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Evaluating a New Approach for Improving Care in an Accident and Emergency Department

The NU-Care Project

L. Mayhew and E. Carney Jones

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The NU-Care project

Leslie Mayhew and Eileen Carney-Jones

Foreword

'For too long, emergency care has been the Cinderella of the NHS. This situation has been changed irrevocably by the NHS Plan, with its attendant targets for Emergency departments. This focus has unleashed a wealth of imaginative and innovative projects led by front-line NHS workers. One problem in the past has been the schism between primary and secondary care. This problem has been tackled head on by the NU-Care project, where care has followed the patient's need, rather than designed to fit organisational boundaries.

One great value of NU-Care has been the careful analysis of the patient pathway. This, together with placing staff where staff are needed, greatly enhanced the speed of treatment and total time spent by patients with corresponding increase in patient satisfaction. The concurrent analysis of attitudes showed where friction points occur and the need for all staff in the system to adopt a 'whole system' approach. Finally, NU-Care showed the defects in the CAS decision-making tool and the need for a quicker, more user-friendly system.

The authors are to be congratulated for the immense hard work and enthusiasm, which has underpinned NU-Care. These are valuable lessons for all those in the NHS involved in improving the care and experience of patients who require urgent care.'

Sir George Alberti
National Clinical Director for Emergency Access
Emeritus Professor of Medicine
University of Newcastle Medical School
Newcastle upon Tyne

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Contents

Acknowledgement

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Evaluation group membership

Core

Eileen Carney-Jones ***Lead Nurse, NHSDirect (Chair)***
Stephen Farrow ***Former Director of Public Health***
Edmund Jahn ***NU-Care Project Director***
Leslie Mayhew ***Professor of Statistics, Cass Business School, City University, London***
Alistair Stinson ***Assistant Director of Nursing, Emergency Care***
Sapal Tachakra ***Director of Emergency Services, North West London Hospitals NHS Trust***

Occasional

Sharon Ahearn ***Senior Sister, A&E***
Mary Halter ***Operational Development Manager, London Ambulance Service***
David Jarrett ***Assistant Director of Operations, A&E***
John Knottenbelt ***Consultant, Accident and Emergency Department, Northwick Park***
David Lloyd ***General Practitioner, Harrow***
Rajpal Singh ***A&E reception manager***
Rosemary Stafford ***Survey co-ordinator***
Sandra Taylor ***Superintendent Radiographer, Northwick Park***
Christine Ward ***Chief Pharmacist***
Caroline Ward ***NU-Care project manager***

Approval for this research was granted on the 11th March 2002 by the Harrow Research Ethics Committee, North West London Hospitals Trust, Northwick Park and St Mark's Hospitals: Ethical submission number 2959.

Executive summary

This report evaluates a partnership initiative between primary and secondary care providers that is intended to improve Accident and Emergency (A&E) services at Northwick Park, one of two large acute hospitals within the North West London Hospitals NHS Trust. It considers how major strides were made during 2002/2003 towards improving A&E services to patients, and how it acted as the site for a major experiment, involving an integrated 'out-of-hours' primary care and A&E service. Known as the NU-Care project (Northwick Urgent Care), the aim was to introduce new skills into the Department, and to improve links with other existing providers, such as primary care and NHS Direct, and thereby improve the overall patient experience.

The NU-Care concept emerged at a time when there were significant concerns about waiting times in A&E departments – a frequent and well-publicised cause of patient resentment. The Government first made its views known in the 1996 'Patients Charter'. Currently, national policy is being progressed, based on ideas set out in the 'Out-of-hours Review', and the more recent, 'Reforming Emergency Care' document, which set stringent targets for the time spent by patients in A&E departments. A central feature of the strategy was the breaking down of traditional barriers between the acute side of secondary care and other services provided by the NHS.

NU-Care was funded by a one-off grant of £1.7m from the 'Out-Of-Hours Review Exemplar Program'. This meant that any improvements in service had to be sustainable in the long term, within normally available resources. One reason why the NU-Care project report should be of wide interest was that, against many people's predictions, the A&E Department managed to both achieve the demanding national service target and substantially improve levels of patient satisfaction. The issue remaining was whether that progress could be sustained and improved upon, based on the changes that were implemented.

The style of evaluation is 'evidence-based', using a 'whole systems' approach, so that it ranges wider than just NU-Care itself to look at the impact on the local health economy. It is also unique because, unlike comparable research projects, it involved constant feedback and analysis, using specially developed techniques as well as standard statistical methods and analyses. Five key aspects were evaluated: waiting and completion times; changes in patient satisfaction and staff endorsement of the changes made; the impact on overall costs, including the wider health economy; and the use of a computerised decision support system for clinical assessment purposes within an A&E environment.

Patient satisfaction:

The harrowing patients' comments that were obtained in the baseline survey, and presented later in the report, bear testimony to the parlous state into which the service at Northwick Park had fallen before the NU-Care project began. Almost without exception, all of these comments were supported by copious statistical analyses, confirming that waiting times were excessive, there was overcrowding and there was a failure to keep patients informed. As a measure of progress, the proportion of patients that were very satisfied between the baseline and 6-month stage following implementation of the project doubled from around 22% to 46%, and the proportion that were dissatisfied declined from 12.4% to 4.1%.

This improvement in the figures was mainly due to the significant reductions in completion times, as stated by patients and as shown in our analyses. By the end of March 2003, they were comparable to the national target – clearance of 90% of patients inside four hours – but at the start of the project, they were half this level. These improvements are not confined to the NU-Care 'out-of-hours' service and have affected all patient categories approximately equally. They are the culmination of several factors, including the deployment of more staff (including GPs and nurse practitioners), a better match with demand patterns and also, better management, particularly with regard to the use of data analysis.

Our analysis of the data shows that overall patient throughput (the number of patients registering in A&E per unit of time) increased by 18% between March 2002 and March 2003; this was, principally, a result of lower waiting times (30%, if only ambulatory patients are counted). In addition, the rate at which patients left the department after registration but before being seen or treated (known as the 'absconder' rate) also fell from around 12.6% in March 2002 to 4.3% in March 2003. If the average rate observed in March 2003 had applied throughout 2002/2003, around 4000 more patients would have completed their treatments than if the March 2002 rate had applied. Although encouraging, there is some concern as to whether these improvements are sustainable without extra resources and, indeed, whether it will be possible to meet the even tighter national target, due in March 2004, of 100% completions in four hours.

Despite the gains that have been achieved, this evaluation indicates that some of the hoped-for 'NU-Care' objectives did not materialise or did not deliver the level of efficiency improvements expected. The reasons for this are just as important as the successes, particularly where the outcomes

invalidate widely held views or hypotheses, or where similar initiatives are being considered. As our analysis strongly indicates, there remain several inefficiencies in the organization and operation of the Department. These relate to the pre-assessment and streaming of patients to see the most appropriate clinician, the avoidable delays in completing blood and urine tests, and the use of space.

Professional endorsement:

From the analysis presented, it is clear that many of the problems in the Department were overtly obvious to the majority of patients, if not to the staff. As the project progressed, it became increasingly apparent that there were differences in approach and style of practice between senior A&E clinicians and the NU-Care project staff. Although many efforts were made to remove these differences, they always simmered at or below the surface, and, to an extent, remain today.

NHS CAS:

A particular disappointment was the testing of the computerised clinical assessment system (