. The total cost of all episodes provided by Trust T_1 and purchased by Health Authority HA_1 is w_{11}. The total cost of all episodes purchased by HA_1 is Σw_{i1}. The total cost of all episodes provided by T_1 is Σw_{1j}. The matrix in Figure 2 relates to four Trusts and three Health Authorities; the actual purchaser-provider matrix employed in this study includes data for 99 Heath Authorities and 327 Trusts. However, 40 of these 327 Trusts recorded a zero spend on acute episodes in 1999-00 and were therefore dropped from the analysis.

[19] Again, the coarse intervals used to collect the outpatient waiting time data make it infeasible to use a maximum waiting time variable although the proportion of those seen who had waited over 26 weeks will be a good proxy for the maximum waiting time. Again, the empirical results support the relevance of this outpatient waiting time variable.

Figure 2 An illustrative purchaser-provider matrix

Trust	Health Authority (purchaser) HA$_1$	HA$_2$	HA$_3$	Total
T$_1$	w_{11}	w_{12}	w_{13}	Σw_{1j}
T$_2$	w_{21}	w_{22}	w_{23}	Σw_{2j}
T$_3$	w_{31}	w_{32}	w_{33}	Σw_{3j}
T$_4$	w_{41}	w_{42}	w_{43}	Σw_{4j}
Total	Σw_{i1}	Σw_{i2}	Σw_{i3}	Σw_{ij}

As Health Authorities were used for resource allocation purposes throughout the study period, we were able to obtain population and 'needs' data for each Authority from the Department. Thus, with the purchaser-provider matrix, we were able to construct population and 'needs' data for each Trust.

Consider first the construction of a 'needs' index for Trust T_1. This will be a weighted average of the 'needs' index for each of the three Health Authorities for which this Trust provides acute services. The weights will reflect the proportion of total Trust costs (Σw_{1j}) attributable to each Health Authority.

Consider next the construction of the population served by each Trust. This will be a weighted average of the population served by each HA for which the Trust provides services but this time the weights will reflect the proportion of each HA's total spend that the Trust enjoys. Thus the population attached to Trust 1 will be a weighted average of the population served by all three Health Authorities with weights $w_{11}/ \Sigma w_{i1}$, $w_{12}/ \Sigma w_{i2}$, and $w_{13}/ \Sigma w_{i3}$.

The use of a purchaser-provider matrix based upon HES data for 1999-00 meant that only those Trusts in existence in 1999-00 were included in the analysis. Initially, only those Trusts in existence for the entire period 1995-96/2001-02 were included and these covered about 60% of the population (about 180 Trusts with outpatient data and 150 Trusts with inpatient data). This requirement - for a balanced panel - was subsequently relaxed so that all Trusts in existence in 1999-00 were included in the analysis. The remaining exclusions were therefore:

(a) Trusts party to a merger that occurred before 1999-00 (although, of course, the merged Trusts were included in the analysis); and

(b) Trusts created after 1999-00 (although the constituent Trusts were included).

The latter group comprised less than 20 Trusts that had been formed by merger in either 2000-01 or 2001-02 and would have recorded a maximum of eight quarterly observations. Activity and other data for the first few quarters following a merger can be less than wholly reliable so the omission of these Trusts from the study is probably of little significance.

With regard to the former group of Trusts, attempts were made to also employ a purchaser-provider matrix based on HES data for an earlier year (1997-98) and which would, in theory, allow us to attach populations to Trusts that were in existence in 1997-98 but which were no longer 'alive' in 1999-00 (that is, they had merged to form a new Trust). The use of this second matrix meant that for Trusts 'alive' in both 1997-98 and 1999-00 we were able to construct two 'needs' indicators and two estimates of the size of the population served by the Trust (one based on HES data for 1997-98 and the other on HES data for 1999-00).

The estimated 'needs' indicators showed very little change between the two years but, in many cases, the population attached to each Trust showed a substantial and unbelievably large amount of variation. This suggested that there were problems with one of the purchaser-provider matrices. Preliminary investigation revealed a number of issues with the earlier matrix. For example, according to the 1997-98 matrix one northern NHS Trust was undertaking an unbelievably large amount of work for the London Health Authorities. Further investigation revealed that the cell entries in the matrix for this northern NHS Trust were identical to those for a London NHS Trust.

There was also a problem with a zero recorded income for a couple of Trusts. Our initial response - to simply drop these Trusts from the analysis - was insufficient because the zero spend apparently recorded by these Trusts was also affecting other Trusts who did work for the same Health Authorities. To illustrate this issue imagine a HA whose budget is split equally between two Trusts but whose expenditure with one Trust is not captured by the purchaser-provider matrix. In these circumstances the use of the purchaser-provider matrix to attach populations to Trusts will erroneously attach a zero population to Trust A and will also erroneously attribute all of the Health Authority's population to Trust B. Both Trusts will be attributed incorrect populations.

In response to these difficulties with the 1997-98 matrix, and the fact that - as we shall see - the use of the 1999-00 matrix alone gave good Trust coverage for the period as a whole, we settled for the use of this single matrix.

7.3 Standardisation of the demand and supply measures (expected additions/admissions)

When modelling the demand for acute care across different populations, it is normal practice to standardise those variables which would otherwise be influenced by the local demographic profile. Thus in the case of the number of admissions to hospital, it is to be expected that this will, in part, reflect the age and sex profile of the local population. Rather than include what might amount to thirty or forty variables reflecting the proportion of the local population in each age and sex group, researchers typically standardise the variable of interest. In the case of the number of hospital admissions, this involves dividing the *actual* number of admissions by the *expected* number of admissions where the expected number of admissions is calculated by applying national admission rates for each age/sex group to the local population's demographic profile.

To estimate national admission rates by age and sex group, we used the HES database for 1998/99 (the mid-point of the study period) to calculate the number of elective admissions that were either booked or from a waiting list.[20] Two sets of admission rates were calculated: one for all specialties (involving about 4.6 million episodes in total); and one for all routine surgical episodes (involving about 3.0 million episodes). These national rates were then applied to the age/sex profile of each

---

[20] In other words, all emergency, maternity, and planned admissions were ignored when calculating the national admission rates.

HA's population to derive, for each year, the expected number of admissions for all specialties combined and all routine surgical specialties.[21] The purchaser-provider matrix was then used to convert this HA based database to one where the NHS Trust was the unit of analysis.

7.4 Trust characteristics data

Hitherto we have extracted data from three sources:

(a) from Trust returns to the DoH we have culled Trust-based data on activity and waiting times for inpatients and outpatients;

(b) we have employed a purchaser-provider matrix to convert HA data - on the 'need' for acute care and the population served by each Authority - to a Trust basis so that, for each Trust, we have an estimate of the size of the population it serves together with that population's 'need' for acute care; and

(c) we have applied national admission rates for all specialties and for routine surgery to each Trust's demographic profile to estimate each Trust's expected number of inpatient admissions for all specialties and for routine surgery.

To this Trust-based database we added a further batch of variables from a data set compiled by researchers at the Centre for Health Economics (see Jacobs (2000) and Soderlund and Jacobs (2001)). This database - based largely on annual data - runs from 1994-95 to 1999-00 but was updated to include observations for 2000-01 and 2001-02 where possible. Table 15 below provides brief details of the variables in this database. Some of these variables are based on measures of competing resources (GP availability and private beds) and will enable us to examine the impact that the availability of substitutes have on NHS supply. Other variables can be interpreted as indicators of supply quality and enable us to examine what impact these demand shifters have on supply volume. Others are indicators of surgical complexity (or resource intensity) and their presence allows us to examine the impact that other factors, such as waiting times, have on supply holding constant the impact of case mix.

[21] Strictly speaking we should calculate separate national rates for each year but these are unlikely to change greatly within the short time period used for this study.

Table 15 Trust characteristics available for inclusion in demand and supply functions

Variable name	Description	Source
(a) variables treated as time invariant		
NEED	Need for health care ('York' index: Smith et al, 1995)	DoH
HERFINDAHL15	Index of local NHS competition, =1 if there are no other acute providers within a 15 mile radius, 1995/96 data	CHE database
MORTA	Brian Jarman's mortality index based on 5 years' data	Dr Foster
POP_PER_BED	Population per bed (both weighted for distance). It is a measure of local supply and/or competition, 1999	CHE database
PRIVATE_BEDS	Availability of local private beds relative to NHS beds, 1999	CHE database
GP_AVAILABILITY	Number of wte GPs per head of population, 1999	CHE database
PI_STARS	Number of stars (Trust performance rating, 2000 & 2001)	DoH
SICK_RATE	Amount of time lost through absence as a proportion of staff time available for directly employed NHS staff, 1999-2001	DoH performance framework
AHP_VACANCY	Allied health professionals vacancy rate (three month vacancies expressed as a percentage of three month vacancies plus staff in post) 1999-2001	NHS vacancy survey, non-medical workforce census
NURSE_VACANCY	Qualified nursing, midwifery & health visitors vacancy rate (three month vacancies expressed as a percentage of three month vacancies plus staff in post), 1999-2001	NHS vacancy survey, non-medical workforce census
CONS_VACANCY	Consultants vacancy rate (three month vacancies expressed as a percentage of three month vacancies plus staff in post), 1999-2001	NHS vacancy survey, medical and dental workforce census
DELAY_DIS_PC	Percentage of patients whose discharge from hospital was delayed, 2001	DoH performance ratings
(b) time variant variables		
OCCUPANCY_RATE	Bed occupancy rate, 1996-2000 (=occupied beds divided by available beds)	DoH (KH03)
LENGTH_OF_STAY	Average length of stay, 1994-2000 (=occupied bed days divided by number of admissions)	HES
TRANSFERS_IN	Proportion of spells that involve a transfer in from another hospital, 1994-1997	HES
TRANSFERS_OUT	Proportion of spells that involve a transfer out to another hospital, 1994-1997	HES
PROP_ADMISS_60+	Proportion of patient admissions aged over 60, 1994-2000	HES
HRG_INDEX	Index of case-mix complexity, 1994-1997	CHE database
RESEARCH_SPEND	Proportion of total revenue spent on research, 1994-1997	DoH surveys
READMISSION_RATE	Number of emergency re-admissions that occur within 28 days of discharge per 100,00 admissions, 1995-1998	DoH
DEATH_NE_SURGERY	Rate of death in hospital within 30 days of surgery: non-emergency admissions, 1995-1998	DoH
DEATH_E_SURGERY	Rate of death in hospital within 30 days of surgery: emergency admissions, 1995-1998	DoH
DAYCASES_PC	Number of day cases divided by number of elective admissions, 1995-2000	HES
EMERGENCIES_PC	Number of emergency admissions divided by total number of admissions, 1994-2000	HES
BEDS_PER_HEAD	Average daily number of available beds divided by population served by Trust, 1994-2000	HES

As Table 15 shows, the variables in this database have been divided into two groups: those that vary through time and those that do not. In principle, almost all of the variables in this database will vary through time but we were not always able to obtain annual updates for every variable for every year of the study period. Thus the mortality index (MORTA) is a single value based on a four year average (from 1992 to 1996) standardised mortality index adjusted for age, sex, primary diagnosis, length of stay and type of admission. In principle, this could be updated annually but updates were not available and we therefore treated this as a time invariant variable. Similarly, the need for acute health care (NEED) is based on Census data for 1991 and the index of local NHS competition (HERFINDAHL15) is based on data for 1995/96. This variable, which ranges between 0 and 1, takes its maximum value if there are no other acute providers within a 15 mile radius of the Trust. In addition, the distance weighted availability of private relative to NHS beds (PRIVATE_BEDS), GP availability, and the distance weighted measure of the local supply of acute NHS beds (POP_PER_BED) are all based on data for a single year (1999/00) and again are treated as time invariant. The delayed discharge of patients variable was only available for 2001/02 so again this was treated as time invariant.

For other variables, however, we had a value for more than one year but deemed it appropriate to take the average of the values we had and treat the variable as if it were time invariant. Thus the performance rating variable (PI_STARS) was only available for 2000/01 and 2001/02 so we calculated the average rating and employed this as the time invariant value for this variable. Similarly, we only had data for the three final years of the study period for the staff sickness variable and the three staff vacancy rates. For these variables we also calculated the average value and used this as the value for these now time invariant variables.

All other variables were treated as time variant although we were not always able to obtain annual updates for every year. In these circumstances missing values were either (a) estimated by interpolation where the missing value(s) fell between two available values or (b) by assuming the missing value was the same as that for the next or previous year where data gaps existed at the very beginning or end of the study period. Thus a missing value for, say, 1998 would be set equal to the average of the values for 1997 and 1999. If data were only available for 1996-2000 the value for 1995 would be set equal to the value for 1996 and the value for 2001 would be set equal to the value for 2000. The variable descriptions in Table 15 include the time period over which data was available and thus provide an indicator of the prevalence of this problem. For example, the daycase variable was available from 1995 to 2000 and thus the values for 1994 and 2001 were imputed using the method outlined above.

For the re-admission rate and two death rates we had values for 1995, 1996, 1997, and 1998. Values for 1999 and thereafter were set equal to the value for 1998. Similarly, for the proportion of total revenue spent on research, the index of case mix complexity, and the two transfer variables we only had values from 1994 to 1997.[22] The values for 1998 and thereafter were set equal to the value for 1997. For the beds per head, emergency admissions, elderly admissions, and length of stay variables we had a full data set except for the final year (2001-02). HES based data for this year had not yet been released. The day case variable was available from 1995 to 2000 and the occupancy rate variable was available form 1996 to 2000.

[22]Values for 1994 will be useful because although our estimation period will commence with 1995 it will be based on quarterly data. We will therefore need to interpolate the annual Trust characteristics data. Values for the first two quarters of 1995 will be based on a weighted average of the annual value for 1994 as well as the annual value for 1995.

We have spelt out in some detail how we have constructed the data set so that the reader is under no illusion that it is complete and wholly accurate. Some may object to the way in which we have made good outstanding gaps in the data set but we faced a difficult choice: if we made no attempt to complete gaps in the data set then we would either have to drop many of the variables or considerably reduce the sample size. Many of the variables in this data set will only change very slowly and we feel that our approach is, on balance, the lesser of two evils. Moreover, this study is the first we know of to combine this data with the Trust returns on waiting time, activity and referral rates. Its exploratory nature makes it important to demonstrate the sort of variables that are available and, of course, as more recent data become available (such as HES for 2001/02) there will be less need to make good the data gaps as we have done.

7.5 Data cleaning (Trust returns)

The referral, activity, and waiting time data culled from the Trust returns to the DoH required a substantial manual clean during which manifest errors were identified and deleted. This was true of both the inpatient and outpatient files and for both specialty groupings. The most frequent problem was a sudden jump or fall in referrals or activity that seemed improbably large. Where data were deemed inaccurate, that particular variable for the particular quarter was dropped from the database. The following examples have been taken from the all specialty inpatient database:

(a) suspiciously low referral and activity data for the early quarters of 1995-96

One Trust records 2,548 decisions to admit and 2,418 admissions in the first quarter of 1995/96. For the next 27 quarters, decisions to admit fluctuate between 6,000 and 8,500, and admissions fluctuate from 4,500 to 7,500 patients.

Similarly, another Trust records 1,619 decisions to admit and 1,463 admissions in the first quarter of 1995/96 and these fall to 1,486 and 1,186 respectively in the second quarter. From the third quarter, however, decisions to admit increase by about 40% and hover between 2,155 and 2,505 for the next six quarters. There is a similar increase in admissions.

(b) suspiciously large fluctuations in referral and activity data

One Trust records 4,024 decisions to admit and 2,038 admissions in the first quarter of 1995/96. In the second quarter, *exactly* the same number of decisions to admit and admissions are recorded. In the third quarter, decisions to admit more than double to 8,717 while admissions fall to 1,630. In the final quarter, decisions to admit soar again to 12,275 while admissions almost quadruple to 6,236, For the next four quarters, decisions to admit fluctuate at about 6,500 with admissions at about 6,000.

Similarly, another Trust records 9,859 decisions to admit in the first quarter of 1998-99 whereas this figure usually falls between 5,000 and 7,000. Actual admissions are, as usual, between 4,000 and 6,000 and, although there has been a 60% surge in decisions to admit, the number of patients awaiting admission continues to fall.

Despite this extensive cleaning exercise and the fact that some Trusts will have been omitted because they were not present in the purchaser-provider matrix for 1999-00, the remaining Trusts account for the vast majority of all inpatient decisions to admit and actual admissions over the seven-year period, 1995-96/2001-02 for both the all specialties and routine surgery databases. Thus the quarterly Trust returns for all specialties record some 24 million decisions to admit and 21 million admissions over this period. After all cleaning and deletions for various reasons, the remaining Trusts account for 20 million decisions to admit and 17.7 million admissions. Thus the inpatient Trust database for all specialties used in this study accounts for over 80% of all decisions to admit and actual admissions.

The inpatient routine surgery database achieves similar coverage. The quarterly Trust returns for the routine surgical specialties record some 18 million decisions to admit and 16 million admissions. After all cleaning and deletions, the remaining Trusts account for 15 million decisions to admit and 13.5 million admissions (again over 80% of all decisions to admit and actual admissions).

The outpatient referral, activity, and waiting time database suffered from similar problems to those exhibited by the inpatient database. In addition to the usual problems of unbelievably large swings in referrals received and/or referrals seen, on some occasions the number of GP referrals seen exceeded the number of GP and other referrals seen so that the implied number of non-GP referrals seen was negative. In addition, the number of other referrals received sometimes bore little relation to the number of other referrals seen. Thus between 1995-96 and 1998-99, one Trust records about 2,500 other referrals received per quarter but 15,000 other referrals seen!

Again, the most obvious errors were removed from the database but the remaining observations in the all specialty outpatient database related to 80% of all GP referrals received and seen. Initially, the database recorded some 63 million GP referrals received and some 54 million GP referrals seen. After cleaning and other deletions, the database incorporated 51 million referrals and 43.5 million referrals seen. For routine surgical specialties, cleaning reduced the coverage from 37.2 million to 30.7 million referrals and from 32 million to 28.4 million referrals seen.

7.6 Descriptive statistics

Descriptive statistics for the demand and waiting time variables employed in the all specialty inpatient demand equation (see equation 1a in Table 28 below) are presented in Table 16. The total number of decisions to admit made by the Trusts in this sample totals just over 19.3 million. The total number of admissions is just over 17 million. The mean waiting time is 16 weeks with 46 per cent of patients waiting over 3 months and 3 per cent waiting over 12 months (remember that these figures relate to patients still awaiting admission). The time to clear the waiting list is, on average, 1.27 quarters (which is almost identical to the mean waiting time). Just under half of all elective admissions were day cases.

Table 16 Variable definitions and descriptive statistics for variables in the all specialty inpatient demand equation (unweighted)

Variable	Definition	Mean	Std. Dev.	Min	Max
Additions	Decisions to admit (per quarter)	4774.089	2642.902	400	20150
Admissions	Actual admissions (per quarter)	4210.945	2327.577	282	20000
Additions/k	Additions per 1,000 population	21.83974	8.763528	6.679417	106.0951
Admissions/k	Admissions per 1,000 population	19.29929	7.672082	4.675553	89.9511
meanwait	Mean waiting time (weeks)	16.76206	3.933134	6	28.31017
3monthwait	Proportion waiting > 3 months	.4645488	.1143966	0	.7427686
12monthwait	1-(proportion waiting > 12 months)	.9690244	.0341618	.8401718	1
timetoclear	Time to clear waiting list (quarters)	1.266403	.4724403	.2065645	4.034729
listlength	Number waiting per 1,000 population	23.22956	9.887651	2.367671	121.9427
daycases	Day cases as a percent of electives	.4681227	.101674	.0218967	.9550632

NB There are 4045 observations for each variable.

We found that some of the supply results were sensitive to the precise sample of Trusts employed. In particular, we found that the inclusion of the single specialty hospitals as well as the children's hospitals could induce serious mis-specification and therefore, following Jarman et al (1999), we excluded these Trusts from our supply analysis.

Descriptive statistics for the supply, waiting time, and other variables employed in the all specialty inpatient supply equation (see Table 29 below) are presented in Table 17. The total number of decisions to admit made by Trusts in this sample totals just over 14 million. The total number of admissions is just under 12.4 million. This is about one-quarter below that for the demand model with this decline attributable to missing observations on the other variables in the supply model for some Trusts and to the exclusion of single specialty and specialist Trusts. Nevertheless, despite these omissions the waiting time data is almost identical to that reported for the demand sample. The mean waiting time is 17 weeks with 47 per cent of patients waiting over 3 months and 3 per cent waiting over 12 months (again, remember that these figures relate to patients still awaiting admission). The time to clear the waiting list is, on average, 1.24 quarters.

Consider next the other variables in the supply model. The average bed occupancy rate is just over 82% with an average length of stay in hospital of 4 days. On average 2% of spells commence with a transfer from another Trust and 1% of spells end with a transfer to another Trust. Two-fifths of admitted patients are aged over 60 and 1.3% of revenue is spent on research. The re-admission rate is about 5% and the death rate for emergency surgery is about nine times that for non-emergency surgery. Just under one-half of all elective admissions are day cases with emergencies accounting for about one-third of all admissions. There are, on average, about three beds per 1,000 head of population.

Table 17 Variable definitions and descriptive statistics for variables in the all specialty inpatient supply equation (unweighted)

Variable	Definition	Mean	Std. Dev.	Min	Max
Additions	Decisions to admit (per quarter)	5115.098	2553.071	929	19943
Admissions	Admissions (per quarter)	4505.747	2228.942	658	19767
Additions/k	Decisions to admit per k population	21.08667	6.074354	6.679417	58.16618
Admissions/k	Admissions per k population	18.64176	5.38604	4.675553	43.72749
meanwait	Mean waiting time (weeks)	17.256	3.867671	7.460405	29.04646
3monthwait	Proportion waiting > 3 months	.4755735	.1039108	.087477	.7408112
12monthwait	1-(proportion waiting > 12 months)	.9637953	.0363763	.8032752	1
timetoclear	Time to clear waiting list (qtrs)	1.240901	.4242835	.3853438	4.019757
listlength	Number on wait list per k population	23.13881	7.093091	6.641313	50.45148
occupancy_rate	Bed occupancy rate (%)	82.00965	5.700162	61.5	98.6
length_of_stay	Length of stay in hospital (days)	4.172482	1.056098	2.265125	18.25388
transfers_in	% spells that transfer from a Trust .0200065	.0116606	.00251	.0673005	
transfers_out	% spells that transfer to a Trust	.0103002	.009115	.0000186	.0525012
prop_admiss60+	% patient admissions aged over 60	.3983698	.0712417	.0397804	.7003621
hrg_index	Index of case mix complexity	90.11457	8.019045	73.99066	127.3245
research_spend	% of revenue spent on research	1.329228	3.554333	.0020195	39.84105
readmiss_rate	Number of re-admissions per 100,000 5179.967	860.1848	3159.26	9687.559	
deathnesurgery	Rate of death, non-emergency admns	408.9831	218.7085	72.17	1395.66
deathesurgery	Rate of death, emergency admissions	3770.561	908.0357	1005.798	7591.834
daycases_pc	Day cases as a % of elective admns	.4850741	.0791	.1584356	.9550632
emergencies_pc	Emergencies as a % of all admissions	.3599096	.0538463	.1547784	.5749437
beds_per_head	Beds per 1,000 head of population	3.118973	.9045365	1.644945	6.813146

NB There are 2758 observations for each variable. The waiting time variables are lagged 4 quarters and the other regressors are lagged one period (as per the all specialty supply equation in Table 29).

Descriptive statistics for the time invariant variables for the group of Trusts used to estimate the all specialty demand equation (which is itself shown in Table 31) are reported in Table 18. For these variables there is only one observation per Trust (they are, by construction, time invariant). Amongst other things, these figures suggest that staff vacancy rates averaged between 2.5% and 4.5% depending on the category of staff, and that almost 5% of patients had their discharge from hospital delayed on non-medical grounds.

Table 18 Variable definitions and descriptive statistics for time invariant variables in the all specialty time inpatient demand equation (unweighted)

Variable	Definition	Obs	Mean	Std. Dev.	Min	Max
need	Index of need for acute care	201	1066.866	90.45005	909.5349	1272.068
herfindahl	Index of competition	195	.3685444	.3040755	.03	1
mortality	Brian Jarman's mortality index	147	100.034	8.725192	68	119
poppbed	Population per NHS bed	163	299.0014	82.95303	143.1836	489.526
private_beds	Availability of private beds	185	106.3064	71.4606	17.24	365.47
gp_availabil	100k*GPs per head of population	201	53.93134	3.435562	45.16314	63.6765
pi_stars	Trust performance (star rating)	175	1.988571	.6672862	0	3
sick_rate	NHS staff sickness rate	176	.0456351	.0070334	.02555	.0603
ahp_vacancy	AHP staff vacancy rate	176	.0317049	.0243072	0	.1463895
nurse_vac~y	Nursing staff vacancy rate	176	.0342605	.0304484	0	.155126
cons_vaca~y	Consultants vacancy rate	176	.0247689	.0248953	0	.1315919
delay_dispc	% patients delayed discharge	146	4.907632	3.065706	0	17.40491

With regard to outpatients, the total number of GP referrals received captured by the all specialty outpatient demand equation (itself reported in Table 43) was just over 46.6 million. The total number of all referrals received captured by the all specialty outpatient demand equation (itself also reported in Table 43) was 61.0 million. The all specialty outpatient supply equation (reported in Table 46) incorporates 28.2 million referrals.

8 ESTIMATION

8.1 Demand model

The demand model to be estimated is

$$D_t = D(w^p_t, z^d_t) \qquad (1)$$

where w^p_t is patients' expected waiting time for those added to the NHS list in period *t* and z^d_t comprises a number of demand shifters such as population morbidity and GP accessibility. We employed various measures of waiting time, both current and lagged values. As relatively few patients are added to the list and treated in the same quarter we do not need to worry about the issue of simultaneity between waiting times and demand when current period waiting times are used as a proxy for expected waiting times. Additions to the list in the current quarter will have little affect on the waiting time of those admitted this quarter.

As demand shifters we had access to the following measures:

(a) the quality and convenience of NHS care

- the daycase rate

(b) the quality of care

- the readmission rate
- the death rate following elective surgery
- the death rate following emergency surgery
- the mortality rate
- the Trust's star rating
- the staff sickness rate
- the allied health professionals staff vacancy rate
- the nurse vacancy rate
- the consultant vacancy rate
- the percentage of patients whose discharge from hospital is delayed

(c) population morbidity

- the need for acute care (the York index)

(d) local competition

- the Herfindahl index
- the availability of local private beds relative to NHS beds
- the number of GPs per head of population

Our approach was to regress demand on some measure of waiting time, the time variant demand shifters, and 200 or so Trust dummies. The coefficients on the Trust dummies were then regressed on the time invariant demand shifters. Initial estimation revealed that three of the time variant quality of care measures - the readmission rate and the death rate following elective surgery and emergency surgery - had no significant impact on demand and, because their inclusion in the regression substantially reduced the number of observations over which the equation could be estimated, they were dropped from the demand equation.

With regard to the supplementary dummy variable regression, we initially regressed the Trust dummies on the seven quality of care time invariant variables, need, and the three measures of local competition. However, we found that the inclusion of all of these variables in the first few supplementary fixed effects models estimated meant that all estimated coefficients were typically either insignificant or exhibited counter-intuitive signs. Given that there is already a time varying 'quality of care' indicator in the model, the six other time invariant quality of care indicators were therefore dropped from the supplementary demand model as was the Herfindahl measure of local competition which was persistently insignificant. The three remaining variables - need, private bed availability, and GP availability - incorporate roles for those factors that are most regularly seen as affecting the demand for health care and which have not already been included in the time varying model.

8.2 Supply model

The supply model to be estimated is

$$S_t = S(\text{waiting time, demand shifters, exogenous supply shifters}).$$

Various measures of waiting time will be employed with various lags. As time variant demand shifters we employed:

- the readmission rate
- the death rate following elective surgery
- the death rate following emergency surgery
- the day case rate.

The dependent variable in our model is the number of admissions. To control for the impact of case mix, various proxies were also included as regressors including:

- the average length of stay
- the proportion of spells that involve a transfer in from another hospital
- the proportion of spells that involve a transfer out to another hospital
- the proportion of patient admissions aged over 60
- an index of case-mix complexity
- the proportion of total revenue spent on research

Some of these variables could also be interpreted as demand shifters. In addition, we included the number of beds per head of population as a measure of the volume of resources available to the Trust together with a measure of resources consumed by non-elective admissions (emergency admissions).

We experimented with various lags on these variables and found that either a four or eight quarter lag worked best.

As was the case for the demand equation, about two hundred Trust dummies were included in the supply regression and the coefficients on these then served as the dependent variable in a subsequent regression which included various time invariant regressors such as:

- the need for health care
- a Herfindahl index of local NHS competition
- Brian Jarman's mortality index based on 5 years' data
- population per bed (both weighted for distance)
- the availability of local private beds relative to NHS beds
- the number of GPs per head of population
- the Trust's performance rating (number of stars)
- the NHS staff sickness rate
- the allied health professionals vacancy rate
- the qualified nursing, midwifery & health visitors vacancy rate
- the consultants vacancy rate
- the percentage of patients whose discharge from hospital was delayed

Again we struck the problem that the inclusion of all these variables generated no statistically significant coefficients. After some searching, we found that four variables - private bed availability, the nurse vacancy rate, the staff sickness rate, and the delayed discharge rate - performed well and it was these that we included as regressors in each dummy variable regression.

8.3 Weighting and time effects

The quarterly returns submitted by Trusts and (what were) Health Authorities on activity and waiting times provide a rich data source which is ideal for the analysis of the impact of waiting time on the demand for and supply of elective surgery. Despite the value of this data and the high political profile of waiting times, we are aware of only three studies that have attempted to use such data in this way.

Martin, Sterne, Gunnell, Ebrahim, Smith and Frankel (2003) use Trust-based waiting time data for the quarter ending December 1999 to examine the contemporary association between waiting times and surgical need, various markers of capacity, and the level of independent sector activity. Their study makes no attempt to distinguish between the impact of demand and supply and therefore their results will reflect a mixture of demand and supply effects. Perhaps not surprisingly, the authors find little and inconsistent support for associations of prolonged waiting with markers of capacity, independent sector activity, or need in the surgical specialties examined.

In a similar vein, the Audit Commission (2003) examines the correlation between waiting times and and various other factors including demand, capacity and cancelled admissions. This analysis draws on both HES data and Trusts' quarterly returns but no attempt is made to disentangle demand and supply effects.

In their study of inpatient supply and demand, Gravelle, Smith and Xavier (2003) employed a panel of 123 English Health Authorities from the second quarter of 1987 to the first quarter of 1993. Panel data models are typically estimated using either a fixed effects (FE) or random effects (RE) model. The random effects model allows the estimation of the impact of time invariant variables and is potentially more efficient than a fixed effects model (i.e., it offers greater precision of parameter estimates). However, the random effects model assumes that the individual effects are uncorrelated with the regressors and, should this assumption be invalid, then the RE model will yield biased estimates. Gravelle, Smith and Xavier (2003) estimated both FE and RE models and tested the validity of the assumption underlying the random effects model.

Throughout their estimation, Gravelle, Smith and Xavier (2003) gave equal weight to all Health Authorities. No attempt was made to apply a differential weighting to different Health Authorities although Authorities will vary in size and one might want to attribute more weight to the larger Authorities. However, it is unlikely that the largest Authority in the Gravelle, Smith and Xavier study was more than five times the size of the smallest Authority. In the present context, however, the differential in size between the smallest and largest Trust is considerably bigger - a factor of 50 would not be far off the mark - so the impact of weighting each Trust, according to the size of the population served, was explored. It was found that the weighting sometimes had a considerable impact on the estimated coefficients. Consequently, throughout this study all Trusts were weighted by the size of the population served.

Unfortunately, standard econometric software (such as STATA) does not permit the estimation of random effects models with a weighting and so only fixed effects models are reported below. These models do not permit the direct estimation of the coefficients on the time invariant variables or those variables for which we only have an observation at a single point in time. However, it is possible to indirectly estimate the coefficients on these time invariant variables via a second stage analysis which regresses the area fixed effects (the coefficients on the Trust dummies) on the time invariant variables and this approach was adopted here.

Because the model assumes that patients have myopic expectations about waiting times and does not impose market clearing, we do not need to take account of simultaneous equation problems and can separately estimate the demand and supply functions. Following Gravelle, Smith and Xavier (2003), time effects were modelled as yearly and seasonal dummies.

For both the supply and demand inpatient models, there is no year dummy for 1997-98 as quarterly activity (additions and admissions) data were not collected for this year. The default base year is 1995-96 and the base quarter is the first one of the financial year (covering April, May, and June).

For the outpatient demand models the default base year is 1995-96 and the base quarter is the first one of the financial year (covering April, May, and June). For the all referral outpatient supply model there is no year dummy for 2001-02 as quarterly activity (all referrals seen) data were not collected for this year. The base year is 1995-96 and the base quarter is the first one of the financial year (covering April, May, and June)

8.4 Model specification

Throughout we employ Ramsey's reset test as a general test of model mis-specification (such as omitted variables or incorrect functional form). This test is based upon the addition of the first three powers of the predicted value of the dependent variable to the model and a test of the joint significance of these three variables. On the supply side we found that this test was rather sensitive to the precise set of variables in the supply equation and the lag imposed on these variables. We also found that relatively large swings in the test statistic were sometimes associated with relatively minor changes to the equation specification and often little or no change to the estimated coefficient on the waiting time variable. We therefore used the test as indicative and did not simply dismiss a result if the test indicated the presence of mis-specification. We would urge the reader to view the results presented in this report as a whole rather than focus on any single equation.

8.5 Estimation technique

There is one final issue that needs to be mentioned. Standard panel data estimation techniques are based on the assumption, amongst others, that observations are independent within groups. This is unlikely to be true in this case as Trusts with a higher than average demand (or supply) in one quarter will typically have a higher-than-average demand (or supply) in other quarters.

We dropped the assumption that observations are independent within Trusts by employing the 'cluster' option on the 'regress' command in STATA. We found that the impact of this was particularly marked when we estimated the supply equation. When the assumption of independence within Trusts was dropped it was not uncommon for several variables that were previously significant to become insignificant.

In sections 9-12 we estimate separate demand and supply equations for inpatients and then for outpatients. In section 13 we combine inpatient and outpatient data to estimate a model for total (inpatient plus outpatient) demand and another for total (inpatient plus outpatient) supply. In an annex we examine whether there is any formal connection between these separate equations and, finding evidence of a strong connection between demand and supply, we use the seemingly unrelated regression (SUR) estimator to jointly estimate our supply and demand models. The exploratory nature of these SUR results leads us to locate them in an annex rather than the main body of the report.

9 RESULTS

ALL SPECIALTIES & ROUTINE SURGERY: INPATIENTS

Because of the large number of regression equations involved, we present the results for these two specialty groupings in two parts. This, the first part, reports the results for inpatients and the second part (section 10) contains the outpatient results. Results for three individual specialties - urology, orthopaedics, ENT - are reported in section 11 (inpatients) and section 12 (outpatients).

9.1 The degree of correlation between the alternative measures of supply, demand, and waiting time

With various measures of supply, demand, and waiting time we began by examining the degree of correlation between these variables.[23] Table 19 shows the correlation matrix for the five inpatient waiting time measures for all specialties combined. This reveals that all five measures are reasonably well correlated with a particularly high correlation between the mean waiting time and the proportion of those patients waiting more than three months (ρ=0.9518).

Table 19 Correlation matrix for five inpatient waiting time measures, all specialties combined

Waiting time measure	mean wait	list length	3month wait	12month wait	timetoclear
meanwait	1.0000				
listlength	0.4201	1.0000			
3monthwait	0.9518	0.4391	1.0000		
12monthwait	0.8377	0.2586	0.6607	1.0000	
timetoclear	0.6943	0.5683	0.7187	0.4922	1.0000

Note: (a) meanwait=the average time that those on the waiting list at the end of the quarter have been waiting; (b) 3monthwait=of those on the list at the end of the quarter, the proportion that have been waiting more than 3 months; (c) 12monthwait=of those on the list at the end of the quarter, the proportion that have been waiting more than 12 months; (d) timetoclear=the time to clear the waiting list; and (e) listlength=the number of patients on the waiting list divided by the Trust population.

Table 20 shows the correlation matrix for the five inpatient waiting time measures for the routine surgical specialties. Again, all five measures are reasonably well correlated with a particularly high correlation between the mean waiting time and the proportion of those patients waiting more than three months (ρ=0.9505).

[23] For information about the construction and definition of these variables see section 7.1.

Table 20 Correlation matrix for five inpatient waiting time measures, routine surgical specialties

Waiting time measure	mean wait	list length	3month wait	12month wait	timetoclear
meanwait	1.0000				
listlength	0.3894	1.0000			
3monthwait	0.9505	0.4105	1.0000		
12monthwait	0.8415	0.2323	0.6635	1.0000	
timetoclear	0.7396	0.5542	0.7524	0.5492	1.0000

Note: for variable definitions see Table 19.

In addition to the five waiting time measures, the inpatient demand model can draw on three alternative measures of demand. Table 21 shows that these measures are very well correlated for all specialties combined with two of the demand measures - the number of additions per head of population (**additions**) and the number of additions per head of population standardised for age and sex (**addstand**) - being almost perfectly correlated (ρ=0.9955). In other words, the standardisation procedure seems to have little effect on the population measure.

Table 21 Correlation matrix for three inpatient demand measures, all specialties combined

Demand measure	addproxy	additions	addstand
addproxy	1.0000		
additions	0.8003	1.0000	
addstand	0.7963	0.9955	1.0000

Note: (a) addproxy=the number of patients who had been waiting three months or less at the end of the quarter, divided by the population served by the Trust; (b) additions=the number of decisions to admit made during the quarter, divided by the population served by the Trust; and (c) addstand=the number of decisions to admit made during the quarter, divided by the expected number of actual admissions.

Table 22 shows that three inpatient demand measures are also highly correlated for the routine surgical specialties.

Table 22 Correlation matrix for three inpatient demand measures, routine surgical specialties

Demand measure	addproxy	additions	addstand
addproxy	1.0000		
additions	0.8570	1.0000	
addstand	0.8543	0.9976	1.0000

Note: for variable definitions see Table 21.

On the inpatient supply side there are just two measures and these differ only in that one (**admissions**) divides the number of admissions by the Trust's population whereas the other (**admissstand**) divides admissions by the Trust's population which has been adjusted for its age and sex profile. As on the demand side, whether the denominator is the population or the population adjusted for age and sex makes little difference as the correlation between these two measures is very high both for all specialties combined (ρ=0.9955) and for all routine surgical specialties (ρ=0.9975).

Table 23 below reports the correlation coefficients between the five waiting time measures, the three demand measures, and the two supply measures for all specialties combined. This shows that with the exception of the proxy measure for the number of additions to the waiting list (**addproxy**), the demand and supply measures are very highly correlated (ρ>0.94) so that the waiting time measures have the same degree of correlation with both the demand and supply measures.

Table 23 Correlation coefficients for the supply, demand, and waiting time measures, all specialties

	mean wait	list length	3month wait	12month wait	timetoclear	addproxy	additions	addstand	admissions
meanwait	1.0000								
listlength	0.4014	1.0000							
3monthwait	0.9518	0.4128	1.0000						
12monthwait	0.8325	0.2489	0.6536	1.0000					
timetoclear	0.6976	0.5457	0.7151	0.5008	1.0000				
addproxy	-0.0894	0.8282	-0.0883	-0.1126	0.1666	1.0000			
additions	-0.2248	0.5441	-0.2604	-0.1616	-0.2505	0.8003	1.0000		
addstand	-0.2149	0.5465	-0.2507	-0.1545	-0.2438	0.7963	0.9955	1.0000	
admissions	-0.2492	0.5004	-0.2860	-0.1753	-0.3369	0.7666	0.9571	0.9494	1.0000
admissstand	-0.2397	0.5051	-0.2767	-0.1686	-0.3303	0.7657	0.9566	0.9579	0.9955

Notes: (a) admissions=the number of admissions divided by the population served by the Trust; (b) admissstand=the number of admissions divided by the expected number of admissions; and (c) for other variable definitions see Tables 19 and 21.

Table 24 is similar to Table 23 but is for the routine surgical specialties rather than all specialties. Again, with the exception of the proxy measure for the number of additions to the waiting list (**addproxy**), the demand and supply measures are very highly correlated (ρ>0.96) so that the waiting time measures have the same degree of correlation with both the demand and supply measures. It is also interesting to note that the correlation coefficient between mean wait and admissions (-0.2266) is almost identical to that we found in an earlier study based on HES data for 1991-92 where the correlation between the mean wait and supply was -0.234 (Martin and Smith, 1999, p153).

Table 24 Correlation coefficients for the supply, demand and waiting time measures, routine surgery

	mean wait	list length	3month wait	12month wait	timetoclear	addproxy	additions	addstand	admissions
meanwait	1.0000								
listlength	0.3765	1.0000							
3monthwait	0.9502	0.3916	1.0000						
12monthwait	0.8359	0.2262	0.6551	1.0000					
timetoclear	0.7410	0.5394	0.7467	0.5539	1.0000				
addproxy	-0.0720	0.8495	-0.0673	-0.1053	0.1725	1.0000			
additions	-0.1998	0.6177	-0.2199	-0.1664	-0.1490	0.8570	1.0000		
addstand	-0.1935	0.6185	-0.2137	-0.1620	-0.1437	0.8543	0.9976	1.0000	
admissions	-0.2266	0.5751	-0.2466	-0.1819	-0.2333	0.8277	0.9653	0.9607	1.0000
admissstand	-0.2203	0.5777	-0.2405	-0.1776	-0.2274	0.8272	0.9657	0.9660	0.9975

Note: for variable definitions see Table 23.

The response of supply and demand to waiting times might involve a lag and we therefore investigated how well correlated each waiting time measure was with its own lagged values. Three lagged variables were constructed for each measure reflecting a one, four, and eight quarter lag. The results were broadly similar for all waiting time measures and those for the mean waiting time for all specialties combined are shown in Table 25. This reveals that the current waiting time is very highly correlated with the previous period's waiting time and that this correlation declines slowly as the time period between the two measures increases. Thus the correlation coefficient between the current wait and lagged wait declines from 0.9654 for a one period lag to 0.6716 for an eight period lag.

Table 25 Correlation coefficients for the current and various lagged values of the mean waiting time, all specialties combined

Waiting time measure	meanwait	meanwait_1	meanwait_4	meanwait_8
meanwait	1.0000			
meanwait_1	0.9654	1.0000		
meanwait_4	0.8239	0.8692	1.0000	
meanwait_8	0.6716	0.6926	0.8026	1.0000

Note: The numeric suffix on the variable name denotes the lag length; thus meanwait_1 is meanwait lagged one period.

The same analysis of the mean waiting time variable for the routine surgical specialties reveals similar results (see Table 26 below).

Table 26 Correlation coefficients for the current and various lagged values of the mean waiting time, routine surgical specialties

Waiting time measure	meanwait	meanwait_1	meanwait_4	meanwait_8
meanwait	1.0000			
meanwait_1	0.9625	1.0000		
meanwait_4	0.8844	0.9110	1.0000	
meanwait_8	0.7830	0.8014	0.8509	1.0000

Note: The numeric suffix on the variable name denotes the lag length; thus meanwait_1 is meanwait lagged one period.

The response of demand and supply to waiting time is of major interest. However, on the supply side we are also interested in how various Trust characteristics affect the supply-waiting time relationship. To this end, we have more than two dozen variables in the data set and these variables will be included in the estimated supply equation. Before we do that, however, let us examine the degree of correlation between some of these variables, the measures of supply and demand, and one measure of waiting time for all specialties combined (see Table 27).

Table 27 confirms that supply and demand are very highly correlated (ρ=0.9582) and that the mean waiting time is negatively correlated with both of these variables with a correlation coefficient of about -0.20. This high degree of correlation between supply and demand is explored further in section 14. As expected, emergency admissions are negatively correlated with elective admissions (ρ=-0.3527) and Trusts with more beds record more elective admissions (ρ=0.4760). There is a strong positive correlation between the proportion of admissions where the patient is aged over 60 and the proportion of elective admissions treated as day cases (ρ=0.5174). This might reflect the fact that those conditions that tend to be treated as day cases also tend to be those incurred by the over sixties.

There is a plausible negative correlation between case complexity and the proportion of electives treated as day cases (ρ=-0.3462) implying that Trusts with more complex cases tend to undertake fewer day cases. There is also a positive correlation between case complexity and length of stay in hospital (ρ=0.3426) so that Trusts with a more complex case mix tend to record longer lengths of stay.

There is also a plausible positive correlation between case complexity and the rate of death within 30 days of (non-emergency) surgery (ρ=0.2079) implying that Trusts with more complex cases tend to have higher death rates. The positive correlation between the complexity (HRG) index and the proportion of revenue spent on research (ρ=0.2584) probably reflects the fact that more complex cases get referred to the more research orientated hospitals.

Table 27 Correlation coefficients for various supply, demand, waiting time, and Trust characteristics variables

	additions	admissions	meanwait	daycases	emergency	bedsph	occupancy	leng_stay	transout	transin	prop60+	hrgindex	readmiss	dnesurg	desurg	research
additions	1.0000															
admissions	0.9582	1.0000														
meanwait	-0.2140	-0.2360	1.0000													
daycases	-0.0780	-0.0678	-0.0428	1.0000												
emergency	-0.3644	-0.3527	0.0682	0.2462	1.0000											
bedsph	0.4665	0.4760	-0.1965	-0.1823	0.1025	1.0000										
occupancy	-0.2726	-0.2869	0.1184	0.0932	0.1752	-0.2044	1.0000									
leng_stay	-0.1264	-0.1528	0.0435	-0.3089	0.0976	0.4037	0.1440	1.0000								
transout	-0.0124	-0.0139	-0.0482	-0.2194	-0.3362	-0.1113	-0.0911	0.1574	1.0000							
transin	-0.0416	-0.0315	0.0260	-0.1136	-0.2397	-0.2457	-0.0692	-0.0719	0.6340	1.0000						
prop60+	-0.1289	-0.1231	0.1368	0.5174	0.2345	-0.1503	0.0860	-0.0422	-0.0302	0.1803	1.0000					
hrgindex	0.0050	-0.0146	0.1153	-0.3462	-0.4876	-0.0993	-0.0769	0.3426	0.5293	0.5268	0.1170	1.0000				
readmiss	-0.2175	-0.2226	0.0260	0.0951	0.4531	-0.0027	0.1355	0.0288	0.0602	0.1306	0.1528	-0.0722	1.0000			
dnesurg	-0.1130	-0.1222	-0.0040	0.1760	-0.1015	-0.2194	0.1135	-0.1059	0.2180	0.2190	0.1286	0.2079	0.2620	1.0000		
desurg	-0.1504	-0.1472	0.0276	0.4422	0.2783	-0.0717	0.2633	-0.1681	-0.2728	-0.1401	0.2783	-0.2874	0.2554	0.4863	1.0000	
research	-0.0260	-0.0618	0.0727	-0.0728	-0.3430	-0.1915	0.0182	0.0151	0.0718	0.0511	-0.1151	0.2584	0.0554	0.3029	-0.0672	1.0000

Key: additions = number of additions to waiting list divided by Trust population (inpatient demand, all specialties)
admissions = number of admissions divided by Trust population (inpatient supply, all specialties)
meanwait = mean waiting time (all specialties)
daycases = proportion of all elective admissions that are day cases
emergency = proportion of all admissions that are emergencies
bedsph = beds per head (average daily number of available beds divided by Trust population)
occupancy = occupancy rate (occupied bed days divided by available bed days)
leng_stay = average length of stay in hospital (occupied bed days divided by number of admissions)
transout = proportion of spells that end in a transfer out to another hospital
transin = proportion of spells that involve a transfer in from another hospital
prop60+ = proportion of admissions where patient is aged over 60
hrgindex = health care resource group case mix index (index increases as complexity of case mix increases)
readmiss = emergency re-admissions that occur within 28 days of ......
dnesurg = rate of death in hospital within 30 days of surgery (non-emergency admissions)
desurg = rate of death in hospital within 30 days of surgery (emergency admissions)
research = percentage of total revenue spent on research

9.2 Regression models

We estimated models for:

- inpatient demand (with three measures of demand and five measures of waiting time)
- inpatient supply (with two measures of supply and five measures of waiting time)

Estimating these models employing both linear and logarithmic specifications, and for two specialty groupings (all specialties, and routine surgical specialties) generated 100 regression equations. The issue of the appropriate lag on the waiting time variable and its impact on either demand and supply increased this figure further. Initially, the impact of the current period's waiting time on demand and supply was examined but this was followed by an examination of the impact of the waiting time variable lagged one period. This doubled the number of equations to be estimated. On the supply side it soon became apparent that the response of supply to waiting time had a much longer lag than did demand. Consequently, the impact of a four quarter lag and then an eight quarter lag were also investigated. In addition, it was also found that the impact of the Trust characteristics variables on supply were best modelled with a slight (one period) lag.

Because of the large number of possible permutations of models we do not report all of the equations estimated. In particular, we restrict ourselves to the log specifications. The linear models typically offered similar results but were usually mis-specified. The use of alternative measures for either demand, supply and/or waiting time typically produced similar results to those reported or the equations were seriously mis-specified.

9.3 Regression results

9.3.1 Inpatient demand - all specialties and routine surgical specialties

The demand function we estimated (see equation 1 in sections 6.1 and 8.1) regressed the number of additions to the waiting list on two time variant variables - waiting time and the proportion of elective admissions treated as day cases - together with six year dummies, three seasonal dummies, and about 200 Trust dummies (whose coefficients are not reported). We found that:

- the log models generally performed well
- linear models were typically mis-specified
- the coefficients on the various waiting time measure were almost always correctly negatively signed and significant
- the coefficients on the various waiting time measures declined as the lag on the waiting time variable increased
- the models employing the proxy for the number of decisions to admit were typically mis-specified (both in linear and logarithmic form)
- the models employing the two other demand measures (**additions** and **addstand**) yielded very similar results

- the inclusion of the day case variable (as an indicator of the quality of treatment) had little impact on the results and the estimated coefficient on this variable was invariably insignificant.[24]

Table 28 reports six regression results: two for all specialties combined (regressions 1a and 1b) and four for the routine surgical specialties (regressions 2a, 2b, 3a, 3b). Consider first the all specialty results. In regression 1a, the waiting time and day case variables are the current period values, whereas in regression 1b they are lagged one period. Both regressions imply that as the time to clear the waiting list increases so demand declines. The proportion of elective admissions treated as day cases has no significant impact on demand. Both regressions exhibit no evidence of mis-specification at the 1% significance level.

The regression with the current period **meanwait** variable generated a significant coefficient of -0.311 but showed evidence of mis-specification (Ramsey's reset test, F = 7.9) as did the regression with **meanwait** variable lagged one period. In the latter case the coefficient was -0.23 and significant at the 1% level (Ramsey's reset test, F =9.0).

For the routine surgical specialties (regressions 2a - 3b), the **meanwait** variable (regression 2a) has the anticipated negative impact on demand and the size of this coefficient is similar to that obtained in our previous work which employed a totally different data set (Martin and Smith: 1999, 2003). The coefficient on the lagged value of **meanwait** (regression 2b) is about one-third below that on the model with the current period value (regression 2a). The coefficient on the **daycase** variable changes little when the lagged rather than the current period value is employed and remains insignificant.

The models (regressions 3a and 3b) with the **12monthwait** waiting time variable also perform well. Note that although the sign on this variable is positive it is as anticipated because of how this variable was transformed before taking logarithms. Originally, the **12monthwait** variable measured the proportion of patients awaiting admission who had waited **more** than 12 months. However, because a non-trivial number of Trusts had zero patients in this category, and that the logarithm of zero is not defined, we subtracted this proportion from one before taking logarithms. Thus this variable now records the proportion of patients awaiting admission who have waited **less** than 12 months. All four regressions for the routine surgical specialties exhibit no evidence of mis-specification at the 1% level.

As some may be sceptical about the use of the day case variable as an indicator of quality, we also estimated each regression without this variable. Its omission had no virtually no impact on the results and, in particular, no impact on the waiting time coefficient.

[24] In principle, we could have included a number of other variables, such as the readmission rate and death rate following surgery, that might be interpreted as indicators of quality. The problem with these is that they are only age adjusted and are certainly not adjusted for case mix complexity. In addition, at the time of this study we only had values for these variables from 1995 to1998 and therefore their inclusion would considerably reduce the sample size for the demand equation. On balance, we decided to employ the proportion of elective admissions treated as day cases as our sole indicator of quality in the demand model.

All six inpatient regressions in Table 28 suggest a reduction in inpatient demand (consultant decisions to admit) in 2000 and 2001 compared to 1995 (there is no dummy for 1997 because there is no quarterly decision to admit data for this year).

Table 28 also reports estimated coefficients on three time invariant variables:

(a) the index of need for acute health care (**need**)
(b) the availability of local private beds relative to NHS beds (**private_beds**)
(c) the number of GPs per head of population that the Trust serves (**GP_availability**)

In practice, of course, these measures will change from year to year but we only have observations for a single year and any annual change is likely to be very small. To obtain these coefficients we estimated a supplementary regression, employing the coefficients on the Trust dummies as the dependent variable and regressing them on the time invariant variables. In other words, we are attempting to explain variations in the coefficients on the Trust dummies using those variables which we have been unable to include in the initial fixed effects regression.

In all six of the supplementary regressions the relative availability of private beds is significantly negatively associated with NHS demand (as is to be expected) but the other two variables have no significant impact. That the needs index should have no impact is surprising but might reflect problems with the way in which we have constructed this index (via the purchaser-provider matrix). It should, however, be noted that a previous study found it difficult to locate any consistent positive impact of need on inpatient demand via this approach to the estimation of coefficients on the time invariant variables (Gravelle et al, 2003).

In addition to these three time invariant variables we also had available eight further time invariant variables. These can be interpreted as indicators of the 'quality of care'. Although these are in principle time variant we only had available one or at most two values for each variable. We therefore took the mean value of each variable and employed these as time invariant variables. These eight further variables were initially included in the supplementary fixed effects model:

(a) the Trust's performance rating (number of stars);
(b) the amount of time lost through absence as a proportion of staff time available for directly employed NHS staff;
(c) the allied health professionals vacancy rate (three month vacancies expressed as a percentage of three month vacancies plus staff in post);
(d) the qualified nursing, midwifery & health visiting professionals vacancy rate (three month vacancies expressed as a percentage of three month vacancies plus staff in post);
(e) the consultants vacancy rate (three month vacancies expressed as a percentage of three month vacancies plus staff in post); and
(f) Professor Brian Jarman's standardised mortality index (see Jarman et al, 1999).
(g) the proportion of patients whose discharge is delayed from hospital
(i) the Herfindahl measure of local NHS competition.

However, we found that the inclusion of all of these variables in the first few supplementary fixed effects models estimated added little to the explanatory power of the supplementary fixed effects regression and that all estimated coefficients were typically either insignificant or exhibited counter-intuitive signs. The inclusion of these variables also reduced the significance of the other three variables so that it was not unusual for all variables in this supplementary regression to be statistically insignificant. Given that there is already a time varying 'quality of care' indicator in the model, these other time invariant quality of care indicators were therefore dropped from the supplementary demand model. The three remaining variables - **need**, **private_beds**, and **GP_availability** - incorporate roles for those factors that are most regularly seen as affecting the demand for health care.

Table 28 Inpatient demand: selected regression results for all specialties and for the routine surgical specialties

Dependent variable: the number of decisions to admit divided by the Trust's population

	All specialties		Routine specialties		Routine specialties	
	Current	Lagged	Current	Lagged	Current	Lagged
Regression	1a	1b	2a	2b	3a	3b
meanwait			-0.198**	-0.122**		
3monthwait						
12monthwait					0.708**	0.530**
timetoclear	-0.359**	-0.289**				
listlength						
daycases	0.067	0.067	0.047	0.050	0.052	0.052
year96	0.029**	0.003	-0.001	-0.015	-0.005	-0.017°
year97						
year98	0.052**	0.053**	0.021	0.000	0.013	-0.003
year99	0.024	0.012	0.019	-0.002	0.016	-0.001
year00	-0.035°	-0.048*	-0.022	-0.040°	-0.024	-0.039°
year01	-0.042*	-0.062**	-0.042*	-0.060*	-0.050*	-0.061**
summer	-0.007*	0.033**	0.010**	0.008*	0.010**	0.007*
autumn	0.009*	0.025**	0.016**	0.018**	0.017**	0.017**
winter	-0.006	0.040**	0.020**	0.022**	0.022**	0.022**
need	0.351	0.464°	-0.369	-0.327	-0.319	-0.302
private_beds	-0.061*	-0.064*	-0.203**	-0.208**	-0.200**	-0.204**
GP_availability	-0.158	-0.118	-0.471	-0.449	-0.422	-0.425
constant	2.860**	2.773**	3.133**	2.907**	2.588**	2.582**
No of obs	4045	3690	3983	3824	3983	3824
R bar squared	0.862	0.851	0.920	0.921	0.919	0.921
RESET test: F =	2.99	1.29	0.79	2.58	1.09	1.67
Prob > F =	0.0296	0.2768	0.5019	0.0520	0.3504	0.1713

Notes to Table 28:

1 In the current period regressions (1a, 2a and 3a) the waiting time and day case variables are the current period values. In the lagged regressions (1b, 2b and 3b) the waiting time and day case variables are lagged one quarter.

2 The **12monthwait** variable is the proportion ofpatients awaiting admission who have waited **less** than 12 months.

3 There is no coefficient on the dummy variable for 1997 because there is no quarterly decision to admit data for this year. The base year is 1995.

4 °denotes significance at the 10% level, * denotes significance at the 5% level and ** denotes significance at the 1% level.

5 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition ofthe first three powers ofthe predicted value ofthe dependent variable to the model and a test ofthe joint significance ofthese three variables.

6 The coefficients on the 200 Trust dummies are not reported. These coefficients are regressed on the three time invariant variables to obtain the estimated coefficients on the **need**, **private_beds** and **GP_availability** variables.

9.3.2 Inpatient supply - all specialties and routine surgical specialties

The supply function to be estimated regressed admissions on a waiting time variable and 13 other time variant variables together with six year dummies, three seasonal dummies, and about 200 Trust dummies (whose coefficients are not reported). Available were two measures of supply: **admissions** which divides the number of admissions by the Trust population and **admissstand** which divides the number of admissions by the Trust population *adjusted for its age/sex profile*. We found that:

- the log models generally performed well although the linear models were typically mis-specified
- there was little evidence of an immediate supply response to waiting time. The response we found was typically after four quarters and so in the models reported below the waiting time variable is lagged four periods
- four of the five waiting time measures yielded similar results (only the **timetoclear** waiting time measure performed poorly)
- the models employing the **admissions** variable typically demonstrated less evidence of mis-specification than those employing the **admissstand** variable and, as their results were otherwise very similar, only the former are reported below
- the results for the routine surgical specialties were better than those for all specialties combined (where we found it difficult to detect a significant waiting time effect)

One further issue concerned the appropriate lag on the other (non waiting time) explanatory variables. In principle, we would expect the impact of, say, the length of stay or the number of beds on supply to be immediate (that is to impact in the same quarter). However, all of these supply side variables were constructed from annual data with quarterly data estimated by linear interpolation. It is therefore possible that such quarterly data might be subject to some inaccuracy - at least in their timing - and therefore we also estimated the supply equation with the non waiting time variables lagged one and four periods.

There is also the possibility that this lag on the non-waiting time variables reflects the presence of a learning effect. Although one might expect, say, an increase in the proportion of day cases to lead to an immediate increase in supply, it might take time for administrators and medical staff to develop new, more appropriate ways of working, to fully exploit the potential benefits of this shift away from overnight admissions and towards day case treatment.

Other reasons for the lagged impact of these non-waiting time variables on supply stem from the various ways in which these variables can be interpreted. Some might serve as quality of care indicators and act as demand shifters. If the latter, there is likely to be a lag between the recorded change in the quality of care - as indicated by, say, the day case rate or the re-admission rates - and a demand and then supply response.

Generally, the lag on the non waiting time variables had little impact on the results but the specification improved marginally with the lag length. As a flavour of the results, we report two sets: in Table 29 the non waiting time variables are lagged one period, and in Table 30 they are lagged four periods.

Table 29 reports six regression results: three for all specialties combined (regressions 1a, 2a, and 3a) and three for the routine surgical specialties (regressions 1b, 2b, and 3b). In all regressions the dependent variable is the number of admissions divided by the Trust's population (**admissions**) with a different measure of waiting time employed in each regression: in regression 1 it is the average waiting time (**meanwait**), in regression 2 it is the proportion of patients waiting less than 12 months (**12monthwait**), and in regression 3 it is number of patients waiting divided by the Trust's catchment population (**listlength**).

Generally, the results are similar for both specialty groupings and for all three waiting time measures except that the waiting time variables are insignificant in the all specialties regressions and that these exhibit evidence of mis-specification. The results in Table 29 suggest that waiting time has a positive impact on supply in the routine surgical specialties so that longer waits in the current period are associated with more supply one year later. Several other variables are also significant. The coefficient on **length_of_stay** is negative implying that longer lengths of stay are associated with fewer admissions (less supply). The positive coefficient on **transfers_out** implies that the greater the proportion of spells that end with a transfer to another hospital the greater the number of admissions. This is plausible: if a hospital does not have the capability to treat more complex cases these are exported to other hospitals leaving more capacity for the more routine cases.

The negative coefficient on **death_e_surgery** is expected with deaths preceded by longer lengths of stay than (live) discharges, possibly in intensive care units. The proportion of elective admissions that are day cases (**daycases_pc**) has a positive impact on supply and, as anticipated, the proportion of all admissions that are emergencies (**emergencies_pc**) has a negative impact on elective admissions. Finally, and again as expected, supply is positively associated with the number of beds per head of catchment population (**beds_per_head**).

Table 29 also reports estimated coefficients on four time invariant variables:

(a) the availability of local private beds relative to NHS beds (**private_beds**);
(b) the qualified nursing, midwifery & health visiting professionals vacancy rate (**nurse_vacancy**);
(c) the amount of time lost through absence as a proportion of staff time available for directly employed NHS staff (**staff_sickness_rate**); and
(d) the proportion of patients whose discharge from hospital is delayed for non-medical reasons (**delayed_discharge**).

In practice, of course, these measures will change from year to year but we only have observations for a single year and annual changes might be quite small. In all six regressions the relative availability of private beds is significantly negatively associated with NHS supply (as is to be expected) but the impact of the other three variables is more mixed. The proportion of patients whose discharge is delayed has a significant negative impact on supply in the all specialties regressions but not in the routine surgical regressions. In the latter, the nurse vacancy rate has a significant negative impact on supply.

In addition to these four time invariant variables we also initially included a number of further variables which might affect the supply of inpatient care including:

(a) the need for health care
(b) an index of local NHS competition
(c) Brian Jarman's mortality index based on 5 years' data
(d) the number of GPs per head of population
(e) the Trust's performance rating (number of stars)
(f) the allied health professionals vacancy rate
(g) the consultants vacancy rate
(i) population per bed (both weighted for distance).

However, we found that the inclusion of these variables added little to the explanatory power of the supplementary fixed effects regression and that the estimated coefficients were either insignificant or of a counter-intuitive sign. We therefore sought a small number of variables that were statistically significant, exhibited the anticipated sign, and which explained as much of the variation as possible in the Trust coefficients. Ultimately the four time invariant variables whose coefficients are reported in Table 29 were selected, on the basis of their performance in this and other supplementary fixed effects supply regressions.

The results in Table 30 are for an identical batch of models except that all explanatory variables are now lagged four periods. The results are broadly similar to those in Table 29 except that:

- the coefficients on the waiting time variables have increased
- the length of stay variable is no longer statistically significant
- the **death_e_surgery** variable is no longer significant in the all specialties regressions and the **transfers_out** variable is no longer significant in the routine surgical specialties models
- the coefficients on the **daycases_pc**, **emergencies_pc**, and **beds_per_head** variables have all declined markedly but remain statistically significant with anticipated signs

In addition, the supplementary fixed effects results are poor with only delayed_discharge (all specialties) and private_beds (routine surgery) being significant and with the correct sign.

Table 29 Inpatient supply: selected regression results for all specialties and for the routine surgical specialties (non waiting time variables lagged one quarter)

Dependent variable: the number of admissions divided by the Trust's population (**admissions**)

	All specialties			Routine specialties		
Regression number	1a	2a	3a	1b	2b	3b
meanwait_4	0.032			0.081*		
3monthwait_4						
12monthwait_4		-0.257			-0.365*	
timetoclear_4						
listlength_4			0.066			0.105**
occupancy_rate_1	-0.072	-0.080	-0.085	0.079	0.090	0.058
length_of_stay_1	-0.112°	-0.109	-0.110*	-0.101	-0.095	-0.106°
transfers_in_1	0.045	0.046	0.042	0.044	0.046	0.042
transfers_out_1	0.046**	0.046**	0.046**	0.036**	0.036**	0.037**
prop_admiss_60+_1	0.074	0.076	0.074	0.048	0.053	0.054
HRG_index_1	-0.911**	-0.936**	-0.872**	-0.939**	-0.953**	-0.863**
research_spend_1	0.026	0.025	0.038	0.205	0.197	0.243
readmission_rate_1	-0.062	-0.064	-0.075	-0.135	-0.150	-0.159
death_ne_surgery_1	0.057	0.058	0.056	0.033	0.035	0.032
death_e_surgery_1	-0.132**	-0.136**	-0.130*	-0.164**	-0.172**	-0.163**
daycases_pc_1	0.182**	0.179**	0.174*	0.156**	0.156**	0.143**
emergencies_pc_1	-0.233*	-0.232*	-0.219*	-0.222*	-0.217*	-0.202*
beds_per_head_1	0.322*	0.326*	0.323*	0.400**	0.394**	0.390**
year96						
year97						
year98	0.092**	0.090**	0.089**	0.092**	0.096**	0.090**
year99	0.027	0.025	0.028	0.018	0.020	0.026
year00	-0.033	-0.036	-0.027	-0.017	-0.016	-0.001
year01	-0.080**	-0.083**	-0.070*	-0.053*	-0.053°	-0.033
summer	0.037**	0.037**	0.039**	0.030**	0.029**	0.092**
autumn	0.015*	0.015*	0.016*	0.011°	0.011°	0.013°
winter	0.037**	0.037**	0.040**	0.032**	0.031**	0.036**
private_beds	-0.116**	-0.119**	-0.119**	-0.328**	-0.329**	-0.342**
nurse_vacancy	0.007	-0.008	0.001	-0.097*	-0.091°	-0.113*
staff_sickness_rate	-0.112	-0.111	-0.112	-0.168	-0.173	-0.195
delayed_discharge	-0.075**	0.075**	-0.074**	0.006	0.004	0.003
constant	8.319**	8.581**	8.189**	8.326**	8.737**	8.200**
No of obs	2758	2758	2758	2339	2339	2339
R bar squared	0.841	0.841	0.841	0.906	0.906	0.907
RESET test: F =	9.72	9.70	10.34	4.30	4.73	5.24
Prob > F =	0.0000	0.0000	0.0000	0.0050	0.0027	0.0013

Notes for Table 29:

1 The waiting time variables are lagged four quarters. The other explanatory variables are lagged one quarter. The numeric suffix on the variable name denotes the lag length; thus meanwait_4 is meanwait lagged four periods.

2 The **12monthwait** variable is the proportion of patients awaiting admission who have waited **less** than 12 months.

3 There is no coefficient on the dummy variable for 1997 because there is no decision to admit data for this year. The base year is 1996.

4 °denotes significance at the 10% level, * denotes significance at the 5% level, and ** denotes significance at the 1% level.

5 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition of the first three powers of the predicted value of the dependent variable to the model and a test of the joint significance of these three variables.

6 The coefficients on the 200 or so Trust dummies are not reported. These coefficients are regressed on the four time invariant variables to obtain the estimated coefficients on the **private_beds**, **nurse_vacancy, staff_sickness_rate** and **delayed_discharge** variables.

Table 30 Inpatient supply: selected regression results for all specialties and for routine specialties

Dependent variable: the number of admissions divided by the Trust's population (**admissions**)

	All specialties			Routine specialties		
Regression number	1a	2a	3a	1b	2b	3b
meanwait_4	0.055			0.103**		
3monthwait_4						
12monthwait_4		-0.342			-0.417*	
timetoclear_4						
listlength_4			0.091*			0.121**
occupancy_rate_4	-0.094	-0.096	-0.109	0.045	0.060	0.029
length_of_stay_4	-0.039	-0.035	-0.032	-0.051	-0.040	-0.049
transfers_in_4	0.011	0.012	0.009	-0.002	-0.002	-0.005
transfers_out_4	0.029**	0.029**	0.029**	0.006	0.007	0.007
prop_admiss_60+_4	0.116	0.112	0.123	0.054	0.051	0.077
HRG_index_4	-1.124**	-1.151**	-1.081**	-0.953**	-0.980**	-0.905**
research_spend_4	-0.143	-0.142	-0.122	0.024	0.022	0.056
readmission_rate_4	0.003	0.002	-0.004	-0.049	-0.054	-0.061
death_ne_surgery_4	0.021	0.027	0.021	-0.000	0.002	-0.002
death_e_surgery_4	-0.069	-0.073	-0.066	-0.086°	-0.094°	-0.085*
daycases_pc_4	0.037	0.038	0.029	0.053°	0.054°	0.037
emergencies_pc_4	-0.149	-0.145	-0.149	-0.180	-0.175	-0.181
beds_per_head_4	0.147	0.142	0.140	0.294**	0.283**	0.287**
year96						
year97						
year98	0.115**	0.115**	0.113**	0.136**	0.146**	0.138**
year99	0.044	0.043	0.046	0.055	0.062**	0.066
year00	-0.019	-0.021	-0.010	0.020	0.025	0.039
year01	-0.064	-0.066	-0.049°	-0.017	-0.014	0.008
summer	0.034**	0.033**	0.035**	0.024**	0.023**	0.025**
autumn	0.009	0.008	0.009	0.001	-0.000	0.001
winter	0.032**	0.032**	0.035**	0.025**	0.023**	0.028**
private_beds	-0.001	-0.007	-0.008	-0.199**	-0.206**	-0.204**
nurse_vacancy	0.093*	0.092**	0.083**	-0.008	-0.004	-0.018
staff_sickness_rate	0.088	0.083	0.078	0.023	0.009	-0.006
delayed_discharge	-0.101*	-0.101*	-0.099**	-0.017	-0.018	-0.022
constant	8.300**	8.597**	8.059**	6.986**	7.401**	6.851**
No of obs	2736	2736	2736	2325	2325	2325
R bar squared	0.836	0.836	0.836	0.902	0.902	0.903
RESET test: F =	13.24	13.28	13.84	2.32	2.24	3.14
Prob > F =	0.0000	0.0000	0.0000	0.0739	0.0812	0.0244

Notes for Table 30:
1 All explanatory variables are lagged four quarters.
2 The **12monthwait** variable is the proportion of patients awaiting admission who have waited **less** than 12 months.
3 There is no coefficient on the dummy variable for 1997 because there is no decision to admit data for this year. The base year is 1996.
4 °denotes significance at the 10% level, * denotes significance at the 5% level, and ** denotes significance at the 1% level.
5 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition of the first three powers of the predicted value of the dependent variable to the model and a test of the joint significance of these three variables.
6 The coefficients on the 200 or so Trust dummies are not reported. These coefficients are regressed on the four time invariant variables to obtain the estimated coefficients on the **private_beds**, **nurse_vacancy, staff_sickness_rate** and **delayed_discharge** variables.

9.4 Summary of inpatient results for two specialty groupings

In this section we have estimated models of the demand for and supply of inpatient elective surgery for two specialty groupings: all specialties combined and the routine surgical specialties. Table 31 presents a brief summary of these results. We constructed three measures of demand, two measures of supply, and five measures of waiting time. Our alternative measures were typically well correlated with each other.

We found that waiting times had a significant negative effect on demand and that this effect declined as the lag on the waiting time variable increased. We also found that the local availability of private beds was negatively associated with the demand for NHS care.

With regard to the supply of inpatient care, we found that waiting times had a positive impact on supply but that this was only significant in the routine surgery models and that the supply response to waiting times was best modelled with a four quarter lag. We also found that a number of other variables (such as the number of beds, the number of emergency admissions and various indicators of case mix complexity) also affected the supply of elective care. There was also a role for the private sector in the supply of NHS care particularly in the routine surgical specialties: the local availability of private beds was negatively associated with the supply of inpatient NHS care.

Table 31 Summary of findings from inpatient models for all specialties and routine specialties

(a) demand

Specialty grouping	Significant negative effect of waiting time on NHS demand (coefficient on *meanwait* where applicable)? lag_0	lag_1	Model well specified?	Significant negative impact of private care on NHS demand (coefficient on *private_beds* from model with *meanwait*)?
All specialties[25]	✔	✔	✔	✔
Routine surgery	✔ (-0.198)	✔ (-0.122)	✔	✔

(b) supply

Specialty grouping	Significant positive effect of waiting time on NHS supply (coefficient on *meanwait* where applicable)? lag_4	Model well specified?	Significant negative impact of private care on NHS supply (coefficient on *private_beds* from model with *meanwait*)?
All specialties*	✖ (0.055)	✖	✖
Routine surgery*	✔ (0.103)	✔	✔

Note: there is a four quarter lag on the non-waiting time variables in these regressions.

[25] The elasticity of demand with respect to the current period mean wait was -0.311 and that with respect to the lagged one period wait was -0.23 although both regressions showed evidence of mis-specification and hence these coefficients are not reported in this Table.

10 RESULTS

ALL SPECIALTIES & ROUTINE SURGERY: OUTPATIENTS

10.1 Correlations

With various measures of supply, demand, and waiting time, we began by examining the degree of correlation between the various ways in which these variables could be constructed.[26] Table 32 shows the correlation matrix for the six outpatient waiting time measures for all specialties combined. This reveals that with the possible exception of one measure - the proportion of those seen who had waited between 4 and 13 weeks (**4-13wkwait**) - the others are reasonably well correlated with a particularly high correlation between the mean waiting time and the proportion of those seen who had waited less than 13 weeks (ρ=-0.9571).

Table 32 Correlation matrix for six outpatient waiting time measures, all specialties combined

Waiting time measure	meanwait	<4wkwait	4-13wkwait	13-26wkwait	26+wkwait	<13wkwait
meanwait	1.0000					
<4wkwait	-0.7760	1.0000				
4-13wkwait	-0.1138	-0.5085	1.0000			
13-26wkwait	0.8115	-0.6661	-0.2138	1.0000		
26+wkwait	0.8674	-0.4405	-0.3465	0.4882	1.0000	
<13wkwait	-0.9571	0.6654	0.3045	-0.9222	-0.7877	1.0000

Notes: (a) meanwait=of those GP referrals seen, the average time that these patients had been waiting; (b) <4weekwait=of those GP referrals seen, the proportion that had been waiting less than 4 weeks; (c) 4-13weekwait=of those GP referrals seen, the proportion that had been waiting between 4 and 13 weeks; (d) 13-26weekwait=of those GP referrals seen, the proportion that had been waiting between 13 and 26 weeks; (e) 26+weekwait=of those GP referrals seen, the proportion that had been waiting more than 26 weeks; and (f) <13weekwait=of those GP referrals seen, the proportion that had been waiting less than 13 weeks.

Table 33 shows the correlation matrix for the six outpatient waiting time measures for the routine surgical specialties. Again, most of the measures are reasonably well correlated with a particularly high correlation between the mean waiting time and the proportion of those seen who had waited less than 13 weeks (ρ=0.9592).

[26]For information about the construction and definition of these variables see section 5.1.

Table 33 Correlation matrix for six outpatient waiting time measures, routine surgery

Waiting time measure	meanwait	<4wkwait	4-13wkwait	13-26wkwait	26+wkwait	<13wkwait
meanwait	1.0000					
<4wkwait	-0.7253	1.0000				
4-13wkwait	-0.3411	-0.3514	1.0000			
13-26wkwait	0.7422	-0.6285	-0.3736	1.0000		
26+wkwait	0.8784	-0.4022	-0.4773	0.3875	1.0000	
<13wkwait	-0.9529	0.6378	0.4970	-0.8899	-0.7654	1.0000

Note: for variable definitions see Table 29.

In addition to the six waiting time measures, there are four measures of outpatient demand. Tables 34 (all specialties) and 35 (routine surgery) show that these are all extremely highly correlated with little difference between the unstandardised and standardised measures (ρ=0.999).

Table 34 Correlation matrix for four outpatient demand measures, all specialties combined

Demand measure	GPrefer	GPreferstand	allrefer	allreferstand
GPrefer	1.0000			
GPreferstand	0.9991	1.0000		
allrefer	0.9633	0.9657	1.0000	
allreferstand	0.9605	0.9643	0.9995	1.0000

Notes: (a) GPrefer=the number of GP referrals received, divided by the population served by the Trust; (b) GPreferstand=the number of GP referrals received, divided by the expected number of inpatient admissions; (c) allrefer=the number of all referrals received, divided by the population served by the Trust; and (d) allreferstand=the number of all referrals received, divided by the expected number of inpatient admissions.

Table 35 Correlation matrix for four outpatient demand measures, routine surgery

Demand measure	GPrefer	GPreferstand	allrefer	allreferstand
GPrefer	1.0000			
Gpreferstand	0.9989	1.0000		
allrefer	0.9523	0.9548	1.0000	
allreferstand	0.9473	0.9519	0.9990	1.0000

Note: for variable definitions see Table 34.

With regard to outpatient supply, four alternative measures have been constructed. Tables 36 (all specialties) and 37 (routine surgery) show that these, like the demand measures, are highly correlated with each other.

Table 36 Correlation matrix for four outpatient supply measures, all specialties

Supply measure	GPrefseen	GPrefseenstand	allrefseen	allrefseenstand
GPrefseen	1.0000			
GPrefseenstand	0.9989	1.0000		
allrefseen	0.9370	0.9410	1.0000	
allrefseenstand	0.9329	0.9385	0.9993	1.0000

Notes: (a) GPrefseen=the number of GP referrals seen, divided by the population served by the Trust; (b) GPrefseenstand=the number of GP referrals seen, divided by the expected number of inpatient admissions; (c) allrefseen=the number of all referrals seen, divided by the population served by the Trust; and (d) allrefseenstand=the number of all referrals seen, divided by the expected number of inpatient admissions.

Table 37 Correlation matrix for four outpatient supply measures, routine surgery

Supply measure	GPrefseen	GPrefseenstand	allrefseen	allrefseenstand
GPrefseen	1.0000			
GPrefseenstand	0.9988	1.0000		
allrefseen	0.9600	0.9634	1.0000	
allrefseenstand	0.9538	0.9595	0.9988	1.0000

Note: for variable definitions see Table 36.

Table 38 reports the correlation coefficients between the six waiting time measures, two demand measures, and the two supply measures for all specialties combined. This shows that the demand and supply measures are very highly correlated with each other (ρ>0.97) so that each waiting time indicator has the same degree of correlation with both the demand and supply measures. Notice that the correlation between waiting time and demand is considerably lower for outpatients (=-0.06) than for inpatients (=-0.21 from Table 23). Similar results were obtained for all routine surgical specialties (see Table 39).

Table 38 Correlation coefficients for the supply, demand, and waiting time measures, all specialties

	meanwait	<4wkwait	4-13wkwait	13-26wkwait	26+wkwait	<13wkwait	GPrefer	allrefer	GPrefseen
meanwait	1.0000								
<4wkwait	-0.7593	1.0000							
4-13wkwait	-0.1050	-0.5388	1.0000						
13-26wkwait	0.8077	-0.6524	-0.1993	1.0000					
26+wkwait	0.8568	-0.3978	-0.3598	0.4699	1.0000				
<13wkwait	-0.9550	0.6408	0.3015	-0.9201	-0.7782	1.0000			
GPrefer	-0.0564	-0.0221	0.1300	-0.0983	-0.0531	0.0935	1.0000		
allrefer	-0.0665	0.0095	0.1006	-0.1176	-0.0423	0.1024	0.9614	1.0000	
GPrefseen	-0.0359	-0.0383	0.1248	-0.0736	-0.0407	0.0704	0.9718	0.9233	1.0000
allrefseen	-0.0457	-0.0084	0.0961	-0.0898	-0.0320	0.0781	0.9401	0.9707	0.9366

Note: for variable definitions see Tables 32, 34, and 36.

Table 39 Correlation coefficients for the supply, demand, and waiting time measures, routine surgery

	meanwait	<4wkwait	4-13wkwait	13-26wkwait	26+wkwait	<13wkwait	GPrefer	allrefer	GPrefseen
meanwait	1.0000								
<4wkwait	-0.7134	1.0000							
4-13wkwait	-0.3684	-0.3372	1.0000						
13-26wkwait	0.7267	-0.6317	-0.3711	1.0000					
26+wkwait	0.8780	-0.3831	-0.5015	0.3620	1.0000				
<13wkwait	-0.9527	0.6347	0.5135	-0.8804	-0.7608	1.0000			
GPrefer	-0.0121	-0.1591	0.2177	0.0147	-0.0863	0.0337	1.0000		
allrefer	-0.0043	-0.1490	0.1991	0.0106	-0.0687	0.0276	0.9538	1.0000	
GPrefseen	-0.0009	-0.1596	0.2043	0.0213	-0.0728	0.0222	0.9697	0.9245	1.0000
allrefseen	0.0108	-0.1542	0.1846	0.0239	-0.0543	0.0110	0.9421	0.9522	0.9628

Note: for variable definitions see Tables 32, 34, and 36.

The response of outpatient supply and demand to waiting time might involve a lag and we therefore investigated how well correlated each waiting time measure was with its own lagged values. Three lagged variables were constructed for each measure reflecting a one, four, and eight quarter lag. The results were broadly similar for all waiting time measures and those for the mean waiting time for all specialties combined are shown in Table 40. This reveals that the current waiting time is very highly correlated with the previous period's waiting time and that this correlation declines slowly as the time period between the two measures increases. Thus the correlation coefficient between the current wait and lagged wait declines from 0.9187 for a one period lag to 0.6869 for an eight period lag.

Table 40 Correlation coefficients for the current and various lagged values of the mean waiting time, all specialties

waiting time measure	meanwait	meanwait_1	meanwait_4	meanwait_8
meanwait	1.0000			
meanwait_1	0.9187	1.0000		
meanwait_4	0.8021	0.8297	1.0000	
meanwait_8	0.6869	0.6974	0.8005	1.0000

Note: The numeric suffix on the variable name denotes the lag length; thus meanwait_1 is meanwait lagged one period.

The same analysis of the mean waiting time variable for the routine surgical specialties reveals similar results (see Table 41 below).

Table 41 Correlation coefficients for the current and various lagged values of the mean waiting time, routine surgical specialties

waiting time measure	meanwait	meanwait_1	meanwait_4	meanwait_8
meanwait	1.0000			
meanwait_1	0.9078	1.0000		
meanwait_4	0.7542	0.7968	1.0000	
meanwait_8	0.5968	0.6164	0.7610	1.0000

Note: The numeric suffix on the variable name denotes the lag length; thus meanwait_1 is meanwait lagged one period.

We also examined the degree of correlation between outpatient supply, demand, and various Trust characteristics (see Table 42 below). Although most of these characteristics refer to inpatient activity (such as the length of stay in hospital, bed occupancy rates, and hospital transfers), it is reasonable to assume that inpatient activity will impinge on outpatient activity. Thus in the present (outpatient) context, many of these characteristics can be broadly interpreted as indicators of the degree of pressure on resources and we would expect outpatient supply to be inversely related to the level of pressure on (inpatient) resources.

Thus as the number of beds per head of population increases there will be less pressure on this resource (holding all other factors constant) and hence we would expect the observed positive relationship between outpatient supply and the beds per head variable. Similarly, the higher the HRG index the more pressure there will be on given resources and thus we would expect the observed inverse relationship between this measure of case mix complexity and outpatient supply.

The negative correlation coefficient between outpatient supply and the day cases variable is at first surprising but there might be two opposing forces at work here. First, more day cases implies less pressure on given resources and hence a positive effect on supply. Second, there may be some procedures that are recorded as day cases by some Trusts but as outpatient activity by others. This would generate a negative relationship between day cases and outpatient supply.

Table 42 Correlation coefficients for various supply, demand, waiting time, and Trust characteristic variables

	allrefer	allreferseen	meanwait	daycases	emergency	bedsph	occupancy	len_stay	transout	transin	prop60+	hrgindex	readmiss	dnesurg	desurg	research
allrefer	1.0000															
allreferseen	0.9174	1.0000														
meanwait	-0.0481	-0.0232	1.0000													
daycases	-0.0540	-0.0205	0.1646	1.0000												
emergency	-0.2190	-0.1798	0.0025	0.3056	1.0000											
bedsph	0.4607	0.4118	-0.1695	-0.1113	0.0821	1.0000										
occupancy	-0.0991	-0.1002	0.1429	0.1687	0.1768	-0.1850	1.0000									
len_stay	-0.1919	-0.2028	-0.1963	-0.3713	0.0331	0.3710	0.0950	1.0000								
transout	-0.1262	-0.1405	-0.0645	-0.3217	-0.4221	-0.1280	-0.1474	0.2305	1.0000							
transin	-0.1902	-0.1995	-0.1150	-0.2288	-0.2978	-0.2534	-0.1470	0.0213	0.6720	1.0000						
prop60+	-0.3062	-0.2372	0.0087	0.4146	0.2806	-0.1043	0.1005	0.0324	0.0450	0.2417	1.0000					
hrgindex	-0.2746	-0.2990	-0.0102	-0.3811	-0.4299	-0.0811	-0.0876	0.3590	0.6050	0.5852	0.1531	1.0000				
readmiss	-0.1559	-0.1022	-0.0656	-0.1001	0.2982	-0.0204	0.0091	0.1893	0.1951	0.2510	0.2518	0.0682	1.0000			
dnesurg	-0.1283	-0.1657	-0.0479	0.0103	-0.0295	-0.0681	0.0540	0.0541	0.1966	0.2068	0.0939	0.2001	0.1334	1.0000		
desurg	-0.0650	-0.0623	-0.0660	0.1019	0.2516	0.0311	0.1398	0.0979	-0.1277	-0.0300	0.2449	-0.2013	0.4294	0.3596	1.0000	
research	-0.0133	-0.0193	-0.0020	-0.0984	-0.3218	-0.1625	0.0544	0.0801	0.1236	0.0178	-0.1577	0.2540	0.0848	0.2231	-0.0954	1.0000

Key:
allrefer = number of written referrals received divided by Trust population (outpatient demand, all specialties)
allreferseen = number of referrals seen divided by Trust population (outpatient supply, all specialties)
meanwait = mean waiting time (outpatients, all specialties)
daycases = proportion of all elective admissions that are day cases
emergency = proportion of all admissions that are emergencies
bedsph = beds per head (average daily number of available beds divided by Trust population)
occupancy = occupancy rate (occupied bed days divided by available bed days)
len_stay = average length of stay in hospital (occupied bed days divided by number of admissions)
transout = proportion of spells that end in a transfer out to another hospital
transin = proportion of spells that involve a transfer in from another hospital
prop60+ = proportion of admissions where patient is aged over 60
hrgindex = health care resource group case mix index (index increases as complexity of case mix increases)
readmiss = emergency readmissions that occur within 28 days of ...
dnesurg = rate of death in hospital within 30 days of surgery: non-emergency admissions
desurg = rate of death in hospital within 30 days of surgery: emergency admissions
research = percentage of total revenue spent on research

10.2 Regression results

We estimated models for:

- outpatient demand (with four measures of demand and six waiting time measures) and
- outpatient supply (with four measures of supply and six waiting time measures).

10.2.1 Outpatient demand - all specialties and routine surgical specialties

The demand function we estimated regressed the number of referrals received against two time variant variables - waiting time and the proportion of electives treated as day cases - together with six year dummies, three seasonal dummies, and about 200 Trust dummies (whose coefficients are not reported). Although the day case variable relates to inpatient admissions, it might also serve as an indicator of the quality of care offered across both inpatients and outpatients.

We found that:

- the logarithmic models performed much better than the linear models so we only report the former (the linear models were often seriously mis-specified)

- with the exception of the waiting time variable recording the proportion of patients having waited between 13 and 26 weeks, the coefficients on the various waiting time measures were typically correctly negatively signed but not always significant

- the coefficients on the various waiting time measures declined as the lag on the waiting time variable increased beyond a one period lag but the coefficient on this lag was typically greater than on the current value of waiting time

- whether the number of (GP or all) referrals is divided by the Trust population or by the Trust population adjusted for the age/sex profile makes very little difference to the results. Consequently, only models employing the former demand measure are reported

- the inclusion of the day case variable (as an indicator of quality of treatment) had little impact on the results and the estimated coefficient on this variable was usually statistically insignificant

- models based on the total number of referrals received typically performed better than those based the number of GP referrals received.

Table 43 reports six regression results for all specialties combined: three where the dependent variable is based on the number of GP referrals received (regressions 1a, 1b, and 1c) and three where the dependent variable is based on the total number of all referrals received (regressions 2a, 2b, and 2c). In each batch of three regressions, the waiting time variable is calculated in a different way.

Consider first regressions 1a - 1c where the dependent variable is based on the number of GP referrals received. In all three regressions waiting time has a negative impact on demand and is statistically significant. The quality of care indicator (**daycases**) is positive in all three regressions but is not significant. The year dummies suggest that demand fell in 1996 but exceeded that in the base year (1995) in each subsequent year. The seasonal dummies suggest that referrals are at their highest level in winter and spring. All three regressions exhibit evidence of mis-specification.

In regressions 2a - 2 the dependent variable is based on the total number of referrals received. Only in the second regression does waiting time have a significant negative impact on demand. The quality of care indicator (**daycases**) is positive but insignificant in all three regressions. The year and seasonal dummies imply similar effects to those noted with GP referrals as the dependent variable. There is no evidence of mis-specification at the 1% significance level. Taken together, both sets of regressions (1a-1c and 2a-2c) imply similar waiting time and year/season effects although one set (1a-1c) shows evidence of mis-specification whereas the other set does not (2a-2c).

Table 43 also reports estimated coefficients on three time invariant variables which we believe may impact on outpatient demand:

(a) the index of need for acute health care (**need**)
(b) the availability of local private beds relative to NHS beds (**private_beds**)
(c) the number of GPs per head of population that the Trust serves (**GP_availability**)

To obtain these coefficients we estimated a supplementary regression, employing the coefficients on the Trust dummies as the dependent variable and regressing them on these time invariant variables. In other words, we are attempting to explain variations in the coefficients on the Trust dummies using those variables which we have been unable to include in the primary fixed effects regression.

The results differ markedly between the GP and all referrals models. With regard to GP referrals, there is evidence that the availability of private health care is associated with a reduction in NHS demand as is GP availability. With regard to all referrals, however, these variables are insignificant in all three regressions (2a -2c) but the need for acute care has a significant positive impact on demand.

Table 44 reports a similar batch of results but these are for routine surgery rather than for all specialties combined. Again, in the first three regressions the dependent variable is based on the number of GP referrals received (regressions 1a, 1b, and 1c) and in the second three the dependent variable is based on the total number of all referrals received (regressions 2a, 2b, and 2c). In each batch of three regressions, the waiting time variable is calculated in a different way.

Overall, the results are similar to those presented for all specialties combined (in Table 43). Again, it was difficult to obtain a significant effect of waiting time on total referral demand. The estimated coefficient on each measure implies that a greater waiting time is associated with lower demand (fewer referrals). The **daycases** variable is insignificant in all six regressions. The year and seasonal dummies imply similar effects to those noted for all specialties (in Table 43) and, again, the three models with GP referrals as the dependent variable show some evidence of mis-specification. The three models with total referrals as the dependent variable now exhibit a little evidence of mis-specification but the waiting time effects are not significant.

Table 44 also reports estimated coefficients on three time invariant variables. The availability of private health care is negatively associated with demand in all six regressions (1a - 2c) and there is some evidence that GP provision has a similar association.

Table 43 Outpatient demand: selected regression results for all specialties

Dependent variable: the number of GP (or all) referrals received divided by the Trust's population

Dependent variable	GP referrals			Total referrals		
Regression number	1a	1b	1c	2a	2b	2c
meanwait_1	-0.090*			-0.057		
<4weekwait_1		0.071*			0.061°	
4-13weekwait_1						
13-26weekwait_1						
1-[>26weekwait]_1			0.427*			0.339
<13weekwait_1						
daycases_1	0.021	0.013	0.024	0.036	0.030	0.039
year96	-0.014°	-0.012	-0.016°	-0.009	-0.007	-0.011
year97	0.015	0.015	0.013	0.034*	0.034*	0.033*
year98	0.033°	0.031°	0.031°	0.048**	0.047*	0.047**
year99	0.042*	0.035°	0.040°	0.067**	0.064**	0.068**
year00	0.061**	0.054*	0.059**	0.096**	0.093**	0.097**
year01	0.066**	0.062**	0.062**	0.112**	0.115**	0.114**
summer	-0.026**	-0.022**	-0.025**	-0.016**	-0.013**	-0.015**
autumn	-0.048**	-0.044**	-0.050**	-0.037**	-0.035**	-0.039**
winter	-0.003	-0.003	-0.004	0.001	0.001	0.001
constant	4.027**	3.571**	1.891*	4.186**	3.839**	2.521*
need	0.001	-0.007	0.014	0.724**	0.716**	0.735**
private_beds	-0.064°	-0.065°	-0.064°	0.016	0.016	0.017
GP_availability	-0.564°	-0.585°	-0.534°	-0.277	-0.304	-0.260
No of obs	4410	4410	4410	4195	4195	4195
R bar squared	0.908	0.908	0.903	0.887	0.887	0.887
RESET test: F =	12.95	19.45	17.25	2.48	2.01	2.80
Prob > F =	0.0000	0.0000	0.0000	0.0595	0.1102	0.0386

Notes to Table 43:

1 In all six regressions the waiting time and day case variables are lagged one period.
2 The base year is 1995 and the base quarter is the first quarter ofthe year running from 1 April to 31 March.
3 °denotes significance at the 10% level, * denotes significance at the 5% level, and ** denotes significance at the 1% level.
4 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition ofthe first three powers ofthe predicted value ofthe dependent variable to the model and a test ofthe joint significance ofthese three variables.
5 The coefficients on about 200 Trust dummies are not reported. These coefficients are regressed on the three time invariant variables to obtain the estimated coefficients on the **need**, **private_beds** and **GP_availability** variables.

Table 44 Outpatient demand: selected regression results for the routine surgical specialties

Dependent variable: the number of GP or all referrals received divided by the Trust's population

Dependent variable	GP referrals			Total referrals		
Regression number	1a	1b	1c	2a	2b	2c
meanwait_1	-0.072°			-0.034		
<4weekwait_1		0.042			0.023	
4-13weekwait_1						
13-26weekwait_1						
1-[>26weekwait]_1			0.299*			0.241
<13weekwait						
daycases	0.037	0.030	0.039	0.055	0.052	0.058
year96	-0.021*	-0.020*	-0.023**	-0.011	-0.010	-0.012
year97	0.001	0.001	0.000	0.021	0.021	0.020
year98	0.025	0.022	0.023	0.033°	0.032°	0.033
year99	0.033	0.025	0.032	0.048*	0.045*	0.051**
year00	0.044°	0.037	0.044°	0.064**	0.061**	0.067**
year01	0.055*	0.051*	0.052*	0.086**	0.085**	0.086**
summer	-0.023**	-0.020**	-0.022**	-0.014**	-0.013**	-0.014**
autumn	-0.044**	-0.042**	-0.046**	-0.040**	-0.039**	-0.042**
winter	-0.005	-0.006	-0.006	-0.009*	-0.009	-0.009*
constant	3.585**	3.272**	2.065**	3.700**	3.543**	2.530**
need	-0.471	-0.474	-0.465	0.287	0.285	0.293
private_beds	-0.161**	-0.162**	-0.161**	-0.076*	-0.076*	-0.075*
GP_availability	-0.773*	-0.754*	-0.755*	-0.469	-0.473	-0.465
No of obs	4320	4320	4321	4105	4105	4106
R bar squared	0.907	0.907	0.907	0.905	0.904	0.905
RESET test: F =	14.88	17.05	17.17	6.39	6.44	6.44
Prob > F =	0.0000	0.0000	0.0000	0.0003	0.0002	0.0002

Notes to Table 44:

1 In all six regressions the waiting time and day case variables are lagged one period.

2 The base year is 1995 and the base quarter is the first quarter of the year running from 1 April to 31 March.

3 °, *, and ** denotes significance at the 10%, 5%, and 1% level respectively.

4 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition of the first three powers of the predicted value of the dependent variable to the model and a test of the joint significance of these three variables.

5 The coefficients on about 200 Trust dummies are not reported. These coefficients are regressed on the four time invariant variables to obtain the estimated coefficients on the **need, private_beds**, and **GP_availability** variables.

10.2.2 Outpatient supply - all specialties and routine surgical specialties

Although almost all of the Trust characteristics variables included in the inpatient supply function relate to inpatient activity, it is not difficult to justify their inclusion in an outpatient supply function. As has been noted above, some of them can be interpreted as indicators of the degree of pressure on (inpatient) resources and it is reasonable to assume that this pressure will also impact on outpatient services. Some of the measures can be interpreted as indicators of quality and it seems reasonable to assume that such indicators, although based on inpatient data, might equally well indicate the quality of outpatient care as the quality of inpatient services. Similarly, some indicate the complexity of inpatient case mix and, again, this might be assumed to also apply to outpatient case mix.

Nevertheless, we began by excluding these variables from the outpatient supply function and then re-estimated with them included in the regression. This enabled us to examine the impact of these other variables on the waiting time coefficient. We therefore began by estimating a supply function by regressing referrals received on an outpatient waiting time variable, six year dummies, three seasonal dummies, and over 200 Trust dummies (whose coefficients are not reported).

Because of the extremely high degree of correlation between the standardised and unstandardised measures of supply, we concentrated on one of these measures, the unstandardised measure, and employed the number of GP (or total) referrals seen (divided by the population) as the dependent variable. Six alternative waiting time measures were available for the outpatient models and all of these were tested in the supply function.

Overall, we found that:

- the logarithmic models performed better than the linear models which were typically mis-specified
- as for inpatients, there was little evidence of an immediate outpatient supply response to waiting time
- the outpatient supply response looks more delayed than the inpatient supply response so that the response we found typically occurred with a two year lag (although there was some evidence of a one year lag for some combinations of supply and waiting time measures). Moreover, once the presence of autocorrelated errors is allowed for, it is difficult to detect a significant supply response.
- the addition of the Trust characteristics variables to the supply function had little impact on the coefficient on waiting time (although some of these characteristics variables were significant)
- the Trust characteristics variables worked equally well whether they entered with a one, four, or even eight period lag
- as was the case for outpatient demand, we obtained better supply results modelling all outpatient referrals rather than just GP referrals

Rather than report all results, we again provide a selection. In Table 45 we report four regression results: two for all specialties (regressions 1a and 1b) and two for the routine surgical specialties (regressions 2a and 2b). In only one regression does the waiting time variable have a significant positive impact on supply (albeit with an eight quarter lag). The year dummies suggest that relative to supply in 1997 (the base year), supply increased in each successive year.[27] There is no coefficient on the year dummy for 2001 as there are no quarterly 'total referrals seen' data for this year. The seasonal dummies imply that supply is larger in both the summer and autumn than in the first quarter of the financial year, but that it is at its maximum in the final quarter (presumably as Trust's seek to achieve their year end targets).[28]

[27]The base year for this regression is 1997. With data from the first quarter of 1995, and an eight quarter lag on the waiting time variable, the first observation in the regression will relate supply in 1997:Q1 to waiting time in1995:Q1.

[28]Supply might also be larger in the final quarter as there tend to be fewer bank holidays in this part of the year and the summer holiday period does not fall within it.

Table 45 Outpatient supply: selected regression results for all referrals

Dependent variable: the number of all outpatient referrals seen divided by the Trust population

Dependent variable	All specialties		Routine surgical specialties	
Regression number	1a	1b	2a	2b
meanwait_8	0.038		0.054*	
<13weekwait_8		-0.082		-0.081
year96				
year97				
year98	0.020**	0.020**	0.021**	0.021**
year99	0.050**	0.050**	0.051**	0.052**
year00	0.071**	0.071**	0.066**	0.066**
year01				
summer	0.020**	0.019**	0.022**	0.021**
autumn	0.021**	0.020**	0.015**	0.014**
winter	0.058**	0.057**	0.048**	0.047**
constant	3.714**	4.161**	3.207**	3.681**
No of obs	2731	2731	2581	2581
F	187.4	187.5	230.2	229.7
R bar squared	0.939	0.939	0.950	0.950
RESET test: F =	3.46	3.49	4.74	5.06
Prob > F =	0.0158	0.0150	0.0027	0.0017

Notes to Table 45:

1 In all four regressions the waiting time variable is lagged eight periods.

2 The base year is 1997 and the base quarter is the first quarter of the year running from 1 April to 31 March.

3 There is no dummy for 2001 as there is no quarterly 'total referrals seen' data for this year.

4 °, *, and ** denote significance at the 10%, 5%, and 1% levels respectively..

5 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition of the first three powers of the predicted value of the dependent variable to the model and a test of the joint significance of these three variables.

6 The coefficients on about 200 Trust dummies are not reported.

To the outpatient supply models presented in Table 45 we added the dozen or so variables that had been included in the inpatient supply function and which were designed to reflect various Trust characteristics. The models with the current period characteristics variables performed poorly but better results were obtained with the characteristics variables lagged one, four or eight periods. To indicate the results obtained, Tables 46 and 47 report these results with the characteristics variables lagged one and four periods respectively.

In Table 46 the all specialty regressions (1a and 1b) show some evidence of mis-specification but are very similar to those for routine surgery (2a and 2b) which demonstrate no evidence of mis-specification (at the 1% level). In two of the four regressions waiting time is significantly positively associated with supply. One way of interpreting the characteristics variables is to view them as indicators of 'pressure on inpatient resources' so that one would expect increased pressure on inpatient resources to be associated with less outpatient supply. Thus the negative coefficient on the **transfers_in** variable suggests that the admission of more complex cases adversely affects the supply of outpatient care. This might be because more complex cases are more resource intensive thus having a negative impact on resources for outpatients.

The positive coefficient on the **research_spend** variable might reflect the fact that the more research-orientated hospitals tend to be in high need areas. The negative coefficient on the deaths from emergency surgery variable (**death_e_surgery**) might again reflect resource pressures: a higher death rate is likely to be associated with longer lengths of stay and the greater use of resources for inpatients leaving fewer resources for other areas including outpatients. The negative sign on the day case variable in the all specialties regression is counter-intuitive: a higher proportion of day cases would require fewer resources leaving more for outpatients. However, we understand that different Trusts report some procedures in different ways so that in one Trust a procedure might be classified under outpatient activity whereas in another it might be recorded as a day case. In this situation the two activities are substitutes and hence the negative sign on this variable.

Table 46 also reports estimated coefficients on four time invariant variables. The number of private beds is significant, with the anticipated sign, in all four regressions. There is also evidence that the nurse vacancy rate adversely affects outpatient supply.

Table 46 Outpatient supply: selected regression results for all referrals

Dependent variable: the number of all outpatient referrals seen divided by the Trust's population

Dependent variable	All specialties		Routine surgical specialties	
Regression number	1a	1b	2a	2b
meanwait_8	0.052°		0.059*	
<13weekwait_8		-0.089		-0.076
occupancy_rate_1	0.101	0.104	0.027	0.037
length_of_stay_1	0.006	0.005	-0.030	-0.032
transfers_in_1	-0.197**	-0.195**	-0.224**	-0.225**
transfers_out_1	0.011	0.009	0.023	0.023
prop_admiss_60+_1	0.062	0.065	-0.007	-0.003
HRG_index_1	0.500	0.463	0.137	0.060
research_spend_1	0.783*	0.774*	0.853*	0.841**
readmission_rate_1	0.051°	0.051°	0.061*	0.062**
death_ne_surgery_1	0.012	0.011	0.022	0.002
death_e_surgery_1	-0.066°	-0.066°	-0.060°	-0.060°
daycases_pc_1	-0.148°	-0.147°	-0.079	-0.079
emergencies_pc_1	-0.066	-0.063	-0.049	-0.045
beds_per_head_1	0.115	0.118	0.116	0.125
year96				
year97				
year98	0.033*	0.032**	0.037**	0.036**
year99	0.064**	0.064**	0.068**	0.067**
year00	0.095**	0.094**	0.087**	0.088**
year01				
summer	0.023**	0.023**	0.026**	0.026**
autumn	0.029**	0.027**	0.025**	0.024**
winter	0.068**	0.067**	0.057**	0.057**
constant	-0.050	0.613	1.338	2.100
private_beds	-0.570*	-0.562*	-0.697*	-0.687*
nurse_vacancy	-0.441**	-0.435**	-0.471**	-0.462**
staff_sickness_rate	-0.133	-0.129	-0.341	-0.338
delayed_discharge	0.136	0.135	0.162	0.161
No of obs	2090	2090	2090	2090
R bar squared	0.931	0.931	0.943	0.943
RESET test: F =	8.28	9.01	2.92	3.63
Prob > F =	0.0000	0.0000	0.0313	0.0124

Notes to Table 46:

1 In all four regressions the waiting time variables are lagged eight quarters and the characteristics variables are lagged one period.

2 The base year is 1997 and the base quarter is the first quarter of the year running from 1 April to 31 March.

3 There is no dummy for 2001 as there is no quarterly 'total referrals seen' data for this year.

4 °denotes significance at the 10% level, * denotes significance at the 5% level, and ** denotes significance at the 1% level.

5 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition of the first three powers of the predicted value of the dependent variable to the model and a test of the joint significance of these three variables.

6 The coefficients on about 200 Trust dummies are not reported. These coefficients are regressed on the four time invariant variables to obtain the estimated coefficients on the **private_beds**, **nurse_vacancy, staff_sickness_rate** and **delayed discharge** variables.

The results in Table 47 are for a similar batch of regressions except that the characteristics variables are now lagged four quarters rather than one quarter. The impact of waiting times on supply is very similar to that shown in Table 46 but the impact of some of the characteristics variables has changed. Thus the **transfers_in** and **death_rate** variables are no longer significant.

The impact of the time invariant variables on supply is similar to that reported in Table 46. Again there is evidence that the availability of private beds and nurse vacancies are negatively associated with supply.

Table 47 Outpatient supply: selected regression results for all referrals

Dependent variables: the number of all outpatient referrals seen divided by the Trust's population

Dependent variable	All specialties		Routine surgical specialties	
Regression number	1a	1b	2a	2b
meanwait_8	0.045		0.051*	
<13weekwait_8		-0.090		-0.076
occupancy_rate_4	0.246°	0.253°	0.226	0.240
length_of_stay_4	-0.067	-0.068	-0.093	-0.094
transfers_in_4	-0.045	-0.044	-0.049	-0.051
transfers_out_4	-0.002	-0.002	0.006	0.006
prop_admiss_60+_4	0.080°	0.083°	0.039	0.043
HRG_index_4	-0.060	-0.072	-0.200	-0.226
research_spend_4	0.119	0.114	0.194	0.183
readmission_rate_4	0.053°	0.052°	0.074*	0.074*
death_ne_surgery_4	0.005	0.005	-0.008	-0.009
death_e_surgery_4	-0.049	-0.049	-0.042	-0.044
daycases_pc_4	-0.080	-0.078	-0.047	-0.044
emergencies_pc_4	-0.054	-0.052	-0.073	-0.070
beds_per_head_4	0.181°	0.184°	0.207*	0.214*
year96				
year97				
year98	0.028*	0.027*	0.033**	0.032**
year99	0.041°	0.040°	0.046**	0.045**
year00	0.064*	0.062*	0.061**	0.060**
year01				
summer	0.022**	0.021**	0.026**	0.025**
autumn	0.024**	0.023**	0.021**	0.020**
winter	0.061**	0.059**	0.052**	0.051**
constant	2.510*	3.038**	2.560*	3.071**
private_beds	-0.094°	-0.089°	-0.223**	-0.215**
nurse_vacancy	-0.083**	-0.080**	-0.121**	-0.115**
staff_sickness_rate	0.137	0.138	-0.039	-0.035
delayed_discharge	0.021	0.021	0.048	0.047
No of obs	2083	2083	2083	2083
R bar squared	0.932	0.932	0.944	0.944
RESET test: F =	5.28	5.78	2.54	2.90
Prob > F =	0.0013	0.0006	0.0551	0.0338

Notes to Table 47:

1 In all four regressions the waiting time variables are lagged eight quarters and the characteristics variables are lagged four periods.
2 The base year is 1997 and the base quarter is the first quarter ofthe year running from 1 April to 31 March.
3 There is no dummy for 2001 as there is no quarterly 'total referrals seen' data for this year.
4 °denotes significance at the 10% level, * denotes significance at the 5% level, and ** denotes significance at the 1% level.
5 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition ofthe first three powers ofthe predicted value ofthe dependent variable to the model and a test ofthe joint significance ofthese three variables.
6 The coefficients on about 200 Trust dummies are not reported. These coefficients are regressed on the four time invariant variables to obtain the estimated coefficients on the **private_beds**, **nurse_vacancy, staff_sickness_rate** and **delayed_discharge** variables.

10.3 Summary of outpatient results for two specialty groupings

In this section we have estimated models of the demand for and supply of outpatient appointments for two specialty groupings: all specialties combined and the routine surgical specialties. Table 48 presents a very brief summary of these results. We constructed four measures of demand, four measures of supply, and six measures of waiting time. Our alternative measures were typically well correlated with each other.

We found that waiting times, lagged one period, had a significant negative effect on demand (as recorded by the number of GP referrals) and that this effect declined as the lag on the waiting time variable increased. With regard to the supply of outpatient appointments, we found it difficult to obtain good models with the dependent variable based on GP referrals alone. For all referrals, however, we had slightly more success and found that waiting times had a positive impact on supply and that the supply response to waiting times was best modelled with an eight quarter lag.[29] We also found that a number of inpatient-related variables (such as the level of research spending and the number of beds) also appeared to be associated with the supply of outpatient services. This effect is probably an indirect one reflecting the fact that more pressure on inpatient resources is associated with less outpatient supply.

We also found that the local availability of private beds was negatively associated with the demand for NHS care as was the nurse vacancy rate. We also found some evidence that the local availability of private care was negatively associated with the supply of NHS outpatient care, particularly in the routine surgical specialties.

[29]This may seem unduly long but our interviews with NHS staff revealed that physical space constraints can be a major problem with outpatients and that securing additional space can be a long process.

Table 48 Summary of some findings from outpatient models for all specialties and routine surgery

(a) demand: GP/all referrals

Specialty grouping	Significant negative effect of waiting time (lag_1) on NHS demand?		Model well specified?		Significant negative impact of private care on NHS demand?	
	GP	all	GP	all	GP	all
All specialties	✔ (-0.090)	✖ (-0.057)	✖	✔	✔	✖
Routine surgery	✔ (-0.072)	✖ (-0.034)	✖	✖	✔	✔

(b) supply: GP/all referrals

Specialty grouping	Significant positive effect of waiting time (lag_8) on NHS supply?		Model well specified?		Significant negative impact of private care on NHS supply?	
	GP	all	GP	all	GP	all
All specialties*	✖	✔ (0.052)	✖	✖	✖	✔
Routine surgery*	✖	✔ (0.059)	✖	✔	✔	✔

Note: *there is a one quarter lag on the non-waiting time variables in these regressions.

11 RESULTS

INDIVIDUAL SPECIALTIES: INPATIENTS

11.1 Introduction

Having presented inpatient and outpatient supply and demand models for two specialty groupings we next report similar models for three individual specialties: urology, orthopaedics, and ENT. In this section the focus is on inpatients while section 12 examines outpatients. A priori, we expected individual specialty results to be poorer than those for the groups of specialties presented above because we have neither a model of the interaction between specialties nor any specialty specific data on Trust characteristics (thus length of stay relates to all specialties not just , say, urology or ENT).

For each individual specialty we again computed five measures of inpatient waiting time but, given our experience of the various demand and supply measures employed with the all specialties model, we focussed the analysis on our preferred measures of supply and demand. For supply this was the number of inpatient admissions divided by the population served by the Trust (**admissions**), and for demand this was the number of additions to the inpatient waiting list divided by the population served by the Trust (**additions**).

Again we do not present all of the regression results but instead report a selection of the better models. All models reported are logarithmic specifications with each observation weighted by the Trust's population. In addition to the fixed effects model reported, we also regressed the Trust dummies on the time invariant variables to obtain an indication of the impact of these variables on demand and supply.

11.2 Inpatient demand: urology

Table 49 reports three pairs of demand regressions for urology. In each pair the waiting time variable is the same but in the first regression of each pair (1a, 2a, 3a) the waiting time variable takes its current value but in the second (1b, 2b, 3b) it is lagged one period. In each pair of regressions, the waiting time variable is significant and has the appropriate negative impact on demand. The coefficient on the waiting time variable declines when the lagged value is employed but remains significant. The quality of care indicator (**daycases**) has the anticipated positive impact on demand but is not significant.

Of the three time invariant variables (**need**, **private_beds**, and **GP_avaialbility**) only the **private_beds** measure is significant and this suggests that the availability of local private care is negatively associated with NHS demand.

There is no evidence of mis-specification in any of the six regressions.

Table 49 Inpatient demand: selected regression results for urology

Dependent variable: the number of decisions to admit divided by the Trust's population

	Current	Lagged	Current	Lagged	Current	Lagged
Regression	1a	1b	2a	2b	3a	3b
meanwait	-0.177**	-0.095**				
3monthwait			-0.080**	-0.046**		
12monthwait					0.661**	0.413°
timetoclear						
listlength						
daycases	0.104	0.110	0.102	0.112	0.124	0.122
year96	-0.028°	-0.033*	-0.027	-0.031	-0.030°	-0.033*
year97						
year98	-0.009	-0.011	-0.018	-0.017	-0.004	-0.009
year99	0.005	-0.013	-0.013	-0.017	0.003	-0.007
year00	-0.034	-0.045	-0.042	-0.047	-0.027	-0.037
year01	-0.045	-0.051	-0.048	-0.054	-0.042	-0.048
summer	0.043**	0.049**	0.041**	0.050**	0.046**	0.047**
autumn	0.031**	0.039**	0.031**	0.038**	0.036**	0.039**
winter	0.046**	0.052**	0.048**	0.052**	0.050**	0.052**
constant	0.361**	0.113	-0.230°	-0.203	-0.101	-0.122
need	0.128	0.189	0.176	0.209	0.171	0.207
private_beds	-0.090	-0.095°	-0.095°	-0.098°	-0.094°	-0.097°
GP_availability	0.365	0.382	0.376	0.385	0.387	0.392
No of obs	2906	2806	2898	2798	2906	2806
R bar squared	0.860	0.859	0.858	0.859	0.855	0.858
RESET test: F =	1.68	0.56	1.83	1.54	0.45	0.92
Prob > F =	0.1681	0.6462	0.1394	0.2011	0.7178	0.4325

Notes to Table 49:

1 In the current period regressions (1a, 2a and 3a) the waiting time and day case variables are the current period values. In the lagged regressions (1b, 2b and 3b) the waiting time and day case variables are lagged one quarter.

2 The **12monthwait** variable is the proportion of patients awaiting admission who have waited **less** than 12 months.

3 There is no coefficient on the dummy variable for 1997 because there is no quarterly decision to admit data for this year. The base year is 1995. The base quarter is spring.

4 °, *, and ** denote significance at the 10%, 5%, and 1% level respectively.

5 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition of the first three powers of the predicted value of the dependent variable to the model and a test of the joint significance of these three variables.

6 The coefficients on the 200 Trust dummies are not reported. These coefficients are regressed on the three time invariant variables to obtain the estimated coefficients on the **need**, **private_beds** and **GP_availability** variables.

11.3 Inpatient demand: orthopaedics

The results for orthopaedics are similar to those for urology. Table 50 reports three pairs of regressions. In each pair the waiting time variable is the same but in the first regression of each pair (1a, 2a, 3a) the waiting time variable takes its current value but in the second (1b, 2b, 3b) it is lagged one period. In each pair of regressions, the waiting time variable is significant and has the appropriate negative impact on demand. The coefficient on the waiting time variable declines when the lagged value is employed but remains significant. The quality of care indicator (**daycases**) has the anticipated positive impact on demand but is insignificant.

Some regressions suggest an increase in inpatient demand (consultant decisions to admit) in every year since 1998 compared with 1995 (there is no dummy for 1997 because there is no quarterly decisions to admit data for this year) and that this increase was at its greatest in 2001. The seasonal dummies imply that demand is significantly higher in the autumn and winter than in spring and summer. There is no evidence of mis-specification in any of the six regressions.

Of the three time invariant variables (**need**, **private_beds**, and **GP_availability**) the first two have a significant effect in all six regressions. As was the case for urology, the availability of local private care is negatively associated with NHS demand. Curiously, the need for acute care has a significant negative effect on demand. Further investigation revealed that this relationship between **need** and demand was probably quadratic with a negative relationship at low levels of need but a positive relationship at high levels of need.[30] A positive relationship between need and demand had been anticipated and our inability to detect this might reflect the way which we have measured 'need'.

[30] We regressed the coefficients on the Trust dummies on the three time invariant variables but replaced **need** with its unlogged value and this value squared. Both coefficients on the needs variables were significant at the 10% level and implied a U-shaped relationship with demand at first decreasing and then increasing with need. The coefficient on the **private_beds** variable was little changed and remained significant.

Table 50 Inpatient demand: selected regression results for orthopaedics

Dependent variable: the number of decisions to admit divided by the Trust's population

	Current	Lagged	Current	Lagged	Current	Lagged
Regression	1a	1b	2a	2b	3a	3b
meanwait	-0.235**	-0.141**				
3monthwait			-0.203**	-0.095**		
12monthwait					0.780**	0.625**
timetoclear						
listlength						
daycases	0.057	0.064	0.048	0.062	0.072	0.074
year96	0.010	-0.005	0.010	-0.003	-0.000	-0.011
year97						
year98	0.056*	0.033	0.039°	0.019	0.045*	0.031
year99	0.078**	0.055*	0.061*	0.042°	0.070**	0.055*
year00	0.076**	0.055*	0.057*	0.040	0.069**	0.057*
year01	0.094**	0.076**	0.083**	0.066*	0.081**	0.075**
summer	0.002	0.003	-0.000	0.002	0.002	0.003
autumn	0.033**	0.038**	0.031**	0.036**	0.034**	0.038**
winter	0.023**	0.028**	0.025**	0.027**	0.023**	0.028**
need	-1.862**	-1.843**	-1.858**	-1.831**	-1.855**	-1.852**
private_beds	-0.342**	-0.345**	-0.350**	-0.350**	-0.335**	-0.338**
GP_availability	-0.819	-0.809	-0.798	-0.788	-0.797	-0.806
constant	1.286**	1.004**	0.453**	0.517**	0.645**	0.637**
No of obs	3592	3465	3589	3463	3592	3465
R bar squared	0.918	0.917	0.918	0.916	0.917	0.918
RESET test: F =	0.30	1.87	0.50	4.16	1.54	2.89
Prob > F =	0.8279	0.1332	0.6792	0.0059	0.2000	0.0339

Notes to Table 50:

1 In the current period regressions (1a, 2a and 3a) the waiting time and day case variables are the current period values. In the lagged regressions (1b, 2b and 3b) the waiting time and day case variables are lagged one quarter.

2 The **12monthwait** variable is the proportion of patients awaiting admission who have waited **less** than 12 months.

3 There is no coefficient on the dummy variable for 1997 because there is no quarterly decision to admit data for this year. The base year is 1995. The base quarter is spring.

4 °, *, and ** denote significance at the 10%, 5%, and 1% level respectively.

5 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition of the first three powers of the predicted value of the dependent variable to the model and a test of the joint significance of these three variables.

6 The coefficients on the 200 Trust dummies are not reported. These coefficients are regressed on the three time invariant variables to obtain the estimated coefficients on the **need**, **private_beds** and **GP_availability** variables.

11.4 Inpatient demand: ENT

The results for ENT are slightly different to those for orthopaedics and urology. Table 51 reports three pairs of regressions. In each pair the waiting time variable is the same but in the first regression of each pair (1a, 2a, 3a) the waiting time variable takes its current value but in the second (1b, 2b, 3b) it is lagged one period. In each pair of regressions, the waiting time variable is significant and has the appropriate negative impact on demand. The coefficient on the waiting time variable declines when the lagged value is employed but remains significant. The quality of care indicator (**daycases**) is not significant in any of the six regressions.

All six regressions suggest a significant decrease in inpatient demand (consultant decisions to admit) in every year since 1998 compared with 1995 (there is no dummy for 1997 because there is no quarterly decisions to admit data for this year) and that this decrease reached its zenith in 2001. The seasonal dummies suggest that demand peaks in the winter and is at its lowest in the summer. Five of the six regressions show no evidence of mis-specification at the 0.1% level.

With regard to the three time invariant variables (**need**, **private_beds**, and **GP_availability**), **need** has the anticipated positive impact on demand in all six regressions, and **GP_availability** has a negative effect. The availability of local private care is negatively associated with NHS demand but this effect is not statistically significant.

Table 51 Inpatient demand: selected regression results for ENT

Dependent variable: the number of decisions to admit divided by the Trust's population

	Current	Lagged	Current	Lagged	Current	Lagged
Regression	1a	1b	2a	2b	3a	3b
meanwait	-0.135**	-0.075*				
3monthwait			-0.082**	-0.040*		
12monthwait					0.597**	0.487**
timetoclear						
listlength						
daycases	-0.050	0.044	-0.041	-0.040	-0.051	-0.048
year96	-0.015	-0.012	-0.018	-0.012	-0.016	-0.013
year97						
year98	-0.043*	-0.051*	-0.056*	-0.059**	-0.045*	-0.048*
year99	-0.064*	-0.063*	-0.076**	-0.070**	-0.060*	-0.058*
year00	-0.073**	-0.072**	-0.082**	-0.077**	-0.071**	-0.067*
year01	-0.098**	-0.100**	-0.105**	-0.104**	-0.107**	-0.100**
summer	-0.047**	-0.042**	-0.048**	-0.042**	-0.049**	-0.042**
autumn	-0.030**	-0.022**	-0.032**	-0.022**	-0.031**	-0.024**
winter	0.015°	0.025**	0.016*	0.025**	0.016*	0.024**
need	1.088*	1.096*	1.095*	1.104*	1.098*	1.100*
private_beds	-0.057	-0.064	-0.064	-0.069	-0.064	-0.064
GP_availability	-1.115°	-1.163*	-1.124°	-1.168*	-1.132*	-1.174*
constant	0.855**	0.660**	0.403**	0.409**	0.492**	0.473**
No of obs	2785	2674	2777	2666	2785	2674
R bar squared	0.897	0.900	0.897	0.898	0.897	0.900
RESET test: F =	5.88	4.17	5.18	3.59	4.49	3.58
Prob > F =	0.0005	0.0059	0.0014	0.0132	0.0038	0.0134

Notes to Table 51:

1 In the current period regressions (1a, 2a and 3a) the waiting time and day case variables are the current period values. In the lagged regressions (1b, 2b and 3b) the waiting time and day case variables are lagged one quarter.

2 The **12monthwait** variable is the proportion of patients awaiting admission who have waited **less** than 12 months.

3 There is no coefficient on the dummy variable for 1997 because there is no quarterly decision to admit data for this year. The base year is 1995. The base quarter is spring.

4 °, *, and ** denote significance at the 10%, 5%, and 1% level respectively.

5 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition of the first three powers of the predicted value of the dependent variable to the model and a test of the joint significance of these three variables.

6 The coefficients on the 200 Trust dummies are not reported. These coefficients are regressed on the three time invariant variables to obtain the estimated coefficients on the **need**, **private_beds** and **GP_availability** variables.

11.5 Inpatient supply: urology

Our approach to estimating supply models for individual specialties was the same as that adopted for all specialties combined. We found that the best models tended to be those with a four quarter lag on the waiting time variable and a one quarter lag on the other explanatory variables. Although we focussed on a single measure of supply - the number of admissions divided by the Trust's population - we experimented with five waiting time measures.

We found it difficult to obtain good supply models for urology. The best model is presented as regression 1 in Table 52. The waiting time measure is significant and has the anticipated positive effect on supply. That the proportion of admissions where the patient is aged over 60 (**prop_admiss_60+**) should have a positive impact on supply is at first surprising but might reflect the fact that admissions from this age group tend to be for the more routine, less resource intensive, procedures (Soderlund and van der Merwe, 1999). As expected, complexity of case mix (**HRG_index**) is negatively associated with supply so that the more complex cases reduce the number of admissions (presumably through requiring a longer length of stay in hospital). The sign on the readmission rate variable is also as anticipated. There is evidence of mis-specification in this regression.

With regard to the time invariant variables, three are statistically insignificant but the availability of local private beds relative to NHS beds (**private_beds**) has the anticipated negative association with NHS supply.

Table 52 Inpatient supply: selected regression results for urology and for orthopaedics

Dependent variable: the number of admissions divided by the Trust's population (**admissions**)

	Urology	Orthopaedics		
Regression number	1	2a	2b	2c
meanwait_4		0.052		
3monthwait_4			0.036	
12monthwait_4				
timetoclear_4				
listlength_4	0.078**			0.102**
occupancy_rate_1	0.086	0.243	0.248	0.228
length_of_stay_1	-0.052	0.002	0.004	-0.014
transfers_in_1	-0.024	0.024	0.024	0.025
transfers_out_1	0.039	0.046**	0.047**	0.050**
prop_admiss_60+_1	0.206*	-0.047	-0.053	-0.043
HRG_index_1	-1.592*	-1.318*	-1.258*	-1.233*
research_spend_1	0.192	0.724*	0.732*	0.688*
readmission_rate_1	-0.427*	-0.237	-0.242	-0.263
death_ne_surgery_1	0.123°	-0.025	-0.026	-0.020
death_e_surgery_1	-0.124	-0.124	-0.125	-0.120
daycases_pc_1	0.191°	0.030	0.034	0.017
emergencies_pc_1	0.245	-0.219°	-0.217°	-0.220°
beds_per_head_1	0.147	0.412**	0.409**	0.406**
year96				
year97				
year98	0.060	0.181**	0.189**	0.163**
year99	0.001	0.154*	0.161**	0.142**
year00	-0.015	0.154	0.161**	0.146**
year01	-0.040	0.142	0.149**	0.135**
summer	0.080**	0.030**	0.030**	0.031**
autumn	0.055**	0.018*	0.018*	0.017*
winter	0.078**	0.048**	0.047**	0.049**
constant	10.977**	7.550*	7.619*	7.615*
private_beds	-0.235*	-0.781**	-0.788**	-0.777**
nurse_vacancy	-0.068	-0.410**	-0.413**	-0.404**
staff_sickness_rate	0.125	-0.592	-0.600	-0.587
delayed_discharge	-0.014	0.186	0.187	0.184
No of obs	1893	2294	2294	2294
R bar squared	0.858	0.923	0.923	0.924
RESET test: F =	13.18	1.71	2.23	2.44
Prob > F =	0.0000	0.1627	0.0829	0.0629

Notes for Table 52:

1 The waiting time variable is lagged four quarters. The other explanatory variables are lagged one quarter. The numeric suffix on the variable name denotes the lag length; thus meanwait4 is meanwait lagged four periods.

2 The **12monthwait** variable is the proportion of patients awaiting admission who have waited **less** than 12 months.

3 There is no coefficient on the dummy variable for 1997 because there is no decision to admit data for this year. The base year is 1996.

4 °denotes significance at the 10% level, * denotes significance at the 5% level, and ** denotes significance at the 1% level.

5 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition of the first three powers of the predicted value of the dependent variable to the model and a test of the joint significance of these three variables.

6 The coefficients on the 200 or so Trust dummies are not reported. These coefficients are regressed on the four time invariant variables to obtain the estimated coefficients on the **private_beds**, **nurse_vacancy, staff_sickness_rate** and **delayed_discharge** variables.

11.6 Inpatient supply: orthopaedics

We found it much easier to obtain a number of good supply models for orthopaedics. Three models, each with a different waiting time variable, are presented as regressions 2a - 2c in Table 52. In all three cases waiting time has a positive impact on supply but in only one of these is it statistically significant. The significant coefficients on **transfers_out, HRG_index,** and **research_spend** are as anticipated and, again as expected, supply is positively associated with the number of beds per head of catchment population (**beds_per_head**).

The estimated coefficients on two of the four time invariant variables are also significant suggesting:

- that the availability of local private beds relative to NHS beds is negatively associated with NHS supply; and
- that the qualified nursing, midwifery & health visiting professionals vacancy rate has a negative impact on NHS supply.

There is no evidence of mis-specification in these three regressions.

11.7 Inpatient supply: ENT

Four inpatient supply models for ENT, each with a different waiting time variable, are presented as regressions 1a - 1d in Table 53. In all four cases, waiting time has a positive impact on supply. The negative coefficient on **transfers_in** implies that the greater the proportion of spells that commence with a transfer from another hospital the lower the number of admissions. This is plausible: if a hospital is importing more complex cases then this is likely to leave less capacity for the more routine cases. Again, and as expected, supply is positively associated with the number of beds per head of catchment population (**beds_per_head**). There is no evidence of mis-specification in any of the four regressions.

With regard to the time invariant variables, we were unable to obtain any significant results.

Table 53 Inpatient supply: selected regression results for ENT

Dependent variable: the number of admissions divided by the Trust's population (**admissions**)

	ENT			
Regression number	1a	1b	1c	1d
meanwait_4	0.078*			
3monthwait_4		0.033°		
12monthwait_4			-0.534**	
timetoclear_4				
listlength_4				0.118**
occupancy_rate_1	-0.126	-0.136	-0.151	-0.130
length_of_stay_1	-0.033	-0.023	-0.025	-0.053
transfers_in_1	-0.126**	-0.126**	-0.124**	-0.120**
transfers_out_1	0.026°	0.029*	0.026*	0.018
prop_admiss_60+_1	-0.137*	-0.142*	-0.136**	-0.109*
HRG_index_1	0.352	0.414	0.321	0.193
research_spend_1	-0.472	-0.476	-0.469	-0.375
readmission_rate_1	-0.129	-0.141	-0.145	-0.119
death_ne_surgery_1	0.004	0.007	0.006	0.018
death_e_surgery_1	0.021	0.024	0.034	-0.032
daycases_pc_1	-0.078	-0.076	-0.082	-0.062
emergencies_pc_1	-0.188	-0.181	-0.186	-0.173
beds_per_head_1	0.441**	0.426*	0.401*	0.449**
year96				
year97				
year98	0.126**	0.139**	0.121**	0.119**
year99	0.032	0.044	0.026	0.040
year00	-0.005	0.005	-0.013	0.018
year01	-0.036	-0.028	-0.044	-0.012
summer	0.041**	0.041**	0.042**	0.050**
autumn	0.009	0.010	0.010	0.018
winter	-0.014	-0.015	-0.014	-0.007
private_beds	0.247	0.252	0.240	0.179
nurse_vacancy	0.184	0.185	0.180	0.148
staff_sickness_rate	0.483	0.464	0.478	0.441
delayed_discharge	-0.069	-0.069	-0.068	-0.067
constant	-0.848	-0.748	-0.368	0.257
No of obs	1796	1791	1796	1796
R bar squared	0.909	0.907	0.908	0.911
RESET test: F =	2.00	1.85	1.80	2.73
Prob > F =	0.1118	0.1360	0.1449	0.0426

Notes for Table 53:

1 The waiting time variable is lagged four quarters. The other explanatory variables are lagged one quarter. The numeric suffix on the variable name denotes the lag length; thus meanwait_4 is meanwait lagged four periods.

2 The **12monthwait** variable is the proportion of patients awaiting admission who have waited **less** than 12 months.

3 There is no coefficient on the dummy variable for 1997 because there is no decision to admit data for this year. The base year is 1996.

4 °denotes significance at the 10% level, * denotes significance at the 5% level, and ** denotes significance at the 1% level.

5 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition of the first three powers of the predicted value of the dependent variable to the model and a test of the joint significance of these three variables.

6 The coefficients on the 200 or so Trust dummies are not reported. These coefficients are regressed on the four time invariant variables to obtain the estimated coefficients on the **private_beds**, **nurse_vacancy, staff_sickness_rate** and **delayed_discharge** variables.

11.8 Summary of inpatient results for individual specialties

In this section we have estimated models of the demand for and supply of elective surgery for three specialties: urology, orthopaedics, and ENT. Table 54 presents a very brief summary of these results.

We constructed five measures of waiting time. Our alternative measures were typically well correlated with each other. We found that waiting times had a significant negative effect on demand in all three specialties and that this effect declined as the lag on the waiting time variable increased. We also found that the local availability of private beds was negatively associated with the demand for NHS care in two of the three specialties (but not in ENT).

With regard to the supply of inpatient care, we found that waiting times had a positive impact on supply and that the supply response to waiting times was best modelled with a four quarter lag. We were able to obtain a well-specified model for two of the three specialties. We also found that a number of other variables (such as the number of beds and the number of transfers) affected the supply of elective care. There was also a role for the private sector in the supply on NHS care for two specialties: the local availability of private beds was negatively associated with the supply of NHS care in both urology and orthopaedics.

Table 54 Summary of findings from the inpatient models for individual specialties

(a) demand

Specialty grouping	Significant negative effect of waiting time on NHS demand (coefficient on *meanwait* where applicable)? lag_0	lag_1	Model well specified?	Significant negative impact of private care on NHS demand (coefficient on *private_beds* from model with *meanwait*)?
Urology	✔ (-0.177)	✔ (-0.095)	✔	✔
Orthopaedics	✔ (-0.235)	✔ (-0.141)	✔	✔
ENT	✔ (-0.135)	✔ (-0.075)	✔	✗

(b) supply

Specialty grouping	Significant positive effect of waiting time on NHS supply (coefficient on *meanwait* where applicable)? lag_4	Model well specified?	Significant negative impact of private care on NHS supply (coefficient on *private_beds* from model with *meanwait*)?
Urology*	✔	✗	✔
Orthopaedics*	✔ (0.052)	✔	✔
ENT*	✔ (0.078)	✔	✗

Note: *there is a one quarter lag on the non-waiting time variables in these regressions.

12 RESULTS

INDIVIDUAL SPECIALTIES: OUTPATIENTS

12.1 Introduction

Having estimated inpatient supply and demand models for urology, orthopaedics, and ENT, we now report similar outpatient models.

For each specialty we computed six measures of outpatient waiting time (as defined in section 7.1.6). However, given our experience of the various outpatient demand and supply measures employed with the all specialties model, we restricted the analysis to our preferred measures of supply and demand:

- the number of GP referrals seen/received divided by the population served by the Trust (**GPreferrals** and **GPreferseen**); and
- the total number of all referrals seen/received divided by the population served by the Trust (**allreferrals** and **allreferseen**).

Again, we do not present all of the regression results but instead report a selection of the better models. All models reported are logarithmic specifications with each observation weighted by the Trust's population. In addition to estimating the basic fixed effects model, we also regressed the Trust dummies on the time invariant variables to obtain an indication of the impact of these variables on demand or supply.

12.2 Outpatient demand: urology

Two pairs of outpatient demand regressions for urology can be found in Table 55. In each pair the waiting time variable is the same but in the first regression of each pair (1a, 2a) the waiting time and daycase variables take their current values but in the second (1b, 2b) they are lagged one period. In each pair of regressions, the waiting time variable is significant and has the appropriate negative impact on demand. The coefficient on the waiting time variable declines when the lagged value is employed but remains significant. The quality of care indicator (**daycases**) has no significant impact on demand.

All four regressions suggest a reduction in outpatient demand in 1996 and 1997 relative to 1995 but thereafter demand significantly exceeded that in the base year. Outpatient demand for urology seems to be at its greatest in the winter quarter.

Of the three time invariant variables (**need**, **private_beds**, and **GP_availability**) only the latter two are significant. In all four regressions both the availability of local private care and GP availability have a negative effect on NHS outpatient demand. There is no evidence of mis-specification in any of the four regressions.

Table 56 is similar to its predecessor except that the dependent variable is now the number of referrals received from all sources divided by the Trust's population. The waiting time variable is significant in three of the four regressions and has a negative effect on NHS demand. The daycase variable (a potential proxy for quality of care) remains insignificant. Of the three time invariant variables only **GP_availability** is significant and this has the by now familiar negative effect on demand. There is no evidence of mis-specification in any of the four regressions.

Table 55 Outpatient demand: selected regression results for GP referrals to urology

Dependent variable: the number of GP referrals received divided by the Trust's population

Regression number	1a	1b	2a	2b
Explanatory variables	current	lagged	current	lagged
meanwait	-0.067*	-0.055*		
<4weekwait				
4-13weekwait				
13-26weekwait				
1-[>26weekwait]			-0.323**	-0.261**
<13weekwait				
daycases	-0.009	-0.000	-0.008	-0.004
year96	-0.037*	-0.033*	-0.040**	-0.035*
year97	-0.045°	-0.043°	-0.044°	-0.042°
year98	0.056	0.055	0.053	0.055**
year99	0.072°	0.073°	0.071°	0.072°
year00	0.084°	0.088*	0.083°	0.088*
year01	0.104*	0.108*	0.105*	0.108*
summer	-0.007	-0.003	-0.007	-0.004
autumn	0.023**	0.029**	0.026**	0.028**
winter	0.050**	0.053**	0.052**	0.055**
constant	0.800**	0.750**	-0.815°	-0.557
need	-0.368	-0.404	-0.373	-0.404
private_beds	-0.098*	-0.102*	-0.101*	-0.104*
GP_availability	-0.847*	-0.853*	-0.829*	-0.841*
No of obs	3911	3754	3926	3781
R bar squared	0.812	0.819	0.813	0.818
RESET test: F =	2.22	2.70	1.42	2.15
Prob > F =	0.0841	0.0439	0.2363	0.0924

Notes to Table 55:

1 In regressions 1a and 2a the waiting time and daycase variables take their current values. In regressions 1b and 2b they are lagged one

2 The base year is 1995 and the base quarter is the first quarter ofthe year running from 1 April to 31 March (spring).

3 °denotes significance at the 10% level, * denotes significance at the 5% level, and ** denotes significance at the 1% level.

4 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition ofthe first three powers ofthe predicted value ofthe dependent variable to the model and a test ofthe joint significance ofthese three variables.

5 The coefficients on about 200 Trust dummies are not reported. These coefficients are regressed on the three time invariant variables to obtain the estimated coefficients on the **need**, **private_beds** and **GP_availability** variables.

Table 56 Outpatient demand: selected regression results for all referrals to urology

Dependent variable: the number of all referrals received divided by the Trust's population

Regression number	1a	1b	2a	2b
Explanatory variables	current	lagged	current	lagged
meanwait	-0.049°	-0.042		
<4weekwait				
4-13weekwait				
13-26weekwait				
1-[>26weekwait]			-0.238**	-0.198*
<13weekwait				
daycases	0.033	0.034	0.032	0.038
year96	-0.051**	-0.047**	-0.053**	-0.047**
year97	-0.047*	-0.046*	-0.046*	-0.043*
year98	0.046	0.048°	0.045	0.049°
year99	0.065°	0.067*	0.065°	0.068*
year00	0.095**	0.099**	0.095**	0.100**
year01	0.120**	0.124**	0.121**	0.126**
summer	0.003	0.006	0.003	0.006
autumn	0.027**	0.032**	0.030**	0.032**
winter	0.052**	0.055**	0.054**	0.056**
constant	0.951**	0.898**	-0.242	-0.094
need	0.118	0.082	0.142	0.080
private_beds	0.005	0.003	0.001	0.000
GP_availability	-0.735°	-0.738°	-0.702°	-0.732°
No of obs	3766	3624	3781	3651
R bar squared	0.827	0.834	0.827	0.833
RESET test: F =	3.31	3.91	2.32	3.12
Prob > F =	0.0190	0.0084	0.0737	0.0250

Notes to Table 56:

1 In regressions 1a and 2a the waiting time and daycase variables take their current values. In regressions 1b and 2b they are lagged one

2 The base year is 1995 and the base quarter is the first quarter ofthe year running from 1 April to 31 March (spring).

3 °denotes significance at the 10% level, * denotes significance at the 5% level, and ** denotes significance at the 1% level.

4 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition ofthe first three powers ofthe predicted value ofthe dependent variable to the model and a test ofthe joint significance ofthese three variables.

5 The coefficients on about 200 Trust dummies are not reported. These coefficients are regressed on the three time invariant variables to obtain the estimated coefficients on the **need**, **private_beds** and **GP_availability** variables.

12.3 Outpatient demand: orthopaedics

Table 57 reports two pairs of regressions seeking to explain variations in the number of GP referrals received at orthopaedic clinics. In each pair the waiting time variable is the same but in the first regression of each pair (1a, 2a) the waiting time and daycase variables take their current values but in the second (1b, 2b) they are lagged one period. In each pair of regressions, the waiting time variable is significant and has the appropriate negative impact on demand. The coefficient on the waiting time variable declines when the lagged value is employed but remains significant. The quality of care indicator (**daycases**) is insignificant.

All four regressions suggest that this measure of outpatient demand is at its greatest in the base quarter (spring) and at its lowest in the autumn.

Of the three time invariant variables (**need**, **private_beds**, and **GP_availability**) only the first two are significant. Surprisingly, the coefficient on **need** is negative although further investigation revealed that the relationship between demand and **need** is negative at low levels of need but positive at high levels.[31] The coefficient on **private_beds** is negative across all four regressions and there is no evidence of mis-specification in any of the four regressions.

With regard to all (as opposed to GP) referrals to orthopaedics, we were unable to obtain a model that was not mis-specified. Nevertheless, we were able to obtain models where waiting time has a significant negative impact on demand. For example, the coefficient on the **meanwait** variable was -0.103 and this was significant at the 1% level. Regressing the Trust dummies on the time invariant variables again suggested that the local availability of private health care has a negative effect on NHS supply.

---

[31] We regressed the coefficients on the Trust dummies on the three time invariant variables but replaced **need** with its unlogged value and this value squared. Both coefficients on the needs variables were significant at the 10% level and implied a U-shaped relationship with demand at first decreasing and then increasing with need. The coefficient on the **private_beds** variable was little changed and remained significant.

Table 57 Outpatient demand: selected regression results for GP referrals to orthopaedics

Dependent variable: the number of GP referrals received divided by the Trust's population

Regression number	1a	1b	2a	2b
Explanatory variables	current	lagged	current	lagged
meanwait	-0.211**	-0.173**		
<4weekwait				
4-13weekwait				
13-26weekwait				
1-[>26weekwait]			0.404**	0.357**
<13weekwait				
daycases	0.057	0.091	0.057	0.091
year96	-0.011	-0.021	-0.012	-0.023
year97	0.021	0.003	0.012	-0.005
year98	0.039	0.016	0.027	0.007
year99	0.054	0.029	0.043	0.019
year00	0.045	0.028	0.037	0.021
year01	0.030	0.015	0.020	0.008
summer	-0.020**	-0.033**	-0.028**	-0.029**
autumn	-0.076**	-0.095**	-0.086**	-0.098**
winter	-0.034**	-0.051**	-0.042**	-0.055**
constant	2.159**	2.121**	-0.159	0.096
need	-1.188*	-1.226*	-1.157*	-1.186*
private_beds	-0.246**	-0.245**	-0.247**	-0.246**
GP_availability	-0.928	-0.946	-0.897	-0.924
No of obs	3830	3689	3839	3700
R bar squared	0.918	0.916	0.917	0.917
RESET test: F =	5.10	0.67	2.31	0.46
Prob > F =	0.0016	0.5710	0.0739	0.7114

Notes to Table 57:

1 In regressions 1a and 2a the waiting time and daycase variables take their current values. In regressions 1b and 2b they are lagged one period.

2 The base year is 1995 and the base quarter is the first quarter ofthe year running from 1 April to 31 March (spring).

3 °denotes significance at the 10% level, * denotes significance at the 5% level, and ** denotes significance at the 1% level.

4 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition ofthe first three powers ofthe predicted value ofthe dependent variable to the model and a test ofthe joint significance ofthese three variables.

5 The coefficients on about 200 Trust dummies are not reported. These coefficients are regressed on the three time invariant variables to obtain the estimated coefficients on the **need**, **private_beds** and **GP_availability** variables.

12.4 Outpatient demand: ENT

The results for ENT follow a similar pattern to those for urology. Table 58 reports two pairs of regressions seeking to explain variations in the number of GP referrals received at ENT clinics. In each pair the waiting time variable is the same but in the first regression of each pair (1a, 2a) the waiting time and daycase variables take their current values but in the second (1b, 2b) they are lagged one period. In each pair of regressions, the waiting time variable is significant and has the appropriate negative impact on demand. The coefficient on the waiting time variable declines when the lagged value is employed but remains significant. The quality of care indicator (**daycases**) has been omitted from these models as its inclusion results in a mis-specified model. Its omission has very little impact on the waiting time coefficient.

All four regressions suggest that this measure of outpatient demand is at its greatest in the spring and winter quarters and at its lowest in the autumn. There is no discernible trend in the annual number of referrals.

Of the three time invariant variables (**need**, **private_beds**, and **GP_avaialbility**) only the latter two are significant. In all four regressions both the availability of local private care and GP availability have a negative effect on NHS outpatient demand. There is no evidence of mis-specification in any of the four regressions.

Table 59 is similar to its predecessor except that the dependent variable is now the number of orthopaedic referrals received from all sources (not just GPs) divided by the Trust's population. The waiting time variable is again significant in all four regressions and has a negative effect on NHS demand. The **daycase** variable still induces mis-specification and so is omitted from the regression. Of the three time invariant variables only **private_beds** and **GP_availability** are significant and these have the by now familiar negative effect on demand. There is no evidence of mis-specification in any of the four regressions.

Table 58 Outpatient demand: selected regression results for GP referrals to ENT

Dependent variable: the number of GP referrals received divided by the Trust's population

Regression number	1a	1b	2a	2b
Explanatory variables	current	lagged	current	lagged
meanwait	-0.090**	-0.076**		
<4weekwait				
4-13weekwait				
13-26weekwait				
1-[>26weekwait]			0.154**	0.087°
<13weekwait				
daycases				
year96	-0.026*	-0.032*	-0.023*	-0.029*
year97	-0.007	-0.015	-0.005	-0.012
year98	0.001	-0.010	-0.004	-0.013
year99	0.011	-0.002	0.002	-0.007
year00	0.026	0.020	0.020	0.012
year01	0.012	0.005	0.006	-0.002
summer	-0.049**	-0.057**	-0.053**	-0.055**
autumn	-0.062**	-0.066**	-0.065**	-0.068**
winter	0.009	0.006	0.006	0.004
constant	1.425**	1.405**	0.539*	0.857**
need	-0.481	-0.491	-0.435	-0.450
private_beds	-0.175**	-0.178**	-0.178**	-0.182**
GP_availability	-0.885*	-0.906*	-0.885*	-0.904*
No of obs	3847	3692	3885	3734
R bar squared	0.855	0.856	0.856	0.858
RESET test: F =	4.97	3.50	1.82	1.19
Prob > F =	0.0019	0.0149	0.1404	0.3129

Notes to Table 58:

1 In regressions 1a and 2a the waiting time variables take their current values. In regressions 1b and 2b they are lagged one period.

2 The base year is 1995 and the base quarter is the first quarter ofthe year running from 1 April to 31 March (spring).

3 °denotes significance at the 10% level, * denotes significance at the 5% level, and ** denotes significance at the 1% level.

4 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition ofthe first three powers ofthe predicted value ofthe dependent variable to the model and a test ofthe joint significance ofthese three variables.

5 The coefficients on about 200 Trust dummies are not reported. These coefficients are regressed on the three time invariant variables to obtain the estimated coefficients on the **need**, **private_beds** and **GP_availability** variables.

Table 59 Outpatient demand: selected regression results for all referrals to ENT

Dependent variable: the number of all referrals received divided by the Trust's population

Regression number	1a	1b	2a	2b
Explanatory variables	current	lagged	current	lagged
meanwait	-0.068**	-0.059*		
<4weekwait				
4-13weekwait				
13-26weekwait				
1-[>26weekwait]			0.126**	0.077°
<13weekwait				
daycases				
year96	-0.025*	-0.030*	-0.023°	-0.028*
year97	-0.005	-0.010	-0.002	-0.007
year98	0.004	-0.004	0.002	-0.005
year99	0.011	0.005	0.007	-0.000
year00	0.039°	0.034	0.036	0.029
year01	0.035**	0.031	0.032	0.028
summer	-0.045**	-0.050**	-0.047**	-0.048**
autumn	-0.054**	-0.055**	-0.055**	-0.057**
winter	0.013*	0.011	0.011*	0.011°
constant	1.647**	1.624**	0.932**	1.150**
need	-0.079	-0.070	-0.022	-0.018
private_beds	-0.144**	-0.147**	-0.145**	-0.149**
GP_availability	-0.909*	-0.916*	-0.906*	-0.913*
No of obs	3709	3573	3746	3614
F	131.5	128.6	133.4	130.8
R bar squared	0.862	0.864	0.864	0.866
RESET test: F =	2.42	2.24	0.78	0.46
Prob > F =	0.0645	0.0810	0.5022	0.7106

Notes to Table 59:

1 In regressions 1a and 2a the waiting time variables take their current values. In regressions 1b and 2b they are lagged one period.

2 The base year is 1995 and the base quarter is the first quarter ofthe year running from 1 April to 31 March (spring).

3 °denotes significance at the 10% level, * denotes significance at the 5% level, and ** denotes significance at the 1% level.

4 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition ofthe first three powers ofthe predicted value ofthe dependent variable to the model and a test ofthe joint significance ofthese three variables.

5 The coefficients on about 200 Trust dummies are not reported. These coefficients are regressed on the three time invariant variables to obtain the estimated coefficients on the **need**, **private_beds** and **GP_availability** variables.

12.5 Outpatient supply: urology

Our approach to estimating supply models for individual specialties was the same as that adopted for all specialties combined. We found that the best models tended to be those with an eight quarter lag on the waiting time variable and a one quarter lag on the other explanatory variables (where these were included in the model). Although we focussed on two measures of supply - the number of GP referrals seen and all referrals seen - we experimented with the same six waiting time measures as were employed in the outpatient demand models.

Table 60 presents a batch of outpatient supply models for urology. The first four regressions (1a - 1d) employ GP referrals seen as the dependent variable whereas the latter two regressions (2a - 2b) use the total number of referrals seen. For each waiting time measure there are two regressions: one without any Trust characteristics variables and the other with such variables. Remember that these characteristics variables typically refer to inpatient activity and can be interpreted as indicators of the degree of pressure on resources. It is to be expected that more pressure on inpatient resources will have an adverse impact on outpatient supply.

In all four of the GP referral regressions (1a - 1d) waiting time has a positive impact on outpatient supply. These results also suggest that supply has exceeded the level achieved in the base year (1997) in every year since then. The seasonal dummies suggest that supply is at its greatest in the final (winter) quarter.

Most of the significant coefficients on the characteristics variables are also plausible. It is to be anticipated that more beds per head would reduce pressure on inpatient activity (ceteris paribus) and thus facilitate more outpatient activity. Hence the positive sign on the **beds_per_head** variable in regressions 1b and 1d is as anticipated.[32] The positive coefficient on the **research_spend** variable might reflect the fact that the more research-orientated hospitals tend to be in high need areas. The negative sign on the day case variable is counterintuitive: more day cases would suggest fewer resources for inpatients leaving more for outpatients. However, we understand that different Trusts report some procedures in different ways so that in one Trust a procedure might be classified under outpatient activity whereas in another it might be recorded as a day case. In this situation the two activities are substitutes and hence the negative sign on this variable. The positive coefficient on the occupancy rate is explicable by the fact that a hospital with a higher occupancy rate ceteris paribus will need more outpatients to 'feed' its beds and maintain the higher occupancy rate.

[32] Another explanation for the positive coefficient on the **beds_per_head** variable would be that areas with more beds per head will be likely to require a greater throughput of outpatients to fill those beds.

Table 60 Outpatient supply: selected regression results for urology

Dependent variable: the number of referrals seen divided by the Trust's population

	GP referrals				All referrals	
Regression number	1a	1b	1c	1d	2a	2b
meanwait_8	0.077*	0.080*			0.056	0.070°
<4weekwait_8						
4-13weekwait_8						
13-26weekwait_8						
1-[>26weekwait_8]			-0.175**	-0.181*		
<13weekwait_8						
occupancy_rate_1		0.832**		0.853**		0.308
length_of_stay_1		-0.169		-0.193		-0.086
transfers_in_1		-0.277°		-0.247		-0.396**
transfers_out_1		0.033		0.031		0.051
prop_admiss_60+_1		0.113		0.052		0.138
HRG_index_1		0.420		0.239		-0.228
research_spend_1		1.316*		1.286*		0.774°
readmission_rate_1		-0.053		-0.050		-0.045
death_ne_surgery_1		0.024		0.012		-0.000
death_e_surgery_1		-0.004		0.009		0.021
daycases_pc_1		-0.171		-0.161*		-0.170
emergencies_pc_1		-0.021		-0.042		0.213
beds_per_head_1		0.473*		0.514**		0.245
year96						
year97						
year98	0.040**	0.026	0.046**	0.036	0.046**	0.041
year99	0.102**	0.083*	0.106**	0.092*	0.101**	0.096*
year00	0.131**	0.110**	0.137**	0.122**	0.132**	0.134**
year01	0.141**	0.124**	0.151**	0.139**		
summer	0.066**	0.068**	0.069**	0.071**	0.065**	0.068
autumn	0.080**	0.081**	0.080**	0.080**	0.074**	0.078
winter	0.126**	0.129**	0.128**	0.131**	0.124**	0.128
constant	-0.014	-6.528	1.038**	-4.791	0.211*	-1.125
private_beds		-0.999*		-0.964*		-0.536*
nurse_vacancy		-0.756**		-0.741**		-0.465**
staff_sickness_rate		-0.742		-0.736		-0.669
delayed_discharge		0.273		0.264		0.151
No of obs	2768	2406	2822	2447	2198	1898
R bar squared	0.840	0.815	0.838	0.826	0.861	0.854
RESET test: F =	4.44	1.28	4.76	0.86	9.97	4.60
Prob > F =	0.0040	0.2780	0.0026	0.4598	0.0000	0.0033

Notes to Table 60:
1 In all six regressions the waiting time variables are lagged eight quarters and the characteristics variables are lagged one period.
2 The base year is 1997 and the base quarter is the first quarter of the year running from 1 April to 31 March.
3 There is no dummy for 2001 in regressions 2a and 2b as there is no quarterly 'total referrals seen' data for this year.
4 °denotes significance at the 10% level, * denotes significance at the 5% level, and ** denotes significance at the 1% level.
5 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition of the first three powers of the predicted value of the dependent variable to the model and a test of the joint significance of these three variables.
6 The coefficients on about 200 Trust dummies are not reported. These coefficients are regressed on the four time invariant variables to obtain the estimated coefficients on the **private_beds**, **nurse_vacancy, staff_sickness_rate** and **delayed_discharge** variables.

Table 60 also reports the coefficients on the four time invariant variables for two of the GP referrals regressions (1b and 1d). The estimated coefficients on two of these four time variables are significant in both regressions suggesting:

- that the availability of local private beds relative to NHS beds is negatively associated with NHS supply; and
- that the qualified nursing, midwifery & health visiting professionals vacancy rate has a negative impact on NHS supply.

The final two regressions (2a and 2b in Table 60) relate to all referrals seen. The results are broadly similar to those where the dependent variable is based on the number of GP referrals seen although **transfers_in** is now significant and there is some evidence of mis-specification in one of these regressions (2a).

12.6 Outpatient supply: orthopaedics

Table 61 presents a similar batch of results for orthopaedics. Again there are two sets of results each with a different dependent variable: one for GP referrals seen (1a - 1b) and another for all referrals seen (2a - 2d). The results are broadly similar irrespective of the dependent variable and the waiting time measure. In three of the six regressions waiting time has a significant positive impact on outpatient supply.

Of the Trust characteristics variables, the **HRG_index, research_spend**, **daycases_pc**, and **beds_per_head** have their by now familiar signs. There is some evidence of marginal mis-specification in a couple of the regressions.

The estimated coefficients on the time invariant variables provide some evidence in support of the significance of two variables, **private_beds** and **nurse_vacancies**. This suggests that the availability of local private beds is negatively associated with NHS outpatient supply. There is also evidence that the nurse vacancy rate adversely affects supply.

Table 61 Outpatient supply: selected regression results for orthopaedics

Dependent variable: the number of referrals seen divided by the Trust's population

	GP referrals		All referrals			
Regression number	1a	1b	2a	2b	2c	2d
meanwait_8	0.056°	0.047	0.040*	0.027°		
<4weekwait_8						
4-13weekwait_8						
13-26weekwait_8						
1-[>26weekwait_8]					-0.065	-0.032
<13weekwait_8						
occupancy_rate_1		0.066		0.047		0.047
length_of_stay_1		-0.040		0.016		0.025
transfers_in_1		-0.264		-0.240		-0.236
transfers_out_1		0.042		0.007		0.014
prop_admiss_60+_1		-0.082		-0.046		-0.053
HRG_index_1		1.218		-0.754°		-0.738°
research_spend_1		2.181*		0.943°		0.935°
readmission_rate_1		0.037		0.072*		0.083*
death_ne_surgery_1		0.021		0.000		0.004
death_e_surgery_1		-0.039		-0.026		-0.040
daycases_pc_1		-0.121		-0.174°		-0.174°
emergencies_pc_1		-0.147		0.070°		0.066
beds_per_head_1		0.311		0.185		0.188°
year96						
year97						
year98	-0.010	0.043**	-0.006	0.025	-0.004	0.030**
year99	0.024	0.091**	0.041**	0.082**	0.045**	0.089*
year00	0.059**	0.124**	0.050**	0.098**	0.055**	0.105**
year01	0.080**	0.145**				
summer	0.029**	0.036**	0.023**	0.029**	0.025**	0.030**
autumn	0.066**	0.083**	-0.031**	-0.018**	-0.029**	-0.015*
winter	0.101**	0.120**	-0.006	0.010	-0.005	0.011
constant	1.053**	-6.644*	1.848**	3.293°	2.235**	3.454°
private_beds		-1.376°		-0.631°		-0.627°
nurse_vacancy		-1.374**		-0.605**		-0.601**
staff_sickness_rate		-4.260		-1.622		-1.603
delayed_discharge		0.154		0.050		0.052
No of obs	2837	2364	2265	1853	2285	1868
R bar squared	0.933	0.924	0.963	0.964	0.964	0.965
RESET test: F =	3.91	7.20	4.33	5.55	4.65	6.33
Prob > F =	0.0085	0.0001	0.0047	0.0009	0.0030	0.0003

Notes to Table 61:

1. In all six regressions the waiting time variables are lagged eight quarters and the characteristics variables are lagged one period.
2. The base year is 1997 and the base quarter is the first quarter ofthe year running from1 April to 31 March.
3. There is no dummy for 2001 in regressions 2a - 2d as there is no quarterly 'total referrals seen' data for this year.
4. °denotes significance at the 10% level, * denotes significance at the 5% level, and ** denotes significance at the 1% level.
5. The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition ofthe first three powers ofthe predicted value ofthe dependent variable to the model and a test ofthe joint significance ofthese three variables.
6. The coefficients on about 200 Trust dummies are not reported. These coefficients are regressed on the four time invariant variables to obtain the estimated coefficients on the **private_beds**, **nurse_vacancy, staff_sickness_rate** and **delayed_discharge** variables.

12.7 Outpatient supply: ENT

Table 62 presents a further batch of outpatient supply results, this time for ENT. Again there are two sets of regressions: one for GP referrals seen (1a - 1b) and another for all referrals seen (2a - 2d). Again, the results are broadly similar irrespective of the dependent variable and the waiting time measure. In all six regressions waiting time has a positive impact on outpatient supply. We were unable to obtain a GP referral model with Trust characteristics that was not mis-specified and so no such model is reported. However, the addition of the Trust characteristics to the regression has little impact on the waiting time coefficient.

In the all referral regressions only two of the Trust characteristics variable are significant in both regressions. Both the proportion of spells that involve a transfer in from another hospital and the proportion of admissions aged over 60 may put pressure on (inpatient) resources and thus have an adverse affect on outpatient supply.

There is no evidence of mis-specification in the six regressions reported.

Of the estimated coefficients on the time invariant variables only the **nurse_vacancy** rate is significant.

Table 62 Outpatient supply: selected regression results for ENT

Dependent variable: the number of referrals seen divided by the Trust's population

	GP referrals		All referrals			
Regression number	1a	1b	2a	2b	2c	2d
meanwait_8	0.038°		0.036°	0.042°		
<4weekwait_8						
4-13weekwait_8						
13-26weekwait_8						
1-[>26weekwait_8]		-0.196**			-0.169*	-0.185*
<13weekwait_8						
occupancy_rate_1				0.070		0.019
length_of_stay_1				0.004		0.012
transfers_in_1				-0.388**		-0.386**
transfers_out_1				0.051		0.069*
prop_admiss_60+_1				-0.283**		-0.264**
HRG_index_1				-0.024		0.212
research_spend_1				0.608		0.545
readmission_rate_1				0.031		0.031
death_ne_surgery_1				-0.024		-0.020
death_e_surgery_1				0.043		0.031
daycases_pc_1				0.010		-0.036
emergencies_pc_1				-0.101		-0.093
beds_per_head_1				0.106		0.079
year96						
year97						
year98	-0.012	-0.012	0.002	0.051**	0.003	0.053**
year99	0.009	0.006	0.024°	0.085**	0.024	0.087**
year00	0.049**	0.046**	0.068**	0.125**	0.068**	0.131**
year01	0.037*	0.028°				
summer	0.018**	0.019**	0.015*	0.023**	0.015*	0.025**
autumn	0.043**	0.040**	0.030**	0.046**	0.029**	0.047**
winter	0.078**	0.075**	0.066**	0.085**	0.065**	0.085**
constant	0.856**	1.838**	1.037**	-1.469	1.886**	-1.176
private_beds				-0.341		-0.326
nurse_vacancy				-0.288*		-0.263*
staff_sickness_rate				-0.217		-0.153
delayed_discharge				0.031		0.039
No of obs	2624	2651	2132	1791	2160	1817
R bar squared	0.854	0.855	0.873	0.870	0.873	0.870
RESET test: F =	1.67	2.72	0.62	3.07	0.54	2.96
Prob > F =	0.1721	0.0429	0.6020	0.0267	0.6532	0.0312

Notes to Table 62:

1 In all six regressions the waiting time variables are lagged eight quarters and the characteristics variables are lagged one period.

2 The base year is 1997 and the base quarter is the first quarter ofthe year running from 1 April to 31 March.

3 There is no dummy for 2001 in regressions 2a - 2d as there is no quarterly 'total referrals seen' data for this year.

4 °denotes significance at the 10% level, * denotes significance at the 5% level, and ** denotes significance at the 1% level.

5 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition ofthe first three powers ofthe predicted value ofthe dependent variable to the model and a test ofthe joint significance ofthese three variables.

6 The coefficients on about 200 Trust dummies are not reported. These coefficients are regressed on the four time invariant variables to obtain the estimated coefficients on the **private_beds**, **nurse_vacancy, staff_sickness_rate** and **delayed_discharge** variables.

12.8 Summary of outpatient results for individual specialties

In this section we have presented models of the demand for and supply of outpatient care for three individual specialties: urology, orthopaedics, and ENT. Table 63 presents a brief summary of these results. We constructed six measures of waiting time and these were typically well correlated with each other.

For each demand and supply model two regressions were estimated: one based on GP referrals and the other based on all referrals. We found that waiting times, either the current value or lagged one period, had a significant negative effect on demand. In most cases we obtained a well specified model and we usually found that the local availability of private beds was negatively associated with the demand for NHS care.

With regard to the supply of outpatient appointments, we found that waiting times had a positive impact on supply and that the supply response to waiting times was best modelled with an eight quarter lag. We also found that a number of inpatient-related variables (such as the number of beds) also appeared to affect the supply of outpatient services. This effect is probably an indirect one and reflects the fact that more pressure on inpatient resources is associated with less outpatient supply.

We also found evidence that the local availability of private care was negatively associated with the supply of NHS outpatient care. There was also some evidence that nurse vacancy rates adversely affect supply.

Table 63 Summary of findings from the individual specialty outpatient models

(a) demand: GP/all referrals

Specialty grouping	Significant negative effect of waiting time (lag_1) on NHS demand?		Model well specified?		Significant negative impact of private care on NHS demand?	
	GP	all	GP	all	GP	all
Urology	✔ (-0.055)	✖ (-0.042)	✔	✔	✔	✖
Orthopaedics	✔ (-0.173)	✔	✔	✖	✔	✔
ENT	✔ (-0.076)	✔ (-0.059)	✔	✔	✔	✔

(b) supply: GP/all referrals

Specialty grouping	Significant positive effect of waiting time (lag_8) on NHS supply?		Model well specified?		Significant negative impact of private care on NHS supply?	
	GP	all	GP	all	GP	all
Urology*	✔ (0.080)	✔ (0.070)	✔	✔	✔	✔
Orthopaedics*	✖ (0.047)	✔ (0.027)	✖	✔	✔	✔
ENT*	✔	✔ (0.042)	✖	✔	✖	✖

Note: *there is a one quarter lag on the non-waiting time variables in these regressions.

13 RESULTS

COMBINING THE INPATIENT AND OUTPATIENT WAIT

13.1 Introduction

Rather than model the influence of waiting times on the outpatient and inpatient wait separately, we can also estimate a single model where the impact of total (outpatient plus inpatient) waiting time affects total (outpatient plus inpatient) demand and total (outpatient plus inpatient) supply. If patients are reluctant to switch between the private and public sectors after the outpatient phase, then both the outpatient and inpatient components of demand might well respond to the anticipated total (outpatient and inpatient) wait. On the supply side one reason for amalgamating outpatients and inpatients would be if some procedures are classified as outpatients by some Trusts but as day cases by others.

In one way a single model is less attractive than separate models for outpatients and inpatients because it forces the demand and supply response to waiting time to be the same for both outpatients and inpatients and that this response is to the total waiting time. However, if patients are willing to switch between the public and private sectors then it is not obvious why the outpatient component of the total wait should affect inpatient demand.

There are also practical problems with the estimation of a joint inpatient-outpatient model. Several measures of waiting time have been constructed both for inpatients and outpatients. One measure - the mean waiting time - is common to both the inpatient and outpatient models - but none of the other measures - reflecting the proportion of patients that have been waiting/had waited for a specified time period - are common to both models and are not easily combined. In this part of the study we therefore employed the mean wait as our sole waiting time measure and this was calculated as the sum of the mean wait in outpatients and the mean wait in inpatients. Even this is not without its difficulties because for outpatients the waiting time data refer to those *patients treated* in the last quarter while the inpatient data refer to *patients still awaiting treatment* at the end of the quarter.

Joint inpatient-outpatient measures of demand and supply are also required and necessitates some method of combining, for example, outpatient referrals seen and inpatient admissions. To do this we sought weights reflecting the relative unit cost of inpatient and outpatient services. CIPFA's *Health Service Database 1999* suggests that the ratio of the cost per inpatient episode to the cost per outpatient attendance is about 15:1 (CIPFA, 1999, p51). However, the outpatient activity data employed in this study only relates to first attendances and for each first attendance there are, on average, two further attendances. When calculating measures of total demand and total supply the individual inpatient and outpatient measures were therefore combined with a 5:1 weighting.

13.2 Demand: all specialties and routine surgical specialties

Table 64 reports four regression results: two for all specialties combined (regressions 1a and 1b) and two for the routine surgical specialties (regressions 2a and 2b). In all four regressions the waiting time variable is the total (outpatient plus inpatient) wait and the demand measure refers to outpatients and inpatients combined.

Consider first the all specialty results. In regression 1a the waiting time and day case variables are the current period values, whereas in regression 1b they are lagged one period. Both regressions imply that as the waiting time increases so demand declines although the elasticity of demand is smaller in the model with the lagged waiting time variable. This is a result that we have found previously for inpatients and outpatients. The coefficient on the *current period* waiting time variable in the total (outpatients plus inpatients) model (-0.224) falls between that on the waiting time variable in the comparable inpatient model (-0.311) and that in the comparable outpatient model (-0.04). Similarly, the coefficient on the *lagged one period* waiting time variable in the total (outpatients plus inpatients) model (-0.162) falls between that on the waiting time variable in the comparable inpatient model (-0.23) and that in the comparable outpatient model (-0.057).

The proportion of elective admissions treated as day cases (quality of care indicator) is insignificant. Neither regression exhibits evidence of mis-specification at the 5% significance level.

For the routine surgical specialties (regressions 2a and 2b), the waiting time variable again has the anticipated negative impact on demand. The coefficient on the lagged value of **meanwait** (regression 2b) is about one-half of that on the model with the current period value (regression 2a). The coefficient on the **daycase** variable changes little when the lagged rather than the current period value is employed and both values are significant. Neither regression exhibits evidence of mis-specification at the 5% level.

Table 64 also reports estimated coefficients on three time invariant variables:

(a) the index of need for acute health care (**need**)
(b) the availability of local private beds relative to NHS beds (**private_beds**)
(c) the number of GPs per head of population that the Trust serves (**GP_availability**)

The coefficients on the **need** variable in regressions 1a and 1b are significant and have the anticipated positive impact on demand. Neither **private_beds** nor **GP_availability** is significant. In the routine surgery regressions (2a and 2b) only the **private_beds** variable is significant and this has the expected negative effect on NHS demand.

Table 64 Total demand: regression results for all specialties and for the routine surgical specialties

Dependent variable: weighted sum of the number of decisions to admit plus the number outpatient referrals received all divided by the Trust's population

	All specialties		Routine specialties	
	Current	Lagged	Current	Lagged
Regression	1a	1b	2a	2b
meanwait	-0.224**	-0.162**	-0.133**	-0.064**
daycases	0.052	0.047	0.054**	0.050**
year96	0.010	-0.006	-0.010°	-0.019**
year97				
year98	0.077**	0.059**	0.016**	-0.001
year99	0.079**	0.059**	0.024**	0.096
year00	0.048**	0.033°	-0.002	-0.017*
year01	0.036*	0.021	-0.008	-0.022**
summer	0.007**	0.002	0.007°	0.003
autumn	-0.000	-0.003	0.003	0.000
winter	0.017**	0.014**	0.017**	0.015**
need	0.788**	0.808**	0.048	0.064
private_beds	-0.024	-0.028	-0.151**	-0.155**
GP_availability	-0.173	-0.163	-0.498	-0.481
constant	5.540**	5.337**	5.017**	4.790**
No of obs	3477	3356	3430	3312
F	123.5	119.4	228.5	224.5
R bar squared	0.881	0.882	0.928	0.929
RESET test: F =	0.48	0.37	1.24	0.15
Prob > F =	0.6928	0.7776	0.2921	0.9300

Notes to Table 64:

1 In the current period regressions (1a and 2a) the waiting time and day case variables are the current period values. In the lagged regressions (1b and 2b) the waiting time and day case variables are lagged one quarter.

2 There is no coefficient on the dummy variable for 1997 because there is no quarterly decision to admit data for this year. The base year is 1995.

3 °,*, and ** denote significance at the 10%, 5%, and 1% level respectively.

4 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition ofthe first three powers ofthe predicted value ofthe dependent variable to the model and a test ofthe joint significance ofthese three variables.

5 The coefficients on the 200 Trust dummies are not reported. These coefficients are regressed on the three time invariant variables to obtain the estimated coefficients on the **need**, **private_beds** and **GP_availability** variables.

13.3 Supply: all specialties and routine surgical specialties

Table 65 reports four regression results: two for all specialties combined (regressions 1a and 1b) and two for the routine surgical specialties (regressions 2a and 2b). In all four regressions the waiting time variable is the total (outpatient plus inpatient) wait and the supply measure refers to outpatients and inpatients combined. The difference between the 'a' and 'b' regressions is that in the former the non-waiting time variables are lagged one period whereas in the latter they are lagged four quarters. We tried various other lags on the waiting time and non-waiting time variables but these performed poorly and are not reported.

In two of the four regressions waiting time has the anticipated significant positive effect on supply and four of the other variables are significant in three or more regressions. As expected, complexity of case mix (**HRG_index**) is negatively associated with supply so that the more complex cases reduce the number of admissions (presumably through requiring a longer length of stay in hospital). The negative coefficient on **death_e_surgery** is expected with deaths preceded by longer lengths of stay than (live) discharges. The proportion of all admissions that are emergencies (**emergencies_pc**) has a negative impact on elective admissions. Finally, and again as expected, supply is positively associated with the number of beds per head of catchment population (**beds_per_head**).

The year dummies suggest that supply was at its greatest in 1998 and that this was significantly greater than in the base year (1996). There is no coefficient on the dummy variable for 1997 because there is no quarterly decision to admit or admission data for this year. There is no coefficient on the dummy variable for 2001 because there is no quarterly total referrals seen data for this year.

Table 65 also reports estimated coefficients on four time invariant variables:

(a) the availability of local private beds relative to NHS beds (**private_beds**);
(b) the qualified nursing, midwifery & health visiting professionals vacancy rate (**nurse_vacancy**);
(c) the amount of time lost through absence as a proportion of staff time available for directly employed NHS staff (**staff_sickness_rate**); and
(d) the proportion of patients whose discharge from hospital is delayed for non-medical reasons (**delayed_discharge**).

There is some evidence that the relative availability of private beds is negatively associated with NHS supply (as is to be expected) although the coefficients on the nurse vacancy rate in the all specialties regressions are significant but have counter-intuitive signs.

There is no evidence of mis-specification in any of the four regressions.

Table 65 Total supply: regression results for all specialties and for the routine surgical specialties

Dependent variable: weighted sum of the number of inpatient admissions plus the number of all outpatients seen divided by the Trust's population

	All specialties		Routine specialties	
Regression number	1a	1b	2a	2b
meanwait_4	0.037	0.054	0.081*	0.087*
occupancy_rate_1/_4	0.087	0.171	0.142	0.236
length_of_stay_1/_4	-0.053	-0.037	-0.044	-0.041
transfers_in_1/_4	0.006	-0.008	0.027	-0.006
transfers_out_1/_4	0.026**	0.001	0.031	-0.004
prop_admiss_60+_1/_4	0.094**	0.070	0.079*	0.075
HRG_index_1/_4	-0.404*	-0.603**	-0.618**	-0.734**
research_spend_1/_4	-0.063	-0.201	0.156	-0.049
readmission_rate_1/_4	-0.033	-0.007	-0.106	-0.055
death_ne_surgery_1 /_4	0.035*	0.009	0.031	0.001
death_e_surgery_1/_4	-0.119**	-0.052**	-0.123**	-0.061°
daycases_pc_1/_4	0.049	0.018	0.074°	0.034
emergencies_pc_1/_4	-0.178**	-0.119	-0.191**	-0.159*
beds_per_head_1/_4	0.264**	0.186	0.264**	0.243*
year97				
year98	0.080**	0.091**	0.071**	0.094**
year99	0.053°	0.056*	0.033	0.044
year00	0.028	0.023	0.015	0.020
year01				
summer	0.037**	0.031**	0.028**	0.020**
autumn	0.022**	0.012*	0.010°	-0.004
winter	0.050**	0.041**	0.035**	0.023**
private_beds	-0.036	0.049	-0.265**	-0.132**
nurse_vacancy	0.035**	0.109**	-0.091**	0.019
staff_sickness_rate	0.062	0.136	-0.037	0.059
delayed_discharge	-0.057*	-0.089°	0.020	-0.020
constant	6.864**	6.609**	7.881**	6.954**
No of obs	2072	2049	1685	1670
R bar squared	0.896	0.896	0.945	0.944
RESET test: F =	1.46	3.41	3.21	1.59
Prob > F =	0.2237	0.0169	0.0223	0.1893

Notes for Table 65:

1 The waiting time variable is lagged four quarters. In regressions 1a and 2a the other explanatory variables are lagged one quarter. In regressions 1b and 2b the other explanatory variables are lagged four quarters.

2 There is no coefficient on the dummy variable for 1997 because there is no quarterly decision to admit or admission data for this year. The base year is 1996. There is no coefficient on the dummy variable for 2001 because there is no quarterly total referrals seen data for this year.

3 °, *, and ** denote significance at the 10%, 5%, and 1% level respectively.

4 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition of the first three powers of the predicted value of the dependent variable to the model and a test of the joint significance of these three variables.

5 The coefficients on the 200 Trust dummies are not reported. These coefficients are regressed on the four time invariant variables to obtain the estimated coefficients on the **private_beds**, **nurse_vacancy, staff_sickness_rate** and **delayed_discharge** variables.

13.4 Demand: individual specialties

Table 66 reports three pairs of regression results, two for each specialty (urology, orthopaedics, and ENT). In the first ('a') regression of each pair the explanatory variables are the current period values but in the second ('b') regression they are lagged one quarter. In all six regressions the waiting time variable is the total (outpatient plus inpatient) wait and the demand measure refers to outpatients and inpatients combined.

In all six regressions the **meanwait** variable is significant and has the appropriate negative sign. The value of this coefficient declines by up to one half when the lagged rather than current period value is employed. The quality of care indicator (**daycases**) has no significant impact on demand. Not one of the six regressions exhibits evidence of mis-specification at the 1% level.

Table 66 also reports estimated coefficients on three time invariant variables:

(a) the index of need for acute health care (**need**)
(b) the availability of local private beds relative to NHS beds (**private_beds**)
(c) the number of GPs per head of population that the Trust serves (**GP_availability**)

The significant negative coefficient on the **need** variable in the orthopaedics regressions (2a and 2b) is not as expected. The **private_beds** variable is significant and exhibits the anticipated negative sign in both the orthopaedic and ENT specialties. **GP_availability** has a significant negative effect on demand in ENT.

These combined outpatient and inpatient models can be compared with the relevant separate ones. The relevant regressions for urology are shown in Tables 49 and 56. With the exception of the year dummies, the combined (outpatient and inpatient) result in Table 66 is very similar to the inpatient regression (Table 49).

With regard to orthopaedics, the relevant comparator regressions are shown in Tables 50 and 57 (although the latter Table only encompasses GP referrals). Again, the combined (outpatient and inpatient) result is very similar to the inpatient regression (Table 50).

The ENT results in Table 66 can be compared with those in Table 51 (for inpatients) and Table 59 (for outpatients). With the exception of the coefficients on the time invariant variables, the combined (outpatient and inpatient) result is again very similar to the inpatient regression (Table 51). The influence of the outpatient result can be seen in the significant negative coefficient on the **private_beds** variable in the joint outpatient-inpatient regression.

Table 66 Total demand: regression results for three individual specialties

Dependent variable: weighted sum of the number of decisions to admit plus the number outpatient referrals received all divided by the Trust's population

	Urology		Orthopaedics		ENT	
	Current	Lagged	Current	Lagged	Current	Lagged
Regression	1a	1b	2a	2b	3a	3b
meanwait	-0.174**	-0.108**	-0.238**	-0.156**	-0.154**	-0.084**
daycases	0.097	0.125	0.076	0.094	0.011	0.028
year96	-0.036**	-0.040**	-0.009	-0.024°	-0.019	-0.025
year97						
year98	0.011	0.004	0.037°	0.011	-0.025	-0.045*
year99	0.029	0.014	0.067**	0.039	-0.033	-0.050*
year00	0.007	-0.007	0.066*	0.042	-0.034	-0.048°
year01	0.004	-0.008	0.072*	0.053°	-0.054°	-0.070*
summer	0.041**	0.045**	0.010	0.004	-0.040**	-0.043**
autumn	0.033**	0.041**	-0.008	-0.014**	-0.037**	-0.037**
winter	0.053**	0.056**	-0.007	-0.013*	0.012°	0.013°
need	0.163	0.183	-1.395**	-1.403**	0.387	0.358
private_beds	-0.066	-0.070	-0.283**	-0.282**	-0.114*	-0.121*
GP_availability	0.057	0.088	-0.768	-0.753	-1.000*	-1.022*
constant	2.468**	2.265**	3.764**	3.507**	3.081**	2.856**
No of obs	2585	2507	2748	2670	2292	2216
F	117.9	113.5	367.6	347.9	167.7	160.4
R bar squared	0.885	0.884	0.959	0.958	0.911	0.910
RESET test: F =	2.04	1.87	3.76	0.84	3.12	2.66
Prob > F =	0.1064	0.1324	0.0105	0.4692	0.0252	0.0467

Notes to Table 66:

1 In the current period regressions (1a and 2a) the waiting time and day case variables are the current period values. In the lagged regressions (1b and 2b) the waiting time and day case variables are lagged one quarter.

2 There is no coefficient on the dummy variable for 1997 because there is no quarterly decision to admit data for this year. The base year is 1995.

3 °,*, and ** denote significance at the 10%, 5%, and 1% level respectively.

4 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition of the first three powers of the predicted value of the dependent variable to the model and a test of the joint significance of these three variables.

5 The coefficients on the 200 Trust dummies are not reported. These coefficients are regressed on the three time invariant variables to obtain the estimated coefficients on the **need**, **private_beds** and **GP_availability** variables.

13.5 Supply: individual specialties

Table 67 reports three supply regressions, one for each specialty. In all three regressions the waiting time variable is the total (outpatient plus inpatient) wait and is lagged four periods, while the supply measure refers to outpatients and inpatients combined. The other, non-waiting time variables, are lagged one quarter. We tried various other lags on the waiting time and non-waiting time variables but these performed relatively poorly and are not reported.

In two of the three regressions the waiting time variable has a significant positive effect on supply with a four quarter lag. Four of the non-waiting time variables are also significant in two of the three regressions: **transfers_out, HRG_index, readmission_rate,** and **beds_per_head**. More **transfers_out** are associated with greater supply. The complexity of case mix (**HRG_index**) is negatively associated with supply so that more complex cases reduce the number of admissions (presumably through requiring a longer length of stay in hospital). The readmission rate is also negatively associated with supply. As anticipated, supply is positively associated with the number of beds per head of catchment population (**beds_per_head**).

Table 67 also reports estimated coefficients on four time invariant variables:

(a) the availability of local private beds relative to NHS beds (**private_beds**);
(b) the qualified nursing, midwifery & health visiting professionals vacancy rate (**nurse_vacancy**);
(c) the amount of time lost through absence as a proportion of staff time available for directly employed NHS staff (**staff_sickness_rate**); and
(d) the proportion of patients whose discharge from hospital is delayed for non-medical reasons (**delayed_discharge**).

In the orthopaedics regression the private beds and nurse vacancy rate variables are negatively associated with supply.

There is no evidence of mis-specification at the 0.1% significance level in any of the three regressions.

These combined outpatient and inpatient supply models can be compared with the relevant separate ones. The relevant regressions for urology are shown in Tables 52 and 60. The combined urology model is better than the inpatient model alone as the latter shows evidence of mis-specification whereas the former does not.

With regard to orthopaedics, the relevant comparator regressions are shown in Tables 52 and 61. The combined (outpatient and inpatient) result is very similar to the inpatient regression shown in Table 52.

The ENT results in Table 67 can be compared with those in Table 53 (for inpatients) and Table 62 (for outpatients). With the exception of the coefficients on the time invariant variables, the combined (outpatient and inpatient) result is similar to the inpatient regression (Table 53). The influence of the outpatient result can be seen in the much changed - and now plausible - coefficients on the time invariant variables in the combined (outpatient and inpatient) result.

Table 67 Total supply: regression results for three individual specialties

Dependent variable: weighted sum of the number of inpatient admissions plus the number of all outpatients seen divided by the Trust's population

	Urology	Orthopaedics	ENT
Regression number	1	2	3
meanwait_4	0.084°	0.069	0.076°
occupancy_rate_1	0.256	0.420*	0.199
length_of_stay_1	-0.197	0.020	-0.082
transfers_in_1	0.005	0.023	-0.043
transfers_out_1	0.058*	0.029*	0.033
prop_admiss_60+_1	0.164*	0.046	-0.080
HRG_index_1	-1.804**	-0.948**	-0.454
research_spend_1	-0.001	0.598*	-0.071
readmission_rate_1	-0.400*	-0.110°	0.067
death_ne_surgery_1	0.048	-0.029	-0.023
death_e_surgery_1	-0.064	-0.098	-0.033
daycases_pc_1	0.076	0.019	-0.024
emergencies_pc_1	0.113	-0.087	-0.242*
beds_per_head_1	0.213	0.256*	0.425**
year96			
year97			
year98	0.014	0.090**	0.070*
year99	-0.022	0.100**	0.017
year00	-0.035	0.103**	0.010
year01			
summer	0.077**	0.030**	0.022**
autumn	0.062**	-0.004	0.009
winter	0.087**	0.021*	0.001
private_beds	-0.037	-0.494*	-0.027
nurse_vacancy	-0.003	-0.406**	-0.029
staff_sickness_rate	0.051	-1.028	0.434
delayed_discharge	-0.035	0.070	0.014
constant	12.695**	6.327**	-1.538
No of obs	1361	1441	1218
R bar squared	0.879	0.963	0.923
RESET test: F =	5.38	2.64	1.19
Prob > F =	0.0011	0.0480	0.3123

Notes for Table 67:

1 The waiting time variable is lagged four quarters but the other explanatory variables are lagged one quarter.

2 There is no coefficient on the dummy variable for 1997 because there is no quarterly decision to admit or admission data for this year. The base year is 1996. There is no coefficient on the dummy variable for 2001 because there is no quarterly total referrals seen data for this year.

3 °, *, and ** denote significance at the 10%, 5%, and 1% level respectively.

4 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition of the first three powers of the predicted value of the dependent variable to the model and a test of the joint significance of these three variables.

5 The coefficients on the 200 Trust dummies are not reported. These coefficients are regressed on the four time invariant variables to obtain the estimated coefficients on the **private_beds**, **nurse_vacancy, staff_sickness_rate** and **delayed_discharge** variables.

14 SIMULATIONS USING SYSTEM DYNAMICS

14.1 Introduction

In this section we outline system dynamics (SD). A basic model of the demand for and supply of elective health care is constructed within a system dynamics framework and this model, together with some of the elasticities derived from the empirical work reported above, are employed to examine the consequences for waiting times and waiting lists of various alternative scenarios (such as a minor and major change in funding levels).

The SD approach is consistent with traditional economic analysis towards modelling dynamic phenomena, but employs different conventions and language. The feedback structure of the system is captured using causal loops. These are either balancing (capturing negative feedback) or reinforcing (capturing positive feedback). After a disturbance, a balancing loop seeks to return the system to an equilibrium situation. In a reinforcing loop an initial disturbance leads to further change, suggesting the presence of an unstable equilibrium.

This structure is formalised via a simulation model consisting of two components: the stock and flow network, and the information network. Stocks capture the inertia of a system. They accumulate or deplete gradually, regulated by their in- and out-flows. Stocks can be 'hard' (tangible) concepts, such as physical capital, or 'soft' concepts (such as perceptions). The flow rates are determined by the information network, and depend on the level of the various stocks in the system. These rates can be interpreted as the output of policies, or decision-making processes. For instance, in the model below one stock will represent the number of hospital beds allocated to elective surgery. The in- and out-flows represent changes in this allocation, which are based on various information sources, such as the present number of beds and the perceived waiting time for surgery.

Such relationships can be modelled mathematically using systems of difference or differential equations as in conventional dynamic economic models. To do this, however, the analyst will require a degree of mathematical fluency that not everyone possesses. The rapid advances in software technology make it possible to readily construct such models within an SD framework and to test a variety of specifications with a much more modest mathematical knowledge. One strength of SD is that this approach can employ conventional micro-economic models to offer readily accessible guidance to policy makers on the dynamic implications of economic models. In particular, SD can illustrate the equilibrium to which the variables will converge, as well as provide numerical estimates of the paths taken by key policy variables to these equilibria (van Ackere and Smith, 1999; Smith and van Ackere, 2002).

14.2 A systems dynamics model of waiting time in the NHS

To illustrate the SD approach, we use i*think* software and employ a 'slimmed down' version of the econometric model that has served as the basis for the empirical work presented above. The stock, flow, and information network of the model is shown in Figure 3. There are five stocks, indicated by rectangles. Three of these (number of patients on the waiting list, number of beds, and expressed demand) are tangible quantities. The remaining two (waiting time as perceived by the patient and general practitioner on the demand side, and waiting time as perceived by hospital management on the supply side) represent perceptions, and seek to capture how the two main actors adjust their perception of average waiting time over time as new information becomes available.

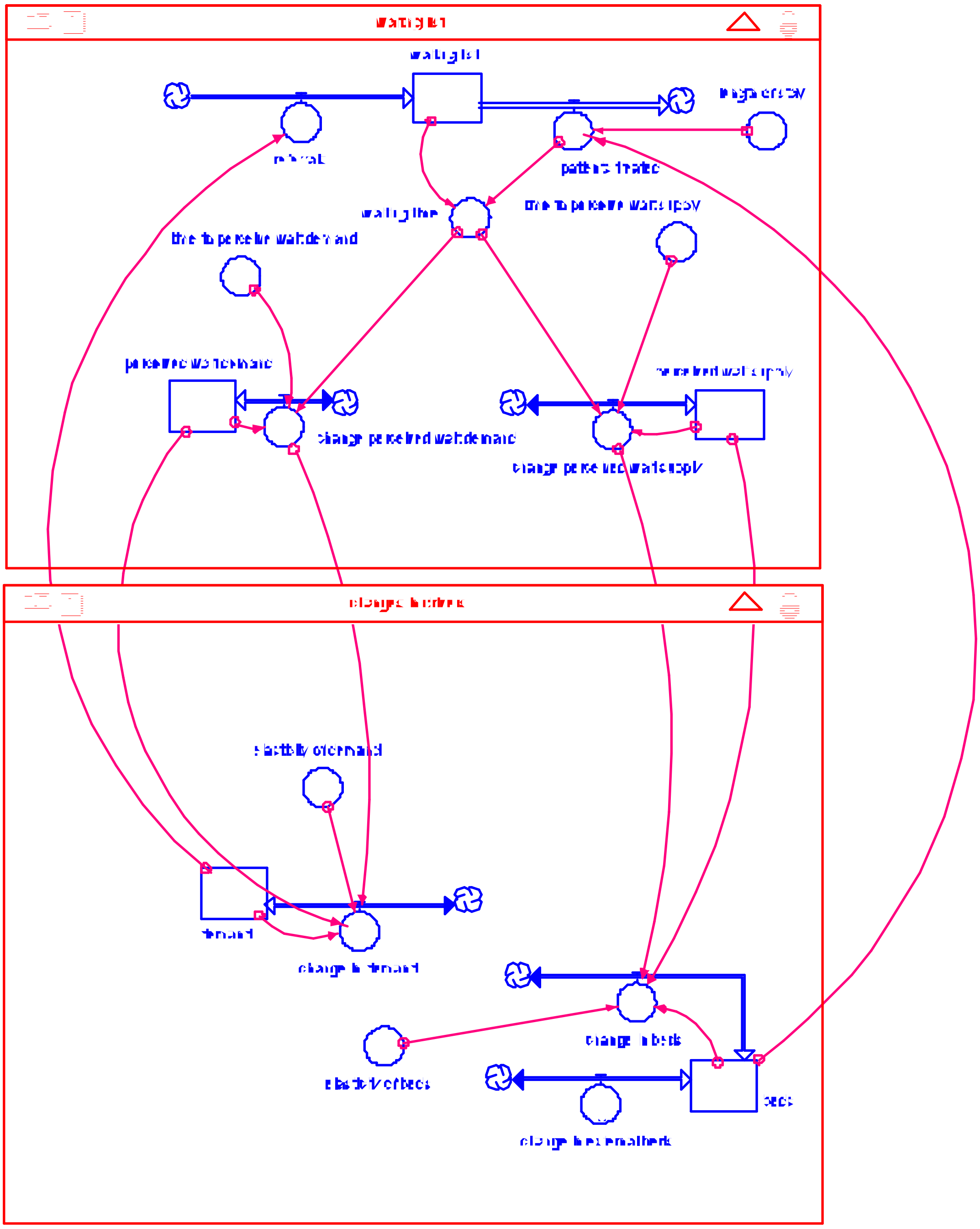
In- and out-flows are represented by double arrows. The white head represents the direction of flow. For instance, when 'change in demand' is positive, demand increases, while if 'change in demand' is negative, demand decreases. Some flows are uniflows, e.g., 'patients treated' is always non-negative.

The stock 'waiting list' is replenished by the flow 'referrals' and depleted by the flow 'patients treated'. The rate of referrals is determined by the level of expressed demand (calculated as patients per month). The number of patients treated per month depends on the number of beds, and the average length of stay.

The stocks 'demand' and 'beds' are affected by the flows 'change in demand' and 'change in beds' respectively. The change in beds is driven by the elasticity of beds with respect to average waiting time as perceived by the supply side. Drawing on the results of the empirical work presented above, we set the elasticity of beds with respect to waiting time at 0.30. This reflects the internal pressures on allocation of resources between elective surgery and other forms of care. The 'change in demand' is driven by the elasticity of demand with respect to average waiting times as perceived by the demand side. Drawing on the results presented above we assume a demand elasticity with regard to the average wait of -0.20.

The perceived waiting time is modelled as a process of partial adjustment, where the perceived value is only gradually brought into line with the actual value. Mathematically, the perceived waiting time is a simple smoothed average of the waiting time with smoothing constant 1/'time to perceive waiting time'. We set the 'time to average waiting time' equal to 3 months for the demand side, and 12 months on the supply side (with both reflecting our modelling experience). Table 68 below lists the illustrative equations we have selected for this demonstration of the SD model. In the specification below, there is an initial equilibrium with a waiting time of 4.5 months and a waiting list of 450 patients. There are 10 beds with an average length of stay of 0.1 months. Demand is 100 cases per month.

Figure 3 A systems dynamics model of waiting times



Key: Stocks are represented by rectangles.
In- and out-flows are represented by pipes with arrows .
The white head represents the direction of flow.
The single line connectors with a single arrow denote dependence.

Table 68 Specification of the systems dynamics model

```
------------------------------------------------------------------------------------------------------------
changes in drivers

beds(t) = beds(t - dt) + (change_in_external_beds + change_in_beds) * dt
INIT beds =  10
INFLOWS:
change_in_external_beds = GRAPH(TIME)
(7.00, 0.00), (8.00, 0.00), (9.00, 0.00), (10.0, 1.00), (11.0, 1.00), (12.0, 1.00), (13.0, 1.00), (14.0,
0.00), (15.0, 0.00), (16.0, 0.00)
change_in_beds = elasticity_of_beds*beds*change_perceived_wait_supply/perceived_wait_supply
demand(t) = demand(t - dt) + (change_in_demand) * dt
INIT demand = 100 [patients]
INFLOWS:
change_in_demand =
elasticity_of_demand*demand*change_perceived_wait_demand/perceived_wait_demand
elasticity_of_beds = 0.30
elasticity_of_demand = -0.20

waiting list
perceived_wait_demand(t) = perceived_wait_demand(t - dt) + (change_perceived_wait_demand) *
dt
INIT perceived_wait_demand = waiting_list/patients_treated
INFLOWS:
change_perceived_wait_demand =
(waiting_time-perceived_wait_demand)/time_to_perceive_wait_demand
perceived_wait_supply(t) = perceived_wait_supply(t - dt) + (change_perceived_wait_supply) * dt
INIT perceived_wait_supply = waiting_list/patients_treated

INFLOWS:
change_perceived_wait_supply =
(waiting_time-perceived_wait_supply)/time_to_perceive_wait_supply
waiting_list(t) = waiting_list(t - dt) + (referrals - patients_treated) * dt
INIT waiting_list = 450 [patients]

INFLOWS:
referrals = demand
OUTFLOWS:
patients_treated = beds/length_of_stay
length_of_stay = 0.1 [months]
time_to_perceive_wait_demand = 3 [months]
time_to_perceive_wait_supply = 12 [months]
waiting_time = waiting_list/patients_treated
------------------------------------------------------------------------------------------------------------
```

14.3 Some illustrative results

We first consider four scenarios as summarised in Table 69. There are two initial equilibria, with respectively a 4.5 month and 3 month average waiting time. We then consider the impact of two alternative shocks: the first involves a 10% increase in NHS resources in month 10 (a 'minor' increase) while the second involves a 10% increase in resources in months 10, 11, 12, and 13 (a more 'major' increase). These are modelled using the 'external change in beds' flow. All simulations are run for 60 months. Figures 4 - 7 illustrate the dynamic impact of these shocks on four variables: demand, waiting time, waiting list, NHS beds devoted to elective surgery. The model assumes unchanging efficiency, as reflected in a constant 'average length of stay', so the number of patients treated is a constant multiple of the number of beds.

Table 69 Overview of scenarios for additional resources model

	initial waiting time	resource change
scenario 1	4.5 months	10% increase (month 10)
scenario 2	3 months	10% increase (months 10)
scenario 3	4.5 months	10% increase (months 10, 11, 12, 13)
scenario 4	3 months	10% increase (months 10, 11, 12, 13)

Scenarios 1 and 3 have an initial average waiting time of 4.5 months. The minor increase in resources leads to a much smaller increase in beds than the more major increase (see Figure 7). However, neither increase is wholly sustained as some of the additional resources are gradually diverted from elective surgery to other uses. The minor increase in resources leads to a considerably smaller reduction in average waiting times (Figure 5) and lists (Figure 6) than does the more major increase in resources. Ultimately the system stabilises at a new equilibrium with increased demand, more elective beds, and lower waiting times and lists. Scenarios 2 and 4 are similar to scenarios 1 and 3 except that the initial equilibrium has a lower waiting time (3 months rather than 4.5 months). The results are broadly similar to those outlined above with a larger initial waiting time.

Figure 4 Simulation results: demand

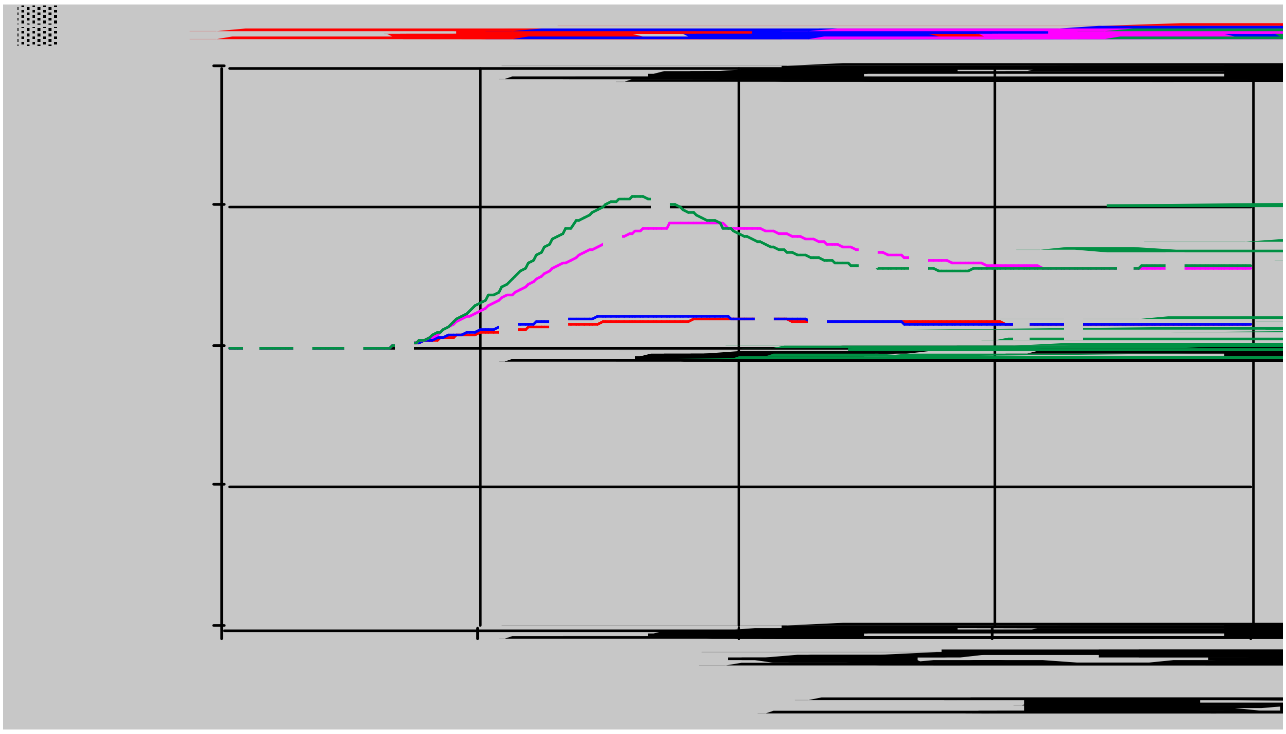


Figure 5 Simulation results: waiting times

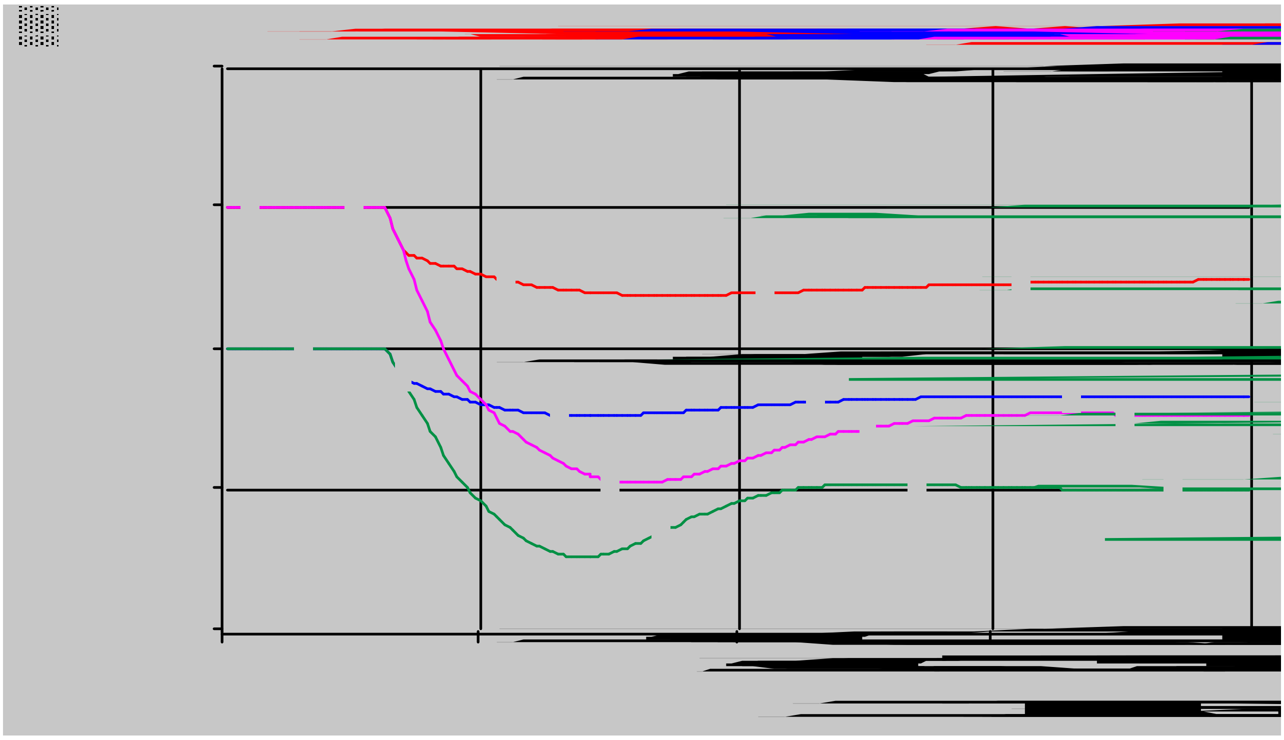


Figure 6 Simulation results: waiting lists

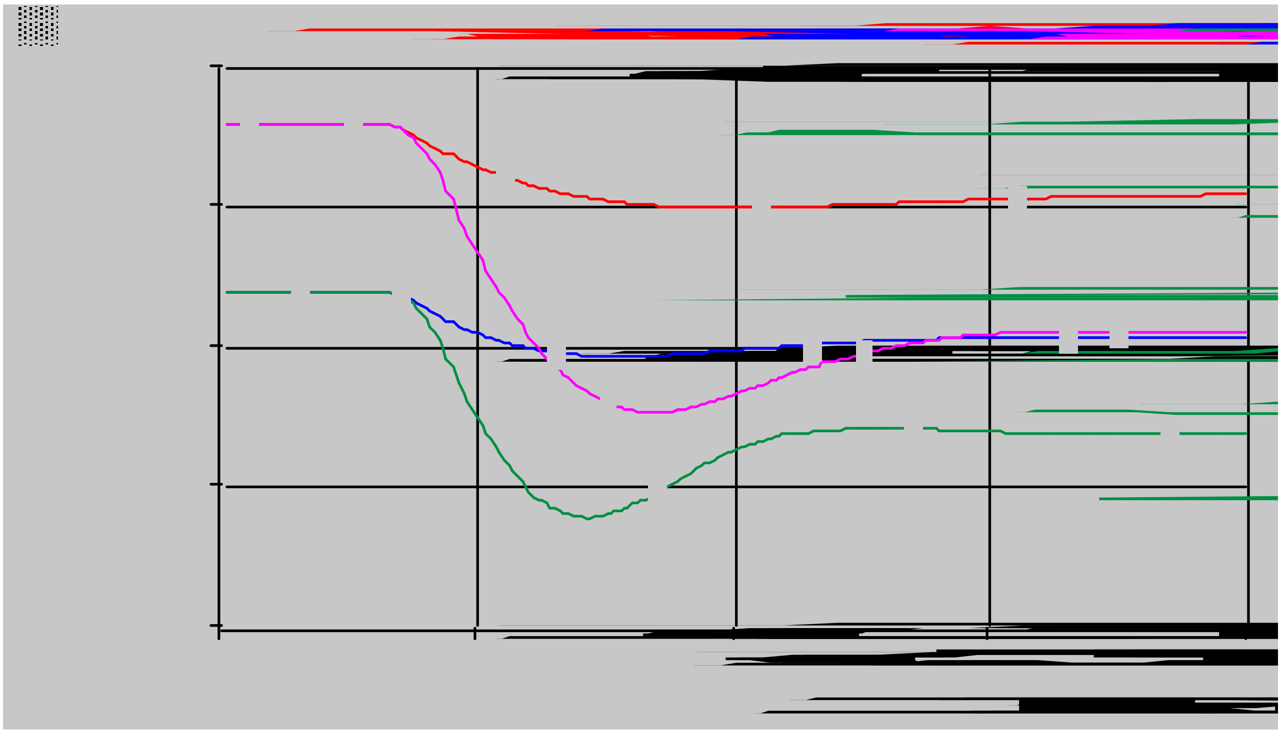
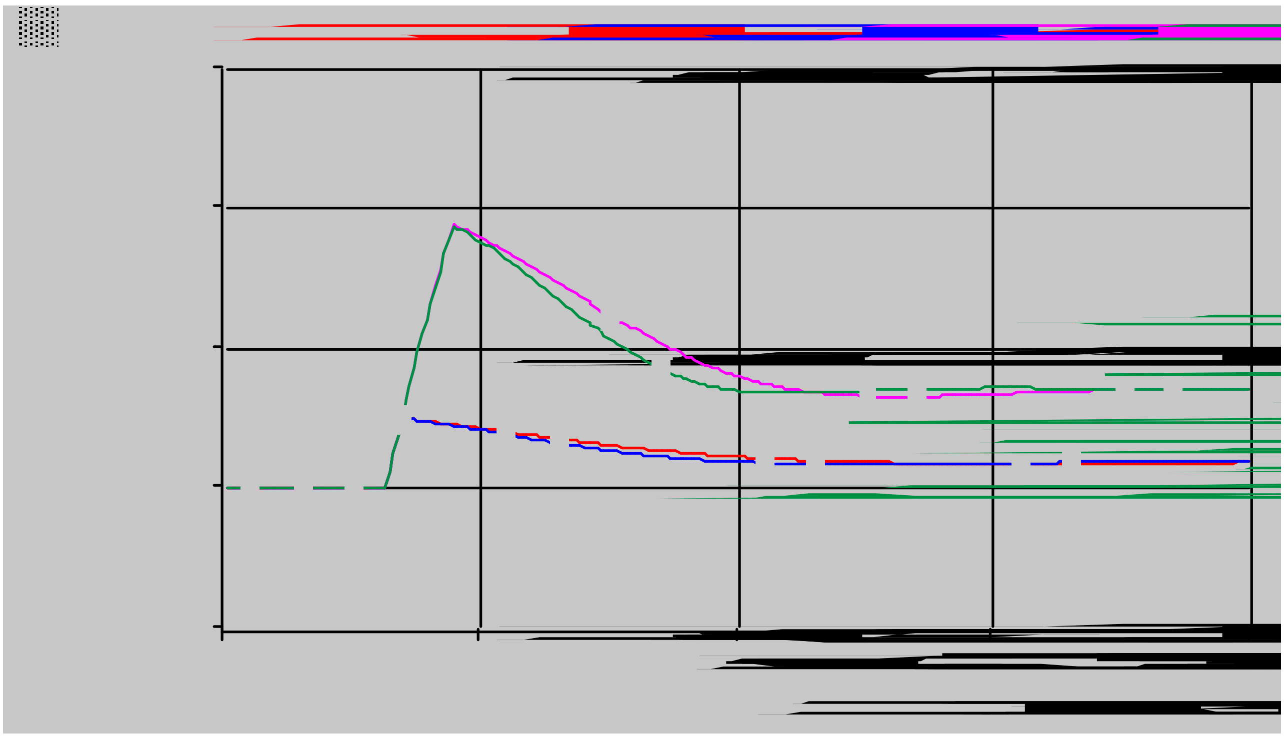


Figure 7 Simulation results: beds



14.4 A consultant-held target waiting time

Some commentators have argued that consultants have an incentive to maintain long waits as this provides them with a pool of patients who are willing to pay for private treatment. To examine the impact of this effect, we can amend the model described in Figure 3 to incorporate a consultant-held target waiting time.

One way in which consultants might seek to affect waiting times is via treatment thresholds. If waiting times start to fall below the target, consultants might lower their treatment thresholds thus boosting the number of patients added to the waiting list. Alternatively, if waiting times start to exceed the target, consultants might increase their treatment thresholds thus reducing the number of patients added to the waiting list.

This effect was modelled by endogenising referral rates, making them dependent, in part, on any discrepancy between the target wait and the actual wait. We set the consultant-held target wait at 3 months. In addition, some assumption has to be made about the degree to which consultants change their thresholds when the actual wait differs from their target wait. We experimented with two multipliers (20 and 50) on the term capturing the discrepancy between the target wait and the actual wait. Thus in Table 68 we replace 'referrals = demand' with 'referrals=demand+*m**(3-waiting_time) when the target wait is 3 months and *m* is the degree to which consultants adjust treatment thresholds.

We examine four different scenarios and these are outlined in Table 70. Again there is a minor increase in resources in month 10. In scenarios 1 and 3 there is an initial waiting time of 4.5 months. However, as Figure 8 shows, this is not an equilibrium position because the actual wait exceeds the target wait and so consultants raise treatment thresholds, referrals for treatment fall, and waiting times decline. They decline faster in scenario 3 than in 1 because the degree to which consultants adjust their thresholds is faster in scenario 3 (*m*=50) than scenario 1 (*m*=20). The boost in resources in month 10 generates a further fall in waiting times but this is relatively small compared to that driven previously by the fact that the target wait exceeded the actual wait.

In scenarios 2 and 4 there is an initial waiting time of 3 months and, as this coincides with the target wait, this is an equilibrium. The boost in resources in month 10 leads to a fall in waiting times below 3 months but they subsequently increase marginally back towards this target. A new equilibrium is established with a lower wait just below the target wait which sufficiently boosts demand to ensure that the additional resources in elective surgery are utilised (recall we assume constant efficiency).

Table 70 Overview of scenarios for target waiting time model

	initial waiting time	referral function
scenario 1	4.5 months	demand+20*(3-waiting time)
scenario 2	3 months	demand+20*(3-waiting time)
scenario 3	4.5 months	demand+50*(3-waiting time)
scenario 4	3 months	demand+50*(3-waiting time)

The same four scenarios, as outlined in Table 70, are illustrated in Figure 9 but this time there is a more substantial increase in resources with the number of external beds increased by 10% in months 10, 11, 12, and 13. The results are broadly similar to those with a more minor increase in resources but the degree of change is magnified. Because of the additional resources, and the assumption of constant efficiency, the new equilibria must embody more patients being treated per period. To achieve this, the waiting time falls below the target rate by more than that in Figure 8 (because the resource injection in Figure 9 exceeds that in Figure 8).

14.5 Incorporating a consultant-held target waiting time into the full SD model

We re-ran the scenarios detailed in Table 69 incorporating a consultant held waiting time of the form: referrals=demand+20*(3-waiting_time). Figures 10 - 13 illustrate the results. One effect that the incorporation of a consultant-held target wait has is to dampen the increase in demand associated with the more permanent increase in funding. This happens because waiting times decline less as consultants reduce their treatment thresholds to maintain waiting times when they fall below the target level (use options 2 and 4 to compare Figures 5 and 11).

Where the new equilibrium waiting time is below the target (options 2 and 4 in Figure 5), a consultant-held target wait increases the equilibrium average waiting time (options 2 and 4 in Figure 11). Similarly, a consultant-held target generates a longer waiting list (options 2 and 4 in Figure 12) than without a target (options 2 and 4 in Figure 6). However, more beds are devoted to elective surgery (compare options 2 and 4 in Figures 7 and 13) which, with a constant length of stay, implies that more patients are being treated with a consultant-held target waiting time yet lists and waits are longer. This is a surprising result.

Figure 8 Simulation results: waiting time

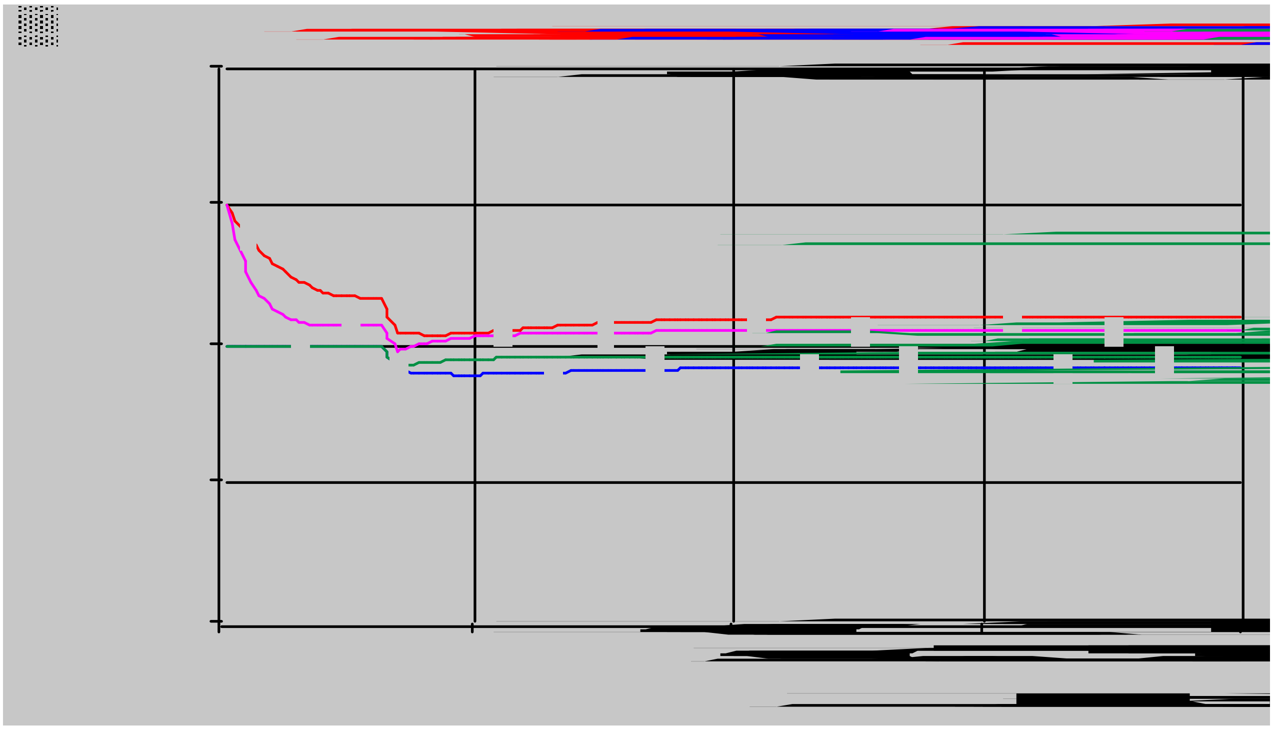


Figure 9 Simulation results: waiting time

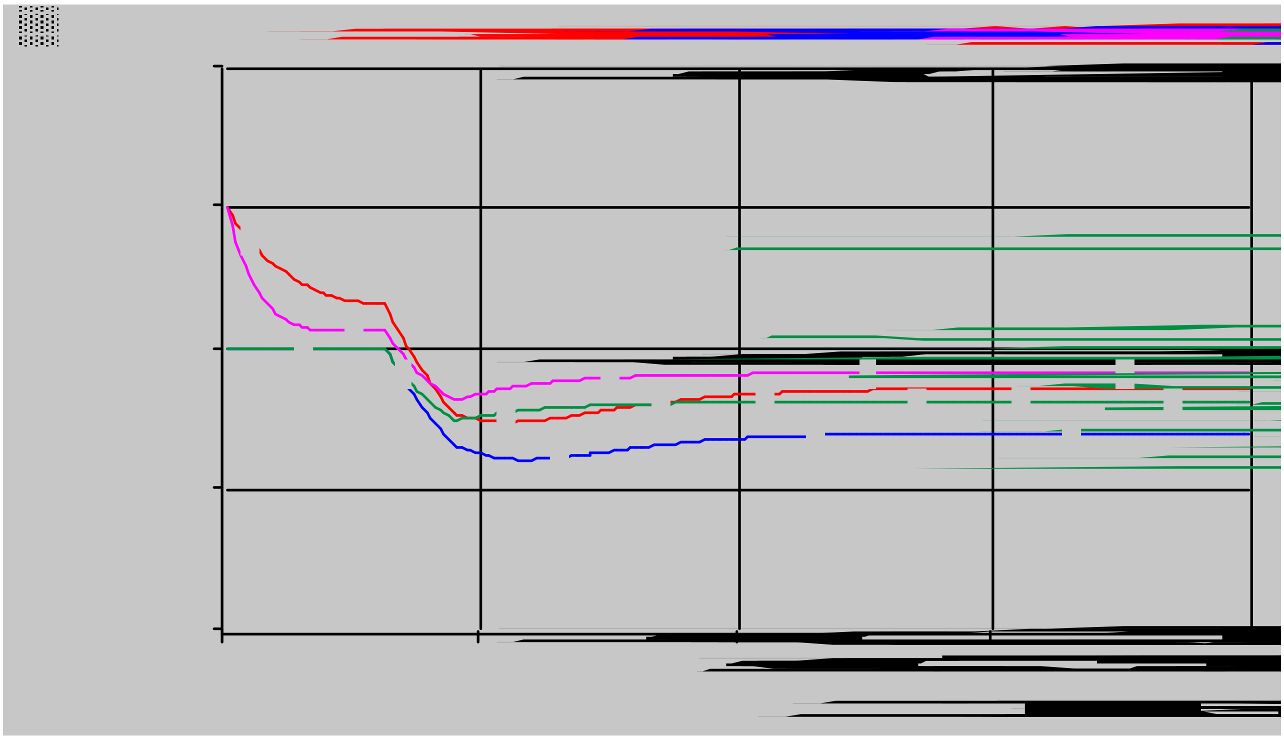


Figure 10 Simulation results: demand

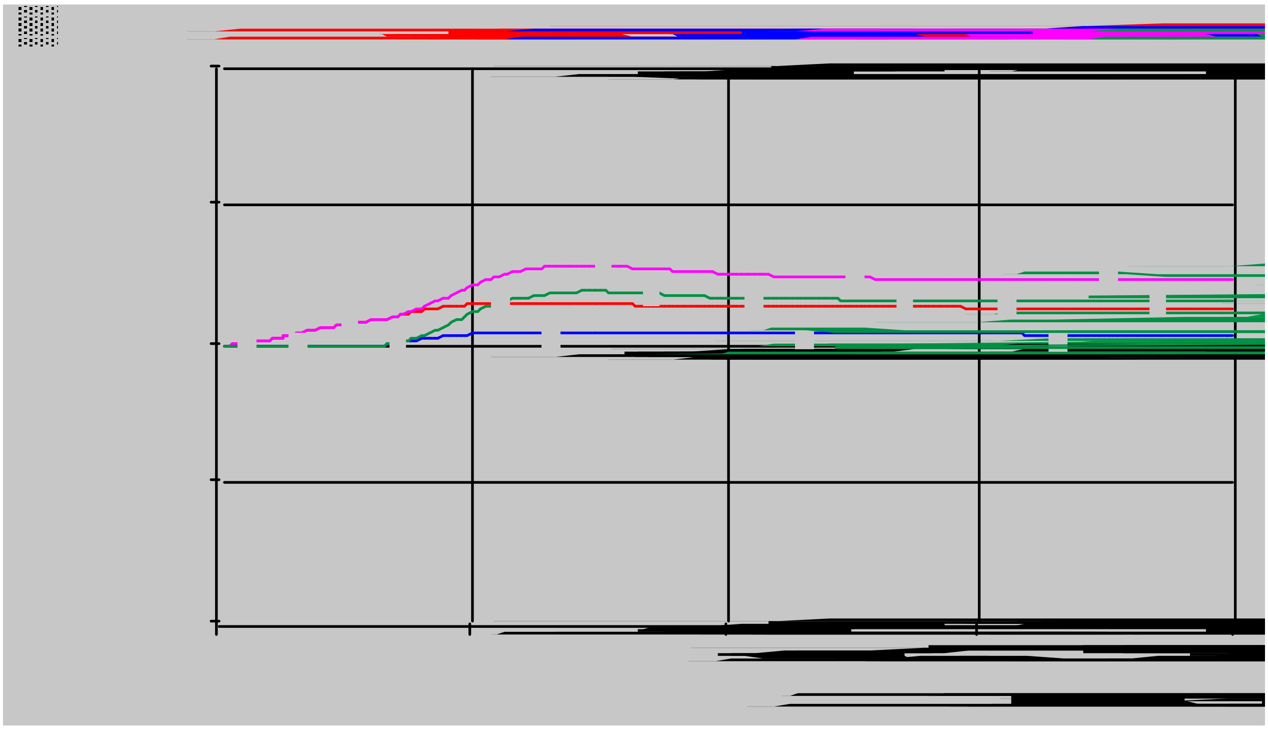


Figure 11 Simulation results: waiting time

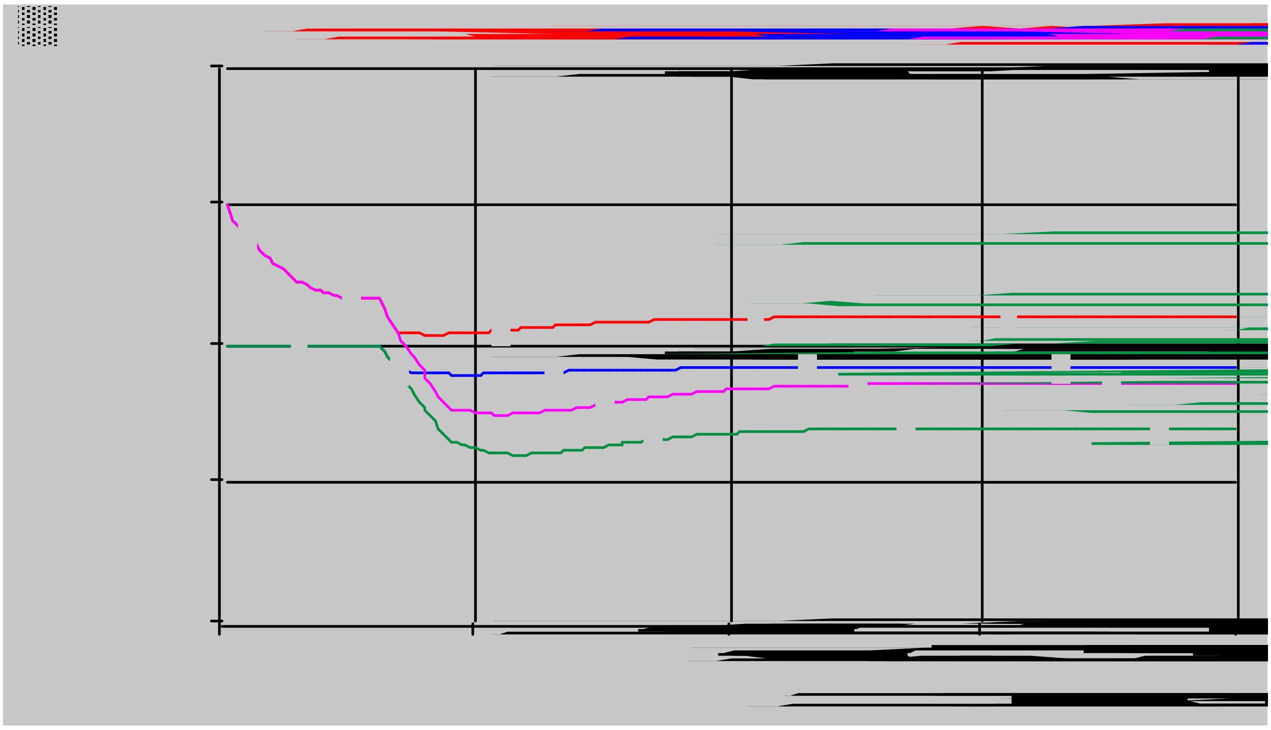


Figure 12 Simulation results: waiting list

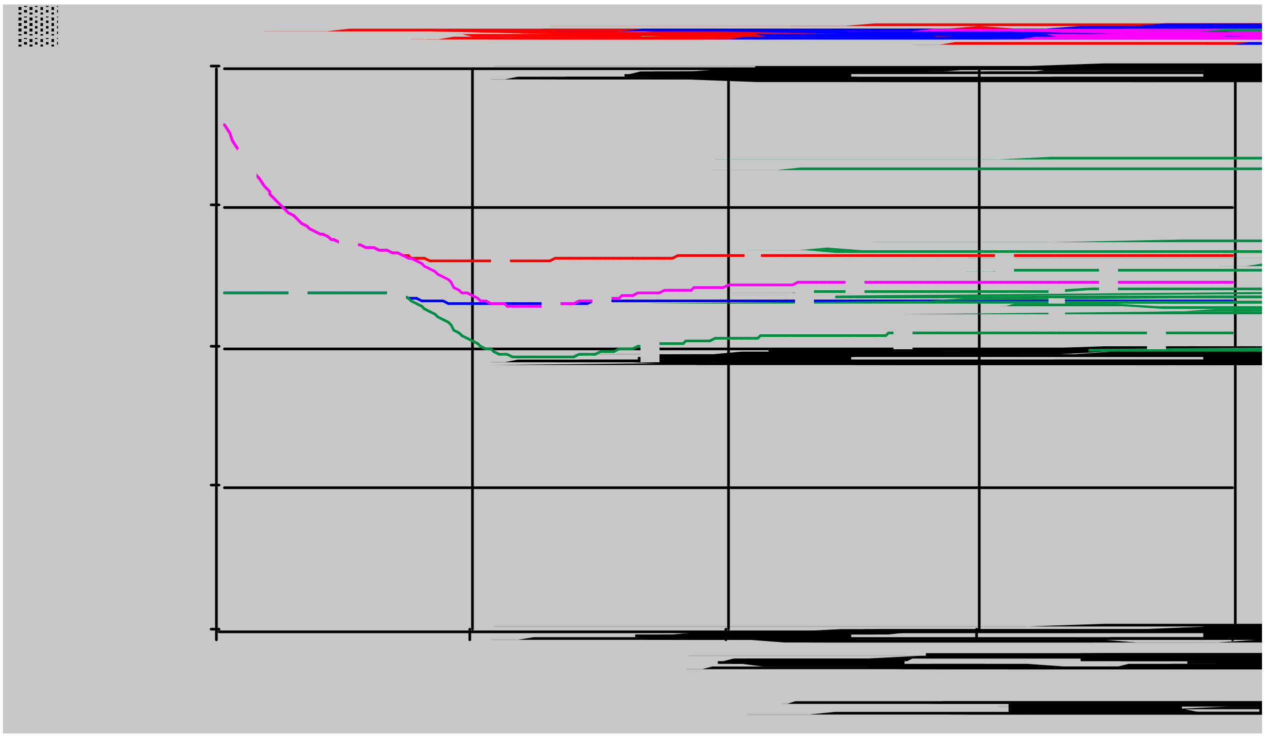
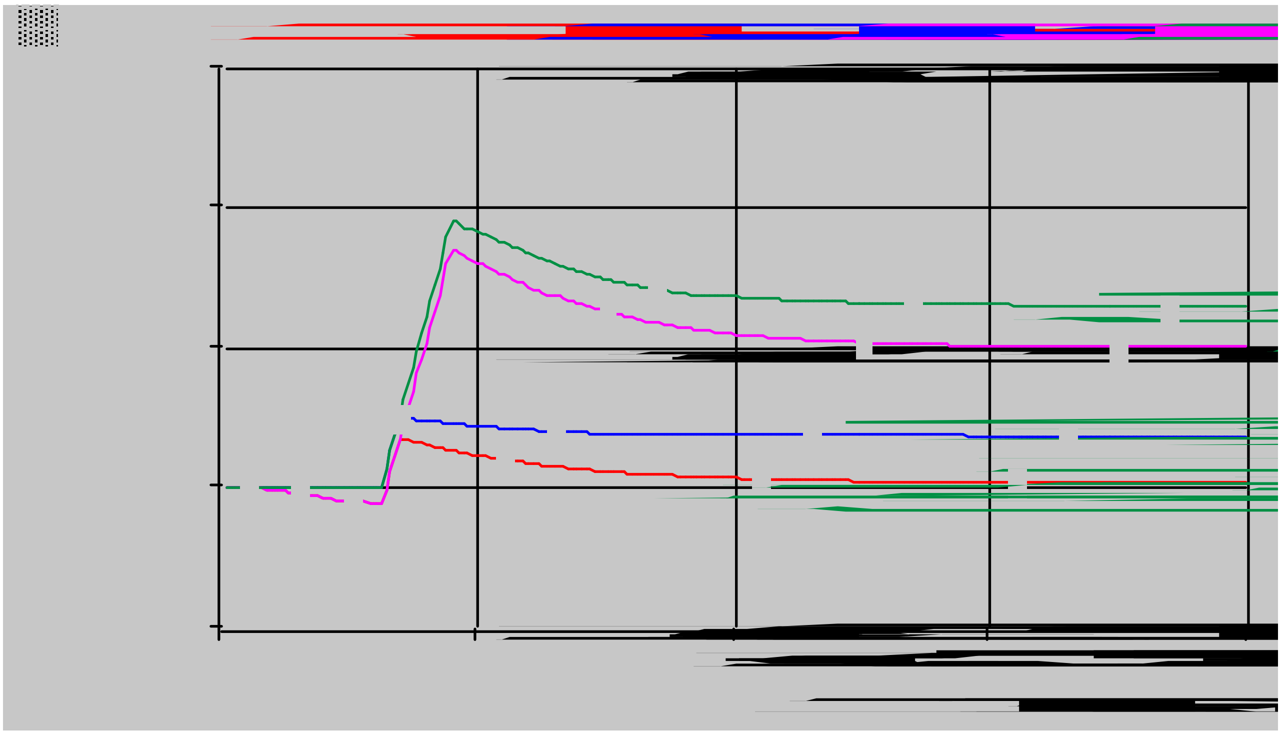


Figure 13 Simulation results: beds



14.6 Conclusion

In this section we have illustrated how a demand for and supply of health care model can be analysed within a system dynamics framework. To do this we employed some of the empirical evidence on elasticities and lags gathered in the econometric work reported above. In this exploratory study of system dynamics, the model has of necessity been rather rudimentary but nevertheless has enabled us to trace the implications for waiting times and lists of various alternative scenarios. In particular, we have incorporated a consultant-held target waiting time into the model so that, when waiting times differ from the target level, consultants adjust their treatment thresholds in an attempt to bring waits back into line with their target wait. We showed that this can generate the rather unexpected result that waits and lists are longer but more patients are being treated than in a situation where consultants hold no target waiting time. This is probably the major strength of system dynamics. It enables the analyst to examine the consequences of various scenarios, holding other factors constant, and the possibilities are, of course, almost limitless.

Although we are confident that the model presented here can offer important insights into the dynamics of NHS waiting lists, it suffers from a number of limitations, due both to our decision to limit the scope of the model (the focus is on elective surgery at an aggregate level) and to the limited availability of data. On the demand side we have assumed a constant elasticity of demand but this might vary with the level of waiting time. The supply side is also rather limited in that we assumed a constant elasticity of beds with respect to waiting time. Clearly, this assumption is only valid within certain limits. The availability of resources is heavily influenced by factors outside the model, such as the total resources devoted to the NHS, priorities set by government, and policy decisions in other parts of the NHS. We have also been forced to assume that the efficiency of NHS bed utilisation remains constant, irrespective of demand pressures although, as a referee noted, this is unlikely.

Nevertheless, even without these refinements we believe that the model described here offers a useful way of graphically illustrating the complex dynamic evolution of NHS waiting lists. It offers the first stage in the development of an NHS ‘macro’ model which seeks to describe the response of the NHS system as a whole to various policy instruments (van Ackere and Smith, 1999). Another attraction of this approach is that it is equally applicable to more disaggregated ‘micro’ situations. For example, if it is believed that specialties behave in different ways similar models could be employed but with different parameterisations to reflect the various differences. In addition, the approach could be applied to data at a more local level, modelling the response to various policy instruments at both the PCT and local hospital level.

15 OVERVIEW OF EMPIRICAL RESULTS AND DISCUSSION

15.1 Overview of results

This section presents a summary and discussion of the empirical results presented above together with an overview of the recent literature on waiting times.

15.1.1 Background to the study

The motivation behind this study was to strengthen our understanding of the supply of and demand for elective surgery. Previous work at York, based on population behaviour, had developed good, stable models of the demand for elective surgery over the period 1991/92-1997/98. However, because of data limitations the supply-side model had been less well developed and both the demand and supply models focussed on only the *in*patient wait. By focussing on NHS Trusts rather than population behaviour, this study was able to estimate a more comprehensive supply-side model for *in*patients as well as both supply and demand models for *out*patients. Also of interest was whether the inpatient demand results obtained previously (employing HES based population data) would be contradicted or confirmed with a wholly different (NHS Trust based) data set.

The NHS Plan sets some ambitious targets, particularly with regard to cutting waiting times both for outpatients and inpatients (DoH, 2000a). These targets were noted as were the data sources for waiting time statistics. Recent trends in waiting times were examined as well as referral and activity rates both for all specialties and selected individual specialties. With regard to monitoring the achievement of waiting time targets, it was noted that it can make a difference whether one looks at those patients *that have been treated* or those patients *that are awaiting treatment.*

Our models of the demand for and supply of NHS care are based on the idea that the supply side (in the form of hospital managers) and the demand side (in the form of patients) seek to maximise their own welfare subject to various constraints, and that the perceived waiting time has an important influence on their choices (Gravelle, Smith and Xavier, 2003). These demand and supply models were initially developed for application to inpatient care but can also be applied to outpatient care. We also apply them to outpatient and inpatient care combined.

Before estimation of the regression models commenced, a substantial data set was assembled. We constructed three measures of demand, two measures of supply, and five measures of waiting time for the inpatient models. For outpatients four measures of demand, four measures of supply, and six measures of waiting time were constructed. The alternative measures were typically well correlated with each other.

To this waiting time and activity data we added an estimate of each Trust's catchment population and the population's 'need' for acute care. To this database we added a further batch of variables from a data set compiled by researchers at the Centre for Health Economics. This database comprises two dozen or so variables based on information extracted from the annual HES database and other sources. It includes such Trust-based data as: the bed occupancy rate, the average length of stay, case mix complexity, the re-admission rate, the death rate, the day case percentage, and the number of beds per head of population. This data set allowed us to estimate broader models of supply than had hitherto been possible.

15.1.2 Inpatient results

Table 71 presents a very brief summary of the inpatient regression results. We found that waiting times had a significant negative effect on demand in all five specialty groupings and that this effect declined as the lag on the waiting time variable increased. The elasticity of demand with respect to the mean wait was between -0.135 and -0.235.[33] We also found that the local availability of private beds had a negative association with the demand for NHS care in four of the five specialty groupings (but not in ENT).

With regard to the supply of inpatient care, we found that waiting times had a positive impact on supply and that the supply response to waiting times was best modelled with a four quarter lag. The elasticity of supply with respect to the mean wait was between 0.052 and 0.103. We also found that a number of other variables (such as the number of beds and the number of emergency admissions) affected the supply of elective care. With the exception of ENT, the local availability of private beds had a negative association with the supply of inpatient NHS care.

[33] The demand elasticity with respect to the mean wait in the all specialty model was -0.311 but the equation exhibited marginal evidence of mis-specification.

Table 71 Summary of findings from inpatient models

(a) demand

Specialty grouping	Significant negative effect of waiting time on NHS demand (coefficient on *meanwait* where applicable)? lag_0	lag_1	Model well specified?	Significant negative impact of private care on NHS demand (coefficient on *private_beds* from model with *meanwait*)?
All specialties[34]	✔ (-0.311)	✔ (-0.230)	✔	✔
Routine surgery	✔ (-0.198)	✔ (-0.122)	✔	✔
Urology	✔ (-0.177)	✔ (-0.095)	✔	✔
Orthopaedics	✔ (-0.235)	✔ (-0.141)	✔	✔
ENT	✔ (-0.135)	✔ (-0.075)	✔	✗

(b) supply

Specialty grouping	Significant positive effect of waiting time on NHS supply (coefficient on *meanwait* where applicable)? lag_4	Model well specified?	Significant negative impact of private care on NHS supply (coefficient on *private_beds* from model with *meanwait*)?
All specialties*	✔ (0.055)	✗	✗
Routine surgery*	✔ (0.103)	✔	✔
Urology	✔	✗	✔
Orthopaedics	✔ (0.052)	✔	✔
ENT	✔ (0.078)	✔	✗

Note: *there is a four quarter lag on the non-waiting time variables in these regressions (one quarter lag in the others).

[34]The elasticity of demand with respect to the current period mean wait was -0.311 and that with respect to the lagged one period wait was -0.23 although both equations exhibited some evidence of mis-specification. The ✔ for specification denotes that another of our measures of waiting time (not the *meanwait* variable) generated a result which showed no evidence of mis-specification.

15.1.3 Outpatient results

Table 72 presents a very brief summary of the outpatient regression results. For each demand and supply model two equations were estimated: one based on GP referrals and the other based on all referrals. We found that waiting times, lagged one period, had a significant negative effect on demand and that this effect declined as the lag on the waiting time variable increased. The elasticity of all referral demand with respect to the mean wait was between -0.034 and -0.059 while that for GP referral demand was between -0.055 and -0.173. However, we found it difficult to obtain well-specified models for GP referrals for the two aggregated specialty groupings. There was also some evidence that the local availability of private health care was negatively associated with the demand for NHS outpatient appointments.

With regard to the supply of outpatient appointments, we found it difficult to obtain good models with the dependent variable based on GP referrals alone. For all referrals, however, we had more success and found that waiting times had a positive impact on supply and that the supply response to waiting times was best modelled with an eight quarter lag. The elasticity of all referral supply with respect to the mean wait was between 0.027 and 0.070. We also found that a number of inpatient-related variables (such as the number of beds and the number of day cases) also appeared to affect the supply of outpatient services. This effect is probably an indirect one reflecting the fact that more pressure on inpatient resources is likely to be associated with less outpatient supply.

We also found some evidence that the local availability of private care was negatively associated with the supply of NHS outpatient care. There was also evidence that the nurse vacancy rate adversely affected outpatient supply.

Table 72 Summary of some findings from outpatient models

(a) demand: GP/all referrals

Specialty grouping	Significant negative effect of waiting time (lag_1) on NHS demand?		Model well specified?		Significant negative impact of private care on NHS demand?	
	GP	all	GP	all	GP	all
All specialties	✔ (-0.090)	✖ (-0.057)	✖	✔	✔	✖
Routine surgery	✔ (-0.072)	✖ (-0.034)	✖	✖	✔	✔
Urology	✔ (-0.055)	✖ (-0.042)	✔	✔	✔	✖
Orthopaedics	✔ (-0.173)	✔	✔	✖	✔	✔
ENT	✔ (-0.076)	✔ (-0.059)	✔	✔	✔	✔

(b) supply: GP/all referrals*

Specialty grouping	Significant positive effect of waiting time (lag_8) on NHS supply?		Model well specified?		Significant negative impact of private care on NHS supply?	
	GP	all	GP	all	GP	all
All specialties	✖	✔ (0.052)	✖	✖	✖	✔
Routine surgery	✖	✔ (0.059)	✖	✔	✔	✔
Urology	✔ (0.080)	✔ (0.070)	✔	✔	✔	✔
Orthopaedics	✖ (0.047)	✔ (0.027)	✖	✔	✔	✔
ENT	✔	✔ (0.042)	✖	✔	✖	✖

Note: *there is a one quarter lag on the non-waiting time variables in the supply regressions.

15.1.4 Combined inpatient and outpatient models

We next estimated combined inpatient and outpatient supply and demand models where the impact of total (outpatient plus inpatient) waiting time affects total (outpatient plus inpatient) demand and total (outpatient plus inpatient) supply. This required the construction of a single measure of waiting time, of demand, and of supply. For the waiting time measure we summed the mean wait in outpatients and the mean wait in inpatients. For demand and supply some method for combining outpatient and inpatient referrals (and activity) was required. To do this we used weights reflecting the relative unit cost of inpatient and outpatient services. CIPFA's *Health Service Database 1999* suggests that the ratio of the cost per inpatient episode to the cost per outpatient attendance is about 15:1 (CIPFA, 1999, p51). However, the outpatient activity data employed in this study only relates to first attendances and for each first attendance there are, on average, two further attendances. When calculating measures of total demand and total supply the individual inpatient and outpatient measures were therefore combined with a 5:1 weighting.

Table 73 presents a very brief summary of the demand and supply results. Generally, the results are similar to those for inpatients alone but in some cases the inclusion of outpatients has enabled us to obtain a better result (e.g., there is no evidence of mis-specification in any of the five supply equations). We found that waiting times had a significant negative effect on demand and that this effect declined as the lag on the waiting time variable increased. The elasticity of total demand with respect to the current mean wait was between -0.133 and -0.238 and, in three of the five equations, there was evidence that the local availability of private health care was negatively associated with the demand for NHS care.

On the supply side, the elasticity of all referral supply with respect to the mean wait varied between 0.054 and 0.087. We again found that a number of inpatient-related variables (such as the number of beds and the number of day cases) also appeared to affect the total supply of services. We also found some evidence that the local availability of private care was negatively associated with the supply of NHS outpatient care.

15.1.5 Seemingly unrelated regression results[35]

In sections 9 -12 we estimated separate OLS regression models for inpatient demand, inpatient supply, outpatient demand, and outpatient supply. In section 13 we constructed a measure of total (inpatient plus outpatient) demand and a measure of total (inpatient plus outpatient) supply, and estimated separate models for total demand and total supply. Throughout, we have implicitly assumed that there is no formal connection between these equations. If the error terms across the individual supply and demand equations are linked, the use of OLS to separately estimate each equation may be inefficient because it fails to utilise the information present in the cross-equation error correlations.

In an annex to this report we reveal that the residuals from the supply and demand equations are highly correlated. However, because the reason for this correlation is not certain - although we believe that it is attributable to the omission of a time varying measure of need from the estimated supply and demand models - the results from the re-estimation of the demand and supply models incorporating this cross-equation correlation are presented in an annex to this report.

These results should be viewed as an exploratory use of a promising tool. The use of the SUR estimator transforms the previously correlated OLS errors so that they are no longer correlated and then applies this transformation to the other variables in the model which are then estimated by OLS. Thus in this particular case the SUR estimator can be viewed as ‘purging’ the other variables of their correlation with the need for health care. Although this transformation leaves the broad structure of our results remained unchanged, SUR estimation reduces the coefficient on the waiting time variable in the demand equation, more so for the combined specialties groupings than for the individual specialties. It may be, for example, that part of the previously observed demand effect is, in fact, a needs effect and that, once the impact of need is removed, the responsiveness of demand to waiting time is reduced.

[35]Due to the preliminary nature of these results, they are presented in an annex to this report.

Table 73 Summary of findings from combined inpatient and outpatient models

(a) total demand

Specialty grouping	Significant negative effect of waiting time on NHS demand (coefficient on *meanwait* where applicable)? lag_0	lag_1	Model well specified?	Significant negative impact of private care on NHS demand (coefficient on *private_beds* from model with *meanwait*)?
All specialties	✔ (-0.224)	✔ (-0.162)	✔	✗
Routine surgery	✔ (-0.133)	✔ (-0.064)	✔	✔
Urology	✔ (-0.174)	✔ (-0.108)	✔	✗
Orthopaedics	✔ (-0.238)	✔ (-0.156)	✔	✔
ENT	✔ (-0.154)	✔ (-0.084)	✔	✔

(b) total supply

Specialty grouping	Significant positive effect of waiting time on NHS supply (coefficient on *meanwait* where applicable)? lag_4	Model well specified?	Significant negative impact of private care on NHS supply (coefficient on *private_beds* from model with *meanwait*)?
All specialties*	✗ (0.054)	✔	✗
Routine surgery*	✔ (0.087)	✔	✔
Urology	✔ (0.084)	✔	✗
Orthopaedics	✗ (0.069)	✔	✔
ENT	✔ (0.076)	✔	✗

Note: *=there is a four quarter lag on the non-waiting time variables in these regressions (one quarter lag in the other supply regressions).

15.1.6 Summary of demand and supply elasticities and estimated confidence intervals

One attractive feature of the logarithmic models we have employed is that the estimated regression coefficients measure the elasticity of the dependent variable with respect to each regressor. The elasticity is the percentage change in the dependent variable (demand or supply) brought about by a one percent change in the regressor. Thus the coefficient on the waiting time variable measures the responsiveness of demand (or supply if supply is the dependent variable) to a 1% change in waiting time.

Table 74 presents a summary of some of the demand and supply elasticities with respect to waiting times that we have obtained in this study. The inpatient demand elasticities vary between -0.135 (for ENT) and -0.311 (for all specialties combined). These elasticities imply that a 1% decrease in ENT inpatient waiting time will bring about a 0.135% increase in ENT inpatient demand, and that a 1% decrease in inpatient waiting times across all specialties will bring about a 0.311% increase in inpatient demand.

In addition to the estimated elasticities, Table 74 also reports the interval within which we are 95% certain that the 'real' elasticity will lie. Thus for inpatient routine surgery our best estimate of the demand elasticity is -0.198 and we are 95% certain that the 'real' or true value of this elasticity will lie somewhere in the range between -0.278 and -0.118.

Overall, the demand elasticities are larger than the supply elasticities. This implies that the demand response to any change in waiting time will be greater than the supply response, all other factors held constant. From a current policy perspective, this relative stability of supply is reassuring. It implies that, as NHS funding increases and waiting times begin to fall, there is unlikely to be a substantial shifted of resources away from elective services and towards other areas of NHS activity.

It may be of interest to consider the implications of our results and, in particular, the supply and demand elasticities, for the response of waiting times to an increase in NHS resources (as proxied by the number of NHS beds in our model). The only way we can do this is to assume that demand and supply are broadly in equilibrium and that the relationships we have identified reflect this position. From the demand equation we have a relationship of the form D=f(wt). With D=S we can substitute D=f(wt) into the supply relationship S=g(wt, NHS beds) to obtain an expression of the form wt=h(NHS beds). Employing the inpatient demand and supply results for routine surgery in Tables 28 (equation 2a) and 30 (equation 1b) we obtain the result that wt=-0.98NHS beds. This implies that a 1 per cent increase in NHS beds will lead to just under a 1 per cent reduction in waiting time.

That the demand elasticity is greater than the supply elasticity is irrelevant here: what matters are the sum of the absolute values of the demand and supply elasticities, and the coefficient on the NHS beds variable. The larger the coefficient on the beds variable the more responsive is waiting time to resource changes. However, some of the reduction in waiting time brought about by an increase in resources will be dissipated by (a) increased demand as patients eschew the private sector and (b) reduced elective supply as resources are shifted away from elective activity and towards other parts of the NHS. The smaller are these dissipation effects (as measured by the elasticities) the greater the impact of any given increase in resources on waiting times.

Table 74 Estimated demand and supply elasticities, and their associated 95% confidence intervals

	Inpatients		Outpatients		Inpatients and outpatients combined	
	Estimated elasticity	95% confidence interval	Estimated elasticity	95% confidence interval	Estimated elasticity	95% confidence interval
Demand						
All specialties	-0.311	-0.398 to -0.225	-0.090	-0.173 to -0.006	-0.224	-0.340 to -0.107
Routine surgery	-0.198	-0.278 to -0.118	-0.072	-0.159 to 0.014	-0.133	-0.259 to -0.006
Urology	-0.177	-0.230 to -0.124	-0.055	-0.111 to 0.000	-0.174	-0.238 to -0.110
Orthopaedics	-0.235	-0.301 to -0.163	-0.173	-0.226 to -0.120	-0.238	-0.308 to -0.167
ENT	-0.135	-0.205 to -0.065	-0.076	-0.127 to -0.026	-0.154	-0.216 to -0.092
Supply						
All specialties	0.055	0.012 to 0.097	0.052	-0.011 to 0.115	0.054	-0.032 to 0.140
Routine surgery	0.103	0.062 to 0.145	0.059	0.011 to 0.107	0.087	0.002 to 0.173
Urology	-	-	0.070	-0.010 to 0.148	0.084	-0.010 to 0.177
Orthopaedics	0.052	-0.037 to 0.141	0.027	-0.006 to 0.059	0.069	-0.018 to 0.156
ENT	0.078	0.011 to 0.144	0.042	-0.004 to 0.089	0.076	-0.013 to 0.164

NB These elasticities are taken from the estimated coefficient on the *meanwait* variable.

15.2 Results in context

In the past five years four reviews of the waiting time literature have been published and we do not propose to repeat this exercise here (Edwards, 1997; Hamblin, Harrison and Boyle, 1998; Harrison and New, 2000; Cullis, Jones and Propper, 2000). As we have noted before, many studies have examined the link between waiting time and demand, and between the resources devoted to surgery and the associated waiting time (Martin and Smith, 1999 and 2003). However, the value of these studies and the reliability of their findings have been at best mixed because most of these studies have not modelled the demand for and supply of surgery as a whole but have typically focussed on one particular aspect (such as the correlation between waiting times and the volume of resources devoted to surgery).[36] Rather than re-visit all of the literature, we will compare the results obtained in this study with some of the more econometrically robust studies published in the last few years.

15.2.1 Demand

A useful starting point is to compare the results from this study with those we obtained previously employing a wholly different data set (Martin and Smith: 1999, 2003). The first study (1999) was based on HES (population) data for routine surgery for 1991-92 and employed the electoral ward as the unit of analysis. The model was an equilibrium one - it assumed that queue lengths were reasonably stable - and we obtained an elasticity of inpatient demand with respect to the mean wait of about -0.21 (Martin and Smith, 1999). The second study was also based on the same model and on HES data for routine surgery but had access to data for several years, from 1992-93 to 1997-98. In this study the elasticity of demand for all routine surgery was -0.09 although this increased to -0.23 in first difference form. The local availability of private beds also had a significant negative effect on NHS demand (Martin and Smith, 2003).

Bearing in mind that the present study employs a wholly different data set, collected over a different time period, and employs a different model, it is remarkable that we find that the elasticity of demand with respect to the mean waiting time is -0.20 for all routine surgery. In this study we have also found that the demand elasticities for three other specialties are of a similar magnitude and this is an improvement on the previous study where we had some difficulty detecting a significant negative effect of waiting time on demand at the individual specialty level.

We can compare the demand elasticities reported above with results reported by Gravelle, Smith and Xavier (2003). In their paper, the authors estimate the same model as employed in this study but apply the model to English Health Authority data for 24 quarters from 1987 to 1993 for routine surgical admissions. For their demand equation they did not have access to a direct measure of demand (the number of additions to the waiting list). As a proxy for this, they employed the number of patients who had been waiting three months or less at the end of the quarter. This does not directly measure the number of additions to the waiting list and will understate the numbers actually added to the list in a quarter whenever there are any patients who have been added to the list and treated within the same quarter. Using this demand measure they obtained an elasticity with respect to the proportion of patients waiting more than three months (lagged one quarter) of about -0.21. Our elasticity estimates with regard to the mean wait are marginally smaller at about -0.20 for routine surgery and averaging about -0.18 across the results for urology, orthopaedics, and

[36]See, for example, Goldacre et al (1987), Frankel (1989), Buttery and Snaith (1979, 1980), Yates (1987), and Henderson et al., (1995).

ENT. However, this might well result from the fact that the demand measure differs between the two studies.[37]

Gravelle, Dusheiko and Sutton (2002) modelled the determinants of admission rates for cataract surgery across general practices in North Yorkshire Health Authority over the period 1995-98. They found that increases in waiting times have the anticipated negative effect on demand and that the elasticity of demand with respect to waiting time was -0.25. This figure is not that different to the demand elasticities that we have obtained in this study, ranging from -0.135 in ENT to -0.235 in orthopaedics. The authors also found that early wave fundholders had lower admission rates than later wave fundholders and non-fundholders and that increases in distance between practices and providers have a significant negative impact on admission rates.

In many health care systems primary care physicians act as 'gatekeepers' to secondary care. Dusheiko, Gravelle, Jacobs and Smith (2003) investigate the impact of the UK fundholding scheme under which general practices could elect to hold a budget to meet the costs of elective surgery for their patients. This study uses a differences in differences methodology on a large four year panel of English general practices before and after the abolition of fundholding. The authors find that fundholding incentives reduced fundholder elective admission rates by 3.3% and accounted for 57% of the difference between fundholder and nonfundholder elective admissions, with 43% a selection effect due to unobservable differences in practice characteristics. Fundholding had no effect on emergency admissions. This study found an elasticity of elective admissions with respect to mean waiting time of -0.10 and a positive association between elective admissions and the distance to a private provider.

Further evidence on demand elasticities in provided by Goddard and Tavakoli (1998) who estimate a demand function for NHS treatment using panel data for 15 Scottish Health Board areas over 12 quarterly observations (1990-92) for six specialisms. In their model, the number of additions to the waiting list in area *i* for quarter *t*, B_{it}, is related to the expected waiting time for NHS treatment, *w*, so that B=B(*w*). To estimate this equation, the number of additions to the waiting list, B_{it}, is standardised using age- and sex-specific population data and national hospitalisation rates for each specialism in 1990. This takes out the need to include demographic variables in the demand model.

Finding that a logarithmic functional form best describes the data, Goddard and Tavokli initially estimate a model of the form $\ln(b_{it})=a_{1i} + a_{2i}(\ln(w_{it}))$ where b_{it} is the age and sex standardised number of additions to the waiting list in area *i* for quarter *t*. However, they find 'some dynamic effects, necessitating the inclusion of a lagged dependent variable' so that their actual estimating equation is $\ln(b_{it})=a_{1i} + a_{2i}(\ln(w_{it})) + a_{3i}\ln(b_{it-1})$. This addition of a lagged dependent variable is justified on the grounds that the relationship between demand and waiting times is a long run equilibrium relationship towards which there is only partial adjustment from one quarter to the next. Goddard and Tavakoli report estimates of a_{2i} and a_{3i}. The former is significant and with the anticipated sign for all six specialisms, ranging from -0.017 for general surgery to -0.096 for orthopaedic surgery.

Our finding that the accessibility of private beds has a negative impact on the demand for NHS care is consistent with some of the work by Besley, Hall and Preston (1999). Estimating a demand function for individually purchased private health insurance over the period 1986-91 using data from the British Social Attitudes (BSA) survey, they found that the size of the *long-term* waiting

[37]Our elasticities average about -0.11 across urology, orthopaedics, and ENT if the lagged one period waiting time measure is used.

list (numbers waiting for more than 12 months per 1,000 population) encouraged the individual purchase of private medical insurance. However, the size of the total waiting list (numbers waiting for any form of in-patient treatment per 1,000 population) had no significant impact on the purchase decision.

Propper (2000) also examined the demand for private health care in the UK using data from the British Household Panel Survey (BPHS) for 1991-95. This is a nationally representative survey of around 5000 households interviewed each year. Propper finds no association between the length of either waiting lists under a year or over a year and the use of public and/or private in-patient health care. However, it should be noted that Propper's waiting time variables are constructed at the regional level according to the Authority in which the survey respondent lives. Given that waiting times vary considerably across both DHAs and wards within any given region, then the apparent insignificance of waiting time on the demand for private health care in Propper's model might be due more to the way in which the waiting time variable has been constructed rather than the nature of the underlying relationship.

Jofre-Bonet (2000) estimates a model of the demand for private health care using data from 21,120 responses to the 1993 National Health Survey of Spain and 21,155 responses to the 1990/91 Family Budget Survey. The author's logit model of the demand for private health insurance includes the usual demographic and socio-economic factors together with the average number of days on the waiting list for surgical procedures financed by the local social security system. Two logit models are estimated depending on whether the interviewee is the head of the household. For the head of household model, the waiting time for publicly funded treatment is of marginal significance at the 10% level (n=7,375, t-ratio=1.69). For the not head of household model, the waiting time for publicly funded treatment is of marginal significance at the 5% level (n=8,763, t-ratio=2.17).

At the end of 2000, 6.88 million people were covered by private medical insurance (PMI). King and Mossialos (2002) use British Household Panel Survey data to examine the determinants of the prevalence of PMI. Their results are similar to those obtained by previously by other studies e.g., by Besley et al (1999) and by Propper et al (1999 & 2001). King and Mossialos (2002) find the usual association between income, age, sex, level of education, political affiliation and the prevalence of individually financed PMI. With regard to waiting times, King and Mossialos employed two variables constructed at the Health (and then again at the Regional Health) Authority level:

- the percentage of patients who waited over 6 months for an inpatient stay
- the percentage of patients who waited over 13 weeks for an outpatient appointment

However, neither variable had a statistically significant impact on the prevalence of PMI.

Overall, the somewhat mixed results we have obtained with regard to the impact of the private sector on NHS demand is perhaps not surprising given the mixed results with regard to the impact of waiting times on the purchase of private medical insurance (although, of course, not all private care is funded via insurance).

15.2.2 Supply

In Martin and Smith (1999) we reported an elasticity of supply with respect to waiting time for all routine surgical specialties of 2.93 and in a later study we obtained an elasticity of 5.29 (Martin and Smith, 2003). These are substantially larger than the elasticities we have found in this study (ranging from 0.050 to around 0.100). One reason for this difference is the very rudimentary nature of the supply model in our previous studies compared with the more comprehensive equation estimated here. The difference may also be due to differences in estimation procedures (cross-section versus panel, or the year used, or the technique used (IV versus OLS)). It might also reflect the fact that the elasticity in equilibrium (as assumed in our earlier study) differs from that in disequilibrium. However, we can note that in our previous studies the mean waiting time and the number of NHS beds both had a significant positive effect on the supply of inpatient activity.

We can compare the supply elasticities from the current study with results reported by Gravelle, Smith and Xavier (2003). In their linear supply equation for inpatient care, Gravelle et al report a coefficient of 0.1695 on their mean waiting time variable. This implies an elasticity of 0.083 (at the mean of the variable). This is very similar to our figure (of 0.103) yet the two studies employ different units of analysis (Health Authorities rather than Trusts) and different time periods (1987-93 rather than 1995-2002).[38] Unfortunately, we are not aware of any other studies that have estimated supply elasticities and with which we can compare the results in this study.

With regard to beds, our results suggest a supply elasticity of about 0.40. This is smaller than we have found previously (0.76 and 0.94) and we have already noted several reasons why our estimates might differ between this and our two previous studies (for example, the estimated supply equation in previous studies was rather rudimentary).

15.2.3 Other recent waiting time studies

There have been a number of other studies recently that have focussed on waiting times. Although these are not of direct relevance to the present study, a brief review of them will provide the reader with a flavour of the sort of work undertaken.

There have been a couple of studies of GP fundholding. Dowling (1997) compared the inpatient waiting time of 57,000 fundholding and non-fundholding patients for elective surgery at four providers in West Sussex over four years (1992-1995). Patients with planned or booked admissions were excluded. Patients from fundholding practices had significantly shorter waiting times than those from non-fundholders for all four providers for all four years. Waiting times for patients did not fall until the year that the practice joined the fundholding scheme. The author concludes that fundholding shortens waiting time. This conclusion differs from the judgement of the Audit Commission (1996). However, the Commission report used data from one hospital over one year and included all three categories of admission (elective, planned and booked). The report also calculated waiting times according to the status of the practice at the time of the operation. Hence people who might have spent a long period on the list as a non-fundholding patient would be counted towards the average waiting time of fundholding patients if they had the operation after the practice joined the fundholding scheme. These two effects would tend to reduce any differential between fundholding and non-fundholding waiting times.

---

[38] The Gravelle et al (2003) waiting time variable was lagged one quarter whereas ours was lagged four quarters.

Propper, Croxson and Shearer (2002) investigate whether GP fundholders were able to secure shorter inpatient waiting times for their patients requiring fundholding procedures and whether the impact of fundholding spilled over into shorter waiting times for all patients. The study uses a difference-in-difference methodology which involves examining the difference in the variable of interest (waiting times) between practices that are fundholding and practices that are not, controlling for any changes contemporaneous with the introduction of fundholding. This approach is implemented within a regression framework to control for changes in observable variables and to account for the fact that the fundholders became fundholders at different points in the 4-year window for which the study team has data. The basic approach is to regress the patient's waiting time on patient characteristics, medical specialty, year and general practice fixed effects, and a dummy which denotes whether the patient is from a fundholding practice.

The data set is similar to the HES database and contains every hospital record over the four year period 1993-97 from one health authority, North West Anglia. This provides almost 350,000 records of which 100,000 were used in the analysis. The authors find that patients from fundholding practices did experience lower waiting times but only for fundholding procedures and that there were no spillover effects to patients from the same practices waiting for non-fundholding procedures. Moreover, the authors found no net overall effect of fundholding on waiting times. Across all specialties and procedures becoming a fundholder had no significant impact on the time fundholders' patients waited for treatment.

Analysing the same data set, Croxson, Propper and Perkins (2001) examine whether fundholders increased referral rates in the year before they became fundholders in order to get a larger budget and reduced them after they became fundholders. Croxson et al did indeed find evidence of such fundholder gaming effects although their admission functions did not include any waiting time variable.

There have also been a few purely theoretical papers that have looked at the impact of the existence of the private sector on public sector waiting times. Iverson (1997) examines theoretically the effect of a private sector on the waiting time for treatment in a public sector hospital. Iverson distinguishes two situations: first, where public treatment is 'unrationed' (and by 'unrationed' he seems to mean that there are no treatment thresholds so that anyone who might gain some benefit, no matter how small, is eligible for treatment); and second, where public treatment is rationed so that consultants require certain criteria to be fulfilled before they will admit a patient to the waiting list.

It is sometimes claimed that the private sector causes a shorter waiting time because fewer patients are cared for in the public sector. This assumes that the capacity in the public sector is not influenced by the introduction of the private alternative. Then the reduction in waiting time is larger the more elastic the demand for public treatment is with respect to waiting time. In Iverson's model, however, the public sponsor is assumed to behave like an economic agent: it determines the hospitals' budget by trading off marginal benefits against marginal costs. The conclusion here is then the opposite of that above: the more elastic the demand for treatment, the longer is the public waiting time with a private option. The reason is that an elastic demand for public treatment makes possible a large reduction in public expenditures by increasing the waiting time in the public sector. In general, however, the effect of the private sector on the public sector waiting time is indeterminate.

When waiting-list admissions are rationed and consultants who work in the public sector also work part-time in the private sector, the private sector will lead to an increase in the waiting time for treatments in the public sector (because the longer the waiting time in the public sector the more private patients the consultant is able to attract although the consultant's ethical values prevent her/him from having too strong a preference for personal income relative to the public waiting time).

Barros and Olivella (1999) develop a theoretical model of waiting lists for public hospitals when physicians deliver both private and public treatment. Public treatment is free but rationed (only cases meeting some medical criteria are admitted for treatment). Private treatment has no waiting time but entails a payment of a fee. The model focusses on the extent to which physicians select the mildest cases from the waiting list for private treatment (cream skimming). The authors concentrate on those patients who are admitted to the public waiting list and their cream-skimming definitions are in reference to this segment. They define full cream-skimming as the situation where all the mildest patients admitted to the waiting list end up being treated in the private sector. Partial cream-skimming occurs where doctors privately treat patients with an intermediate range of illness severities.

Their most important result is that full cream-skimming is only compatible with intermediate rationing policies so that if rationing (admission to the public waiting list) is either very lax or very stringent then cream skimming will always be partial. The intuition behind this is that a very strict rationing policy, with only the most severe cases admitted, will lead to short waiting lists and so people will be willing to wait for public sector treatment to save the private sector fee. With lax rationing many people are admitted to the public waiting list and the list will be long. As there will be patients in the waiting list with mild conditions these patients will be willing to wait because their cost of doing so is small.

Morga and Xavier (2001) analyse UK NHS waiting times and waiting lists for elective surgery looking at hospital specialists' behaviour and the conflict of interest these may face when allowed to practice privately. They examine the relationship between the government as the health care purchaser and principal of a two-tier hierarchy, and two hospital specialists, the agents, that deal with elective and emergency treatment. Specialists are organised in a separated structure, each responsible for only one type of surgery (either elective or emergency). They examine how specialists' interest in the income obtained with private practice (and altruism) affects negatively (positively) the optimal NHS numbers treated and increases the waiting time for elective surgery.

Olivella (2002) constructs a model that analyses the public health administration's (PHA's) decisions on waiting lists for public treatment. The PHA maximises a utilitarian social welfare function. Patients differ in their waiting costs which, in turn, depend on the severity of their condition. Patients choose between waiting for free treatment in the public sector and paying for immediate treatment in the private sector. Olivella shows that as public treatment is free the PHA provides an incentive for patients to shift to the private sector by maintaining long waiting times.

Farnworth (2003) develops a formal model of service rates, joining rates, and waiting times. He notes that Lindsay and Feigenbaum (1984) developed the idea that waiting lists can be used to allocate goods according to willingness to wait. In their model consumers choose between joining a single waiting list and not joining at all. There is an arbitrary flow off one waiting list. Farnworth (2003) extends Lindsay and Feigenbaum's model by having consumers choose between two waiting lists and by formally modelling the flow off waiting lists.

Iversen (1993) develops a model in which a hospital is a utility maximising agent with a waiting list. One hospital's interaction with a public funding agency determines the expected waiting time for the hospital's services. The hospital derives utility from its expected service rate and derives disutility from the expected waiting time. Iversen has an arbitrary flow onto the waiting list. Farnworth (2003) extends Iversen's model by examining how two hospitals may interact with each other and by formally modelling the flow on to waiting lists.

In Farnworth's model there are two private hospitals that are publicly funded; there is a waiting list for services at each hospital. Policy makers may be interested in altering waiting times. Charging a price to patients when the service is received is one policy option. For equity reasons, policy makers may want patients to face no financial price at one hospital. Farnworth finds that, under certain conditions, an increase in the price charged to patients will lower the waiting time at each hospital. However, no empirical application of the model is attempted.

Returning to the demand for hospital care, Oliveira (2002) constructs and estimates a 'flow' demand model of hospital inpatient utilisation. Oliveira's model is designed to explain the 'flow' between each population point (small area) and each hospital. She contrasts this with other models, so-called 'stock' demand models, where demand is typically analysed at the small area level with little, if any, interest in *which* hospital meets demand. Oliveria estimates her model using Portugese data for 1999 on 275 population points and 68 hospital sites. Among her findings she notes that the impact of need, the availability of hospital supply, and the perception of availability on flows (demand) are positive, while distance to supply and primary care utilisation are negative. However, as Oliveira notes, one of the limitations of her results is that there is no waiting time variable in her estimated demand equations. The omission of this variable casts some doubt on the reliability of the estimated coefficients. Also, inpatient demand is measured by the number of patient discharges from each hospital site to each population point. The implicit assumption is therefore that demand and supply are in equilibrium with little change in the length of waiting lists.

15.3 Discussion

Our inpatient supply and demand results are broadly consistent with our previous findings. This is a reassuring result, and notable because this study used an entirely different data set to that employed previously. This study was based on acute trust returns, whereas our previous work relied on HES data with electoral wards as the unit of analysis. Moreover, the current results are based on the most recently available data (from 1995 to 2002) whereas our previous study covered an earlier period (from 1992 to 1997). Our results are also in line with the small number of other studies that have examined this topic, confirming that waiting times have a small but significant impact on both the demand for and supply of inpatient NHS care.

The study offers some important messages for policy. Within the limitations of the data available, it confirms that lower waiting times provide a relatively modest stimulus to demand for inpatient and outpatient surgery. It reinforces previous findings that, other things being equal, the dramatic reductions in waiting times in the NHS are unlikely to lead to major increases in demand. On the supply side, longer waiting times appear to have only a marginal positive impact on NHS activity, both in aggregate and in the three specialities studied. The precise response of the NHS supply side as waiting times are reduced in the future will depend heavily on the incentives put in place to sustain the improvements. However, this study suggest that – over the years studied – NHS hospitals did not 'ease up' in any major fashion when waiting times fell.

Using new analytic techniques, we have been able for the first time to model simultaneously the links between inpatients and outpatients and demand and supply. This analysis is exploratory - hence its presence as an annex to this report - but it does suggest that the impact of waiting times on system behaviour may if anything be less than we had previously suggested, reinforcing our confidence that the new targets will not in themselves have a major influence on demand or supply.

We have also demonstrated how the results of this study could be used to simulate dynamic responses to extra resources, and have demonstrated the implications of a consultant-held target. These simulations probably have limited predictive power, but they can help policy makers understand the components of the waiting time problem and the potentially complex dynamics of the health system.

Our study offers some evidence that better access to private healthcare provision may depress both the demand for NHS services and also NHS supply. These results must be viewed in the light of the rudimentary measures of private supply we had available, but they do suggest that interactions with private sector provision may be quite subtle and require careful examination before drawing policy conclusions.

Of course our conclusions are subject to the usual caveats applicable to almost all empirical work. They depend on the validity of the assumptions made in the construction of the model and the extent to which the empirical proxies used accurately reflect the model's theoretical concepts (e.g., the use of the number of beds as a proxy for resource availability). Strictly speaking our results also only apply within the range of the values in the data set . If waiting times were radically changed by government initiatives so that they started to fall outside the values found in the data set, then our conclusions would be on less reliable ground. However, as at March 2002 over three-quarters of all patients were admitted within six months so that even a maximum wait of six months will benefit less than one-quarter of all elective patients. This is not meant to belittle the achievement of such a challenging target but to point out that a considerable majority of NHS patients are already treated within this time period and that, as a result, we can be reasonably confident that our empirical results will be robust the planned reductions in maximum waiting times other things being equal.

It is however important to note that our supply side responses have been developed under a certain set of policies and incentives. The radically new set of policies implicit in the NHS Plan might lead to fundamentally different supply side responses, the nature of which cannot be predicted from historical statistical models. On the one hand, the very ambitious waiting time targets in the Plan might lead to even more supply side attention to waiting times. On the other hand, the increased attention paid to other performance measures, such as clinical outcomes, may lead to a diminution of the supply side effort directed at waiting times.

This study offers an advance on previous research in a number of ways. First, we have been able to estimate demand and supply models for both *out*patients and *in*patients and have demonstrated the usefulness of Trust returns as data source for modelling the demand for and supply of health care. Second, by combining these returns with a database of Trust characteristics we have been able to estimate more general models of hospital supply (based not just on waiting time). We have examined the impact of many factors on hospital supply and have applied these models to both groups of specialties and individual specialties. Third, we have obtained a reasonably stable set of results, based on a panel that runs from 1995 to 2002. Use of a panel has allowed us to explore the lag with which demand and supply respond to waiting times, suggesting that the supply response is rarely instantaneous. Fourth, the exploratory use of the seemingly unrelated regression technique allows us to model interactions between various aspects of hospital activity, and may merit further development as an analytic tool in this area. And fifth, we have assembled an important dataset that could in principle answer a number of other research questions unrelated to our original intentions.

Although our results are robust and intuitively plausible, this work can be viewed as an initial exploration of a potentially rich data resource related to hospital productivity. The quarterly returns submitted by Trusts, on both inpatients and outpatients, offer a data set which has been little used to date but which, when combined with other Trust based information, offers a data source that is ripe for analysis, in respect of both the impact of waiting times and the broader determinants of hospital activity. Our database on Trust characteristics has proved immensely valuable, and would benefit from continued updating, both of existing variables and through the addition of new variables. There is also the potential for estimating models of specialties other than the three examined here. Our results have suggested important links between NHS activity and private supply, and we would recommend that this is an area in which further research may yield important results. Finally, our initial application of the seemingly unrelated regression technique suggests that this methodology might provide a useful direction for future modelling of hospital productivity.

The study therefore suggests a number of avenues for future research. These include:

- further analysis of the quarterly hospital waiting list returns;
- to that end, updating and extending our database of hospital characteristics;
- more detailed analysis of individual specialities;
- more detailed modelling of the interaction between NHS and private supply; and
- further exploration of the usefulness of seemingly unrelated regression estimation methods.

ANNEX

LINKING THE SUPPLY AND DEMAND MODELS: SOME PRELIMINARY SEEMINGLY UNRELATED REGRESSION RESULTS

1 Seemingly unrelated regressions

In sections 9 -12 we estimated separate OLS regression models for inpatient demand, inpatient supply, outpatient demand, and outpatient supply. In section 13 we constructed a measure of total (inpatient plus outpatient) demand and a measure of total (inpatient plus outpatient) supply, and estimated separate models for total demand and total supply. Throughout, we have implicitly assumed that there is no formal connection between these regressions.

However, it is not difficult to imagine circumstances in which the regressions, or more precisely the error terms, might well be linked. For example, there might be some unobservable variable, such as efficiency, that we have omitted. Some Trusts will be more efficient than others and any efficiency effect on supply might well apply to both inpatient and outpatient services. In this case the error terms in the two supply regressions are likely to be positively correlated: Trusts exhibiting positive errors in the outpatient supply regression would also record positive errors in the inpatient supply regression. Alternatively, some Trusts might prioritise inpatient facilities over outpatient services and, in these circumstances, one would anticipate a negative correlation between the error terms in the two supply regressions.

If the error terms across the individual supply and demand regressions are linked, the use of OLS to separately estimate each regression is inefficient because it fails to utilise the information present in the cross-regression error correlations. In other words, the OLS estimator no longer offers the most efficient estimates of the standard errors although OLS remains a consistent estimator. To avoid this loss of information the seemingly unrelated regression (SUR) estimator can be employed. This is a method of estimating systems of regressions in which the parameters for all equations are determined in a single procedure.

In this annex we present some exploratory results employing the SUR estimator. We find that the OLS errors from the demand and supply models are significantly correlated. However, because the reason for this correlation is not certain - although we do offer an hypothesis - the results presented below should be viewed as preliminary pending further investigation.

2 Seemingly unrelated regression estimation of the total supply and demand equations

To improve the precision of the parameter estimates, SUR estimation transforms the errors so that they all have the same variance and are uncorrelated. This transformation is then applied to the other variables in each equation and OLS is applied to these transformed variables. This procedure - known as joint generalised least squares estimation - offers more precise parameter estimates than single equation least squares because it incorporates the additional information provided by the correlation between the individual equation errors.

Table 75 presents the correlation matrix for the residuals from OLS estimation of four regressions (inpatient demand, inpatient supply, outpatient demand, and outpatient supply) for all specialties combined. The Breusch-Pagan test of the independence of the residuals is a test of the joint significance of the six correlations and, in this case, clearly rejects the null hypothesis of no correlation. The most marked correlations are between supply and demand, with that for inpatients (0.6365) exceeding that for outpatients (0.4074). The other correlations are considerably smaller and are of marginal significance. For both inpatients and outpatients the implication is that Trusts with a large demand residual also have a large supply residual. One interpretation of this would be that there is some unobserved factor that boosts both demand and supply but which has not been included in the model.

Table 75 Correlation matrix of residuals from OLS estimation of individual regressions for all specialties combined

Regression	Inpatient supply	Outpatient supply	Inpatient demand	Outpatient demand
Inpatient, supply	1.0000			
Outpatient, supply	0.0939	1.0000		
Inpatient, demand	0.6365	0.1146	1.0000	
Outpatient, demand	0.0652	0.4074	0.0907	1.0000

Breusch-Pagan test of independence of residuals: chi2(6) = 928.209, probability = 0.0000

In section 13 we combined inpatient and outpatient demand to obtain a single total measure of demand and we undertook a similar process to obtain a single total measure of supply. Using these combined measures of demand and supply, and a total (inpatient plus outpatient) mean waiting time, we estimated total demand and total supply models (see Tables 64 and 65). We estimated the correlation coefficient between the residuals from these two regressions for all specialties combined and found that it was 0.6372. Again the implication is that there is a significant positive correlation between the errors in the demand and supply regressions and that, as a consequence, OLS estimation will yield less precise estimates than other estimation techniques that utilise this information in their estimation procedure.

We therefore re-estimated the total demand and total supply regressions using the SUR estimator and the results from this estimation for all specialties combined are presented in Table 76 together with comparable regressions from OLS estimation.[39] We also employed the SUR estimator to jointly estimate the four regressions for inpatient demand, inpatient supply, outpatient demand, and outpatient supply and also compared these with the results from OLS estimation. As the impact of SUR estimation is similar in both cases only the results for the total demand and total supply models are presented below.[40]

Although there are minor changes to most of the parameter (coefficient and standard error) estimates, there are major changes to two variables: to the beds per head variable in the supply

[39]Unfortunately, SUR estimation in STATA does not permit the 'cluster' option and so these results assume that within Trust errors are uncorrelated with each other. We know that this is unlikely but present these results as initial, exploratory findings. To make the OLS results comparable with the SUR results we omitted the 'cluster' option from the 'regress' command.

[40]Moreover, the very low correlations between inpatient and outpatient activity revealed in Table 75 justifies concentrating on supply and demand rather than on inpatients and outpatients.

regression and to the waiting time variable in the demand equation. The coefficient on the beds per head variable declines from 0.266 to 0.052 with the standard error falling from 0.040 to 0.030. The coefficient on the waiting time variable falls from -0.189 to -0.035 and the standard error declines from 0.022 to 0.017. Thus although SUR estimation reduces the estimated standard errors it has a proportionally much larger effect on the estimated coefficients.

To understand what is happening here, it is useful to recall how the SUR estimator works. It estimates each regression by OLS and uses the residuals to estimate the error variances both for each equation and across equations. The errors are then transformed so that they all have the same variance and are uncorrelated. The other variables are then subject to the same transformation and OLS estimation is applied to these transformed variables.

The SUR estimator 'purges' the errors of their cross equation correlation and the transformation that achieves this is also applied to the other variables in the model. If the unobservable (omitted) factor driving the correlated errors is also correlated with another variable in the model, then it is to be expected that the 'purging' transformation will also affect the estimated coefficient on this variable.

In the present context the obvious candidate for the unobserved factor that has been omitted from the model is some measure of the need for health care. In principle, this variable should be in both the demand and supply equations but we have available only an imperfect measure of need, based mainly on 1991 Census data, and which does not vary through time. The need for health care will positively affect both the demand for and supply of health care and its omission is consistent with the observed positive correlation between the errors in the supply and demand equations. Moreover, it is likely that 'need' and the measure of beds per head will be positively correlated not least because of the relationship between 'need' and the national resource allocation formula for HCHS expenditure. Thus one plausible interpretation of the substantial decline in the coefficient on beds per head when the SUR estimator replaces OLS is that the SUR transformation purges the beds variable of its correlation with need.

As is well known, collinearity can make it difficult to identify the individual effect of each collinear regressor (need and beds) on the dependent variable (i.e., the estimated coefficient is a composite parameter). With OLS estimation one of the collinear variables (need) is omitted and hence the estimated coefficient on the other variable (beds per head) is relatively large.[41] SUR estimation effectively purges the beds variable of its correlation with need and hence the estimated coefficient on this variable is reduced.

A similar argument can also be employed to explain the decline in the estimated coefficient on the waiting time variable in the demand equation. The correlation between our time invariant measure of 'need' and the mean waiting time (across Trusts at a given point in time) is about -0.25 so that Trusts in low 'need' areas tend to have longer waiting times. With the need for health care omitted from the demand equation it is likely that the coefficient on the waiting time variable will incorporate part of the effect of the missing 'need' variable. With SUR estimation the waiting time variable is purged of its correlation with 'need'. This will reduce its estimated coefficient (i.e., it becomes less negative) because 'need' will have a positive impact on demand and 'need' is negatively correlated with waiting time. This suggests that part of the hitherto observed demand effect is, in fact, a needs effect and that once the impact of need is removed the responsiveness of

---

[41] Strictly speaking, it is the time varying part of need that is omitted. The Trust dummies will in part reflect the time invariant element of need.

demand to waiting time is much reduced. The implication of this is that if waiting times are reduced the level of stimulated demand is likely to be less than that previously anticipated.

We also examined the impact of adding the demand shifters in the supply equation to the demand equation. These variables - such as the transfer of cases between Trusts, the HRG index, the readmission rate, and the death rate - have hitherto been excluded because the lack of data on these variables dramatically reduces the size of sample over which estimation can occur and because their initial inclusion had little impact on the demand results. With joint estimation of the supply and demand models the sample size argument for their omission from the demand equation no longer applies and we therefore re-estimated the SUR model with these additional variables in the demand regression. However, their inclusion had no material impact on the results.

Table 76 Total supply and total demand:
SUR and OLS regression results for all specialties combined

Dependent variables: supply - weighted sum of the number of inpatient admissions plus the number of all outpatients seen divided by the Trust's population
demand - weighted sum of the number of decisions to admit plus the number outpatient referrals seen all divided by the Trust's population

	SUR estimation		OLS estimation	
	Supply	Demand	Supply	Demand
Regression number	1a	1b	2a	2b
meanwait	0.043**	-0.035*	0.039*	-0.189**
occupancy_rate	-0.030		0.074	
length_of_stay	-0.008		-0.043°	
transfers_in	0.007		0.023	
transfers_out	0.017*		0.026**	
prop_admiss_60+	0.076**		0.095**	
HRG_index	-0.499**		-0.478**	
research_spend	-0.097		0.050	
readmission_rate	-0.045		-0.042	
death_ne_surgery	-0.003		0.044**	
death_e_surgery	-0.072**		-0.116**	
daycases_pc	0.065**	0.107**	0.053*	0.099**
emergencies_pc	-0.127**		-0.165**	
beds_per_head	0.052°		0.266**	
year96				
year97				
year98	0.070**	0.048**	0.081**	0.065**
year99	0.044**	0.043**	0.055**	0.061**
year00	0.018°	0.012°	0.030*	0.029*
year01				
summer	0.038**	0.006	0.038**	0.007
autumn	0.021**	-0.006	0.022**	-0.004
winter	0.050**	0.007	0.052**	0.009°
constant	7.868**	4.974**	7.344**	5.495**
No of obs	2034	2034	2034	2034
F	n/a	n/a	96.3	109.6
R bar squared	0.892	0.882	0.886	0.891
RESET test: F =	n/a	n/a	0.91	0.13
Prob > F =	n/a	n/a	0.4358	0.9431

Notes for Table 76:

1. The waiting time variable is lagged four quarters in the supply regression and is the current period value in the demand regression. The other variables in the supply regression are lagged one period.
2. There is no coefficient on the dummy variable for 1997 because there is no quarterly decision to admit or admission data for this year. The base year is 1996. There is no coefficient on the dummy variable for 2001 because there is no quarterly total referrals seen data for this year.
3. °, *, and ** denote significance at the 10%, 5%, and 1% level respectively.
4. The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition of the first three powers of the predicted value of the dependent variable to the model and a test of the joint significance of these three variables.
5. The coefficients on the 200 Trust dummies are not reported.
6. The correlation coefficient between the errors in the OLS demand and supply regressions is 0.6372. The Breusch-Pagan test of independence: chi2(1)=825.8, prob = 0.0000.

Table 77 reports the results of SUR and OLS estimation of total demand and total supply regressions for all routine surgical specialties combined. The correlation coefficient between the residuals from the two OLS regressions is 0.5990. As was the case for all specialties, the implication is that there is a significant positive correlation between the errors in the demand and supply regressions and that, as a consequence, OLS estimation yields less precise estimates than other estimation techniques that utilise this information.

SUR estimation generates minor changes to most of the parameter (coefficient and standard error) estimates with more dramatic changes to the beds per head variable in the supply regression and to the waiting time variable in the demand regression.[42] The coefficient on the beds per head variable declines from 0.302 to 0.089 with the standard error falling from 0.042 to 0.032. The coefficient on the waiting time variable changes from -0.089 to 0.022 and the standard error declines from 0.024 to 0.019. Again, although SUR estimation reduces the estimated standard errors it has a proportionally much larger effect on the estimated coefficients.

SUR and OLS results for urology (Table 78), orthopaedics (Table 79), and ENT (Table 80) are also presented below. The reduction in the size and significance of the beds and waiting time variables noted for all specialties combined also occurs for these three individual specialties but to a slightly lesser extent. This might be because many of the characteristics variables present in the supply regression are based on total Trust activity rather than specialty specific activity alone. The urology results differ slightly from those for orthopaedics and ENT in that they reveal quite dramatic changes in some of the coefficients on the characteristics variables. For example, the coefficient on the bed occupancy rate declines from 0.283 with a standard error of 0.145 (OLS) to 0.037 and a standard error of 0.106 (SUR).

[42] The coefficient on the research spending variable also declines dramatically from 0.333 to -0.002 probably because research is positively correlated with need.

Table 77 Total supply and total demand : SUR and OLS regression results for routine surgery

Dependent variables: supply - weighted sum of the number of inpatient admissions plus the number of all outpatients seen divided by the Trust's population

demand - weighted sum of the number of decisions to admit plus the number outpatient referrals seen all divided by the Trust's population

	SUR estimation		OLS estimation	
	Supply	Demand	Supply	Demand
Regression number	1a	1b	2a	2b
meanwait	0.063**	0.022	0.064**	-0.089**
occupancy_rate	0.061		0.176**	
length_of_stay	-0.002		-0.058*	
transfers_in	0.013		0.039*	
transfers_out	0.022**		0.031**	
prop_admiss_60+	0.046*		0.060*	
HRG_index	-0.600**		-0.602**	
research_spend	-0.002		0.333**	
readmission_rate	-0.099**		-0.101*	
death_ne_surgery	0.009		0.033*	
death_e_surgery	-0.086**		-0.126**	
daycases_pc	0.082**	0.139**	0.070**	0.133**
emergencies_pc	-0.151**		-0.206**	
beds_per_head	0.089**		0.302**	
year96				
year97				
year98	0.070**	0.004	0.082**	0.016°
year99	0.032*	0.006	0.047**	0.019**
year00	0.014	-0.023**	0.030*	-0.011
year01				
summer	0.031**	-0.001	0.032**	-0.000
autumn	0.011*	-0.012*	0.015**	-0.010*
winter	0.035**	0.000	0.041**	0.002
constant	8.021**	4.503**	7.647**	4.880**
No of obs	1651	1651	1651	1651
F	n/a	n/a	161.6	149.1
R bar squared	0.946	0.938	0.941	0.932
RESET test: F =	n/a	n/a	2.80	0.76
Prob > F =	n/a	n/a	0.0386	0.5187

Notes for Table 77:

1 The waiting time variable is lagged four quarters in the supply regression and is the current period value in the demand regression. The other variables in the supply regression are lagged one period.

2 There is no coefficient on the dummy variable for 1997 because there is no quarterly decision to admit or admission data for this year. The base year is 1996. There is no coefficient on the dummy variable for 2001 because there is no quarterly total referrals seen data for this year.

3 °, *, and ** denote significance at the 10%, 5%, and 1% level respectively.

4 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition of the first three powers of the predicted value of the dependent variable to the model and a test of the joint significance of these three variables.

5 The coefficients on the 200 Trust dummies are not reported.

6 The correlation coefficient between the errors in the OLS demand and supply regressions is 0.5990. The Breusch-Pagan test of independence: chi2(1)=592.4, prob = 0.0000.

Table 78 Total supply and total demand : SUR and OLS regression results for urology

Dependent variables: supply - weighted sum of the number of inpatient admissions plus the number of all outpatients seen divided by the Trust's population

demand - weighted sum of the number of decisions to admit plus the number outpatient referrals seen all divided by the Trust's population

	SUR estimation		OLS estimation	
	Supply	Demand	Supply	Demand
Regression number	1a	1b	2a	2b
meanwait	0.030°	-0.072**	0.051*	-0.182**
occupancy_rate	0.037		0.283°	
length_of_stay	-0.047		-0.144*	
transfers_in	0.020		-0.010	
transfers_out	0.031**		0.041**	
prop_admiss_60+	0.024		0.156**	
HRG_index	-0.737**		-1.229**	
research_spend	0.037		0.098	
readmission_rate	-0.149*		-0.383**	
death_ne_surgery	0.030		0.075*	
death_e_surgery	-0.103**		-0.088°	
daycases_pc	0.168**	0.173**	0.129°	0.192**
emergencies_pc	0.018		0.160°	
beds_per_head	0.054		0.129	
year96				
year97				
year98	0.053**	0.041**	0.016	0.042*
year99	0.015	0.043**	-0.019	0.048**
year00	0.001	0.017	-0.029	0.022
year01				
summer	0.079**	0.040**	0.083**	0.040**
autumn	0.056**	0.027**	0.063**	0.025*
winter	0.082**	0.044**	0.091**	0.043**
constant	7.031**	2.184**	9.961**	2.594**
No of obs	1338	1338	1338	1338
F	n/a	n/a	61.7	72.7
Adj R bar squared	0.880	0.888	0.868	0.877
RESET test: F =	n/a	n/a	4.66	1.91
Prob > F =	n/a	n/a	0.0030	0.1264

Notes for Table 78:

1 The waiting time variable is lagged four quarters in the supply regression and is the current period value in the demand regression. The other variables in the supply regression are lagged one period.

2 There is no coefficient on the dummy variable for 1997 because there is no quarterly decision to admit or admission data for this year. The base year is 1996. There is no coefficient on the dummy variable for 2001 because there is no quarterly total referrals seen data for this year.

3 °, *, and ** denote significance at the 10%, 5%, and 1% level respectively.

4 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition of the first three powers of the predicted value of the dependent variable to the model and a test of the joint significance of these three variables.

5 The coefficients on the 200 Trust dummies are not reported.

6 The correlation coefficient between the errors in the OLS demand and supply regressions is 0.6420. The Breusch-Pagan test of independence: chi2(1)=551.5, prob = 0.0000.

Table 79 Total supply and total demand : SUR and OLS regression results for orthopaedics

Dependent variables: supply - weighted sum of the number of inpatient admissions plus the number of all outpatients seen divided by the Trust's population

demand - weighted sum of the number of decisions to admit plus the number outpatient referrals seen all divided by the Trust's population

	SUR estimation		OLS estimation	
	Supply	Demand	Supply	Demand
Regression number	1a	1b	2a	2b
meanwait	0.021	-0.171**	-0.000	-0.250**
occupancy_rate	0.345**		0.431**	
length_of_stay	0.034		0.076°	
transfers_in	0.041*		0.046*	
transfers_out	0.044**		0.046**	
prop_admiss_60+	0.025		0.037	
HRG_index	-0.991**		-1.030**	
research_spend	0.685**		1.036**	
readmission_rate	-0.017		-0.054	
death_ne_surgery	0.004		-0.008	
death_e_surgery	-0.101**		-0.100**	
daycases_pc	-0.003	0.087*	0.004	0.058
emergencies_pc	-0.124**		-0.068	
beds_per_head	0.229**		0.358**	
year96				
year97				
year98	0.109**	0.033**	0.143**	0.046**
year99	0.116**	0.067**	0.151**	0.082**
year00	0.121**	0.064**	0.155**	0.080**
year01				
summer	0.030**	-0.005	0.031**	-0.005
autumn	-0.003	-0.021**	0.000	-0.019**
winter	0.020**	-0.027**	0.024**	-0.024**
constant	6.172**	3.533**	6.229**	3.783**
No of obs	1396	1396	1396	1396
F	n/a	n/a	219.8	213.2
R bar squared	0.963	0.958	0.959	0.954
RESET test: F =	n/a	n/a	4.02	5.82
Prob > F =	n/a	n/a	0.0074	0.0006

Notes for Table 79:

1 The waiting time variable is lagged four quarters in the supply regression and is the current period value in the demand regression. The other variables in the supply regression are lagged one period.

2 There is no coefficient on the dummy variable for 1997 because there is no quarterly decision to admit or admission data for this year. The base year is 1996. There is no coefficient on the dummy variable for 2001 because there is no quarterly total referrals seen data for this year.

3 °, *, and ** denote significance at the 10%, 5%, and 1% level respectively.

4 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition of the first three powers of the predicted value of the dependent variable to the model and a test of the joint significance of these three variables.

5 The coefficients on the 200 Trust dummies are not reported.

6 The correlation coefficient between the errors in the OLS demand and supply regressions is 0.4023. The Breusch-Pagan test of independence: chi2(1)=225.9, prob = 0.0000.

Table 80 Total supply and total demand : SUR and OLS regression results for ENT

Dependent variables: supply - weighted sum of the number of inpatient admissions plus the number of all outpatients seen divided by the Trust's population
demand - weighted sum of the number of decisions to admit plus the number outpatient referrals seen all divided by the Trust's population

	SUR estimation		OLS estimation	
	Supply	Demand	Supply	Demand
Regression number	1a	1b	2a	2b
meanwait	0.075**	-0.106**	0.063**	-0.171**
occupancy_rate	0.092		0.194°	
length_of_stay	-0.113		-0.109°	
transfers_in	-0.040		-0.050°	
transfers_out	0.018°		0.029*	
prop_admiss_60+	-0.054		-0.076°	
HRG_index	0.236		0.453	
research_spend	-0.132		-0.029	
readmission_rate	0.018		0.147°	
death_ne_surgery	-0.019		-0.004	
death_e_surgery	-0.044		-0.072°	
daycases_pc	-0.079	0.020	-0.046	0.026
emergencies_pc	-0.254**		-0.280**	
beds_per_head	0.298**		0.451**	
year96				
year97				
year98	0.047**	-0.030*	0.070**	-0.021
year99	-0.001*	-0.022*	0.022	-0.012
year00	0.001	-0.020°	0.021	-0.013
year01				
summer	0.023**	-0.054**	0.023**	-0.053**
autumn	0.009	-0.045**	0.011	-0.045**
winter	0.003	0.016*	0.005	0.017*
constant	0.479	2.880**	-2.001	3.106**
No of obs	1183	1183	1183	1183
F	n/a	n/a	99.7	121.0
Adj R bar squared	0.922	0.928	0.913	0.921
RESET test: F =	n/a	n/a	1.03	1.77
Prob > F =	n/a	n/a	0.3795	0.1506

Notes for Table 80:

1 The waiting time variable is lagged four quarters in the supply regression and is the current period value in the demand regression. The other variables in the supply regression are lagged one period.

2 There is no coefficient on the dummy variable for 1997 because there is no quarterly decision to admit or admission data for this year. The base year is 1996. There is no coefficient on the dummy variable for 2001 because there is no quarterly total referrals seen data for this year.

3 °, *, and ** denote significance at the 10%, 5%, and 1% level respectively.

4 The RESET test is Ramsey's test for omitted variables and, in this case, is based upon the addition of the first three powers of the predicted value of the dependent variable to the model and a test of the joint significance of these three variables.

5 The coefficients on the 200 Trust dummies are not reported.

6 The correlation coefficient between the errors in the OLS demand and supply regressions is 0.4559. The Breusch-Pagan test of independence: chi2(1)=245.9, prob = 0.0000.

3 Conclusion

SUR estimation can offer more precise parameter estimates than OLS estimation when the error terms in the individual OLS regressions are correlated with each other. We found that the error terms in the individual supply and demand equations are indeed significantly positively correlated. However, because the reason for this correlation is not certain - although we believe that it is attributable to the omission of a time varying measure of need from the estimated supply and demand models - the results presented above should be viewed as preliminary pending further investigation.

The SUR estimator transforms the OLS errors so that they are no longer correlated and then applies this transformation to the other variables in the model which are then estimated by OLS. Thus in this particular case the SUR estimator can be viewed as 'purging' the other variables of their correlation with the need for health care and this transformation had a marked impact on the coefficient estimates for the beds per head variable in the supply regression and the waiting time variable in the demand regression. Nevertheless, these initial preliminary findings leave the broad structure of our results unchanged, with waiting time having a positive impact on supply and a negative - albeit less marked - effect on the demand for NHS health care.

REFERENCES AND OTHER RELEVANT WORKS

Audit Commission (1996). *What the doctor ordered: a study of GP fundholders in England and Wales*. London: HMSO.

Audit Commission (2003). *Waiting for elective admission: review of national findings*. London: Audit Commission.

Barros, P. P. and Olivella, P. (1999). *Waiting lists and patient selection*. Discussion Paper 499-99, Universitat Autonoma de Barcelona, pp33.

Besley, T., Hall, J. and Preston, I. (1999). The demand for private health insurance: do waiting lists matter? *Journal of Public Economics*, 72, 155-181.

Buttery, R.B. and Snaith, A.H. (1979). Waiting for surgery. *British Medical Journal*, 403-404.

Buttery, R. B. and Snaith, A. H. (1980). Surgical provision, waiting times and waiting lists. *Health Trends*, 12, 57-61

Carr-Hill, R., Hardman, G., Martin, S., Peacock, S., Sheldon, T. and Smith, P. (1994). *A formula for distributing NHS revenues based on small area use of hospital beds*. Occasional Paper, Centre for Health Economics, University of York.

CIPFA (1999). *The Health Service Database 1999*. CIPFA: London.

Croxson, B., Propper, C. and Perkins, A. (2001). Do doctors respond to financial incentives? UK family doctors and the GP fundholding scheme. *Journal of Public Economics*, 79, 375-98.

Cullis, J.G. and Jones, P.R. (1986). Rationing by waiting lists: an implication. *American Economic Review* 76(1), 250-256.

Cullis, J.G., Jones, P. and Propper, C. (2000). Waiting lists and medical treatment: analysis and policies in Culyer, A.J. and Newhouse, J.P. (eds), *Handbook of Health Economics*. Elsevier: Amsterdam.

Deacon, R. T. and Sonstelie, J. (1985). Rationing by waiting and the value of time: results from a natural experiment. *Journal of Political Economy*, 93(4), 627-647.

Dixon, J. and Glennerster, H. (1995). What do we know about fundholding in general practice? *British Medical Journal*, 311, 727-730.

DoH (2000a). *The NHS Plan: a plan for investment, a plan for reform*. Cm 4818-I. Department of Health: London.

DoH (2000b). *The NHS Cancer Plan*. Department of Health: London.

DoH (2000c). *The NHS Plan Implementation Programme*. Department of Health: London.

DoH (2000d). *Outpatient and ward attenders: England 1999-2000*. Department of Health: London.

DoH (2001a). *Priorities and Planning Framework 2002/2003*. Department of Health: London.

DoH (2002). *Improvement, expansion and reform: the next 3 years. Priorities and planning framework 2003-2006*. Department of Health: London.

Dowling, B. (1997). Effect of fundholding on waiting times: database study. *British Medical Journal*, 315, 2 August, 290-292.

Dusheiko, M., Gravelle, H, Jacobs, R. and Smith, P. C. (2003). *The Effect of Budgets on Doctor Behaviour: Evidence from a Natural Experiment*. Department of Economics, University of York, Discussion Paper 04/2003.

Edwards, R. T. (1997). *NHS waiting lists: towards the elusive solution*. Office of Health Economics: London.

Farnworth, M. G. (2003). A game theoretic model of the relationship between prices and waiting times. *Journal of Health Economics*, 22, 47-60.

Frankel, S. (1989). The natural history of waiting lists – some wider explanations for an unneccessary problem. *Health Trends* 21: 56-58.

Frost, C. E. B. and Francis, B. J. (1979). Clinical decision making: a study of general surgery within Trent RHA. *Social Science and Medicine*, 13A, 193-198.

Goddard, J. A., Malek, M. and Tavakoli, M. (1995). An economic model of the market for hospital treatment for non-urgent conditions. *Health Economics*, 4(1), 41-55.

Goddard, J. A. and Tavakoli, M. (1998). Referral rates and waiting lists: some empirical evidence. *Journal of Health Economics*, 7, 545-549.

Iverson, T. (1997). The effect of a private sector on the waiting time in a national health service. *Journal of Health Economics*, 16, 381-396.

Godfrey, L. (1988). *Misspecification tests in econometrics*. Cambridge: CUP.

Goldacre, M., Lee, A. and Don, B. (1987). Waiting list statistics. I: relation between admissions from waiting list and length of waiting list. *British Medical Journal,* 295, 1105-1108.

Gravelle, H., Dusheiko, M. and Sutton, M. (2002). The demand for elective surgery in a public system: time and money prices in the UK National Health Service. *Journal of Health Economics*, 21, 423-49.

Gravelle, H., Smith, P.C. and Xavier, A. (2003). Performance signals in the public sector: the case of health care. *Oxford Economic Papers,* 55, 81-103.

Hamblin, R., Harrison, A. and Boyle, S. (1998). *Access to elective care: why waiting lists grow.* King's Fund: London.

Harrison, A. and New, B. (2000). *Access to elective care: what should really be done about waiting lists*. King's Fund: London.

Hausman, J.A. (1978) Specification tests in economics. *Econometrica*, 46: 1251-1271.

Henderson, J., Newton, J.N. and Goldacre, M. (1995). Waiting list dynamics and the impact of earmarked funding. *British Medical Journal*, 311, 783-785.

Iversen, T. (1993). A theory of hospital waiting lists. *Journal of Health Economics*, 12(1), 55-71.

Iverson, T. (1997). The effect of a private sector on the waiting time in a national health service. *Journal of Health Economics*, 16, 381-396.

Jacobs, R. (2000). *Alternative methods to examine hospital efficiency: data envelopment analysis and stochastic frontier analysis*. Centre for Health Economics University of York, Discussion Paper 177, pp26.

Jarman, B., Gault, S., Alves, B.,Hider, A., Dolan, S., Cook, A., Hurwitz, B. and Iezzoni, L (1999). Explaining differences in English hospital death rates using routinely collected data. *British Medical Journal*, 318, 1515-20.

Jofre-Bonet, M. (2000). Public health care and private insurance demand: waiting time as a link. *Health Care Management Science*, 3, 51-71.

Kendall, M.G. and Stuart, A. (1961). *The Advanced Theory of Statistics. Volume 2: Inference and Relationship*. Charles Griffin: London.

King, D. and Mossialos, D. (2002). *The Determinants of Private Medical Insurance Prevalence in England*. LSE Health and Social Care Discussion Paper Number 3.

Lindsay, C.M. and Feigenbaum, B. (1984). Rationing by waiting lists. *American Economic Review,* 74(3), 404-417.

Martin, R., Sterne, J., Gunnell, D., Ebrahim, S., Smith, G., and Frankel, S. (2003). NHS waiting lists and evidence of national or local failure: analysis of health service data. *British Medical Journal*, 326, 188-198.

Martin, S. and Smith, P.C. (1999). Rationing by waiting lists: an empirical investigation. *Journal of Public Economics*, 71, 141-164.

Martin, S. and Smith, P.C. (2003). Using panel methods to model waiting times for National Health Service surgery. *Journal of the Royal Statistical Society*, 166, Part 2, 1-19.

Martin, S., Rice, N., Siciliani, L. and Smith, P.C. (2001). *Modelling Waiting Times for Elective Surgery*. Report to Department of Health, 2001, mimeo.

McAvinchey, I. and Yannopoulos, A. (1993). Elasticity estimates from a dynamic model of interrelated demands for private and public acute health care. *Journal of Health Economics*, 12, 171-186.

Morga, A. and Xavier, A. (2001). *Hospital specialists' private practice and its impact on the number of NHS patients treated and on the delay for elective surgery*. Department of Economics, University of York, Discussion Paper 01/2001.

Mundlak, Y. (1978) On the pooling of time series and cross-section data. *Econometrica*, 46, 69-85.

NAO (2001). *Inpatient and outpatient waiting in the NHS*. National Audit Office: London.

NHS Executive (1994). *HCHS revenue resource allocation: weighted capitation formula*. NHS Executive, Leeds.

Office of Health Economics (1997). *Compendium of Health Statistics*, London, OHE.

Office for Health Economics (2001). *Compendium of Health Statistics. 13th edition*. London, OHE.

Oliveira, M. (2002). *A flow demand model to predict hospital utilisation*. LSE Health and Social Care Discussion Paper Number 5. LSE: London.

Olivella, P. (2002). Shifting public-health-sector waiting lists to the private sector. *European Journal of Political Economy*, 19, 103-132.

Pascoe, G. (2001). Creating bed room. *Health Services Journal*, 3 May 2001, 28-29.

Pope, C. (1992). Cutting queues or cutting corners: waiting lists and the 1990 NHS reforms. *British Medical Journal,* 305, 577-579.

Propper, C., (1990). Contingent valuation of time spent on NHS waiting lists. *Economic Journal*, 100, Conference, 193-199.

Propper, C. (1995). Agency and incentives in the NHS internal market. *Social Science and Medicine,* 40, 1683-1690.

Propper, C. (2000). The demand for private health care in the UK, *Journal of Health Economics*, 19, 855-876.

Propper, C., Croxson, B. and Shearer, A. (2002). Waiting times for hospital admissions: the impact of GP fundholding, *Journal of Health Economics*, 21, 227-252.

Roland, M. and Morris, R. (1988). Are referrals by general practitioners influenced by the availability of consultants? *British Medical Journal* 197: 599-600.

Sanderson, H. (1982). What's in a waiting list? *British Medical Journal* 285: 1368-1369.

Smith, P. C and van Ackere, A. (2002). A note on the integration of system dynamics and economic models. *Journal of Economic Dynamics and Control*, 26, 1-10.

Soderlund, N. and Jacobs, R. (2001). *Towards panel data specifications of efficiency measures for English acute hospitals*. Centre for Health Economics University of York, Discussion Paper 185.

Soderlund, N. and van der Merwe, R. (1999). *Hospital benchmarking analysis and the derivation of cost indices*. Centre for Health Economics University of York, Discussion Paper 174.

Street, A. and Duckett, S. (1996). Are waiting lists inevitable? *Health Policy*, 36, 1-15.

van Ackere, A. and Smith, P. C. (1999). Towards a macro model of National Health Service waiting lists. *System Dynamics Review*, 15, 3, 225-252.

Williams M. H., Newton, J. N., Frankel, S. J., Braddon, F., Barclay, E., and Gray J. A. M. (1994). Prevalence of total hip replacement: how much demand has been met? *Journal of Epidemiology and Community Health*, 48, 188-191.

Worthington, D. J. (1987). Queuing models for hospital waiting lists. *Journal of the Operational Research Society*, 38(5), 413-422.

Worthington, D. J. (1991). Hospital waiting list management models. *Journal of the Operational Research Society*, 42(10), 833-843.

Yates, J., (1987). *Why are we waiting?* Oxford: Oxford University Press.

Yates, J. (1995). *Private eye, heart and hip*. London: Churchill Livingstone.

Yates, J. (2002). Blank checks. *Health Service Journal*, 10 January, 30-31.

Yorkwaitsreport.wpd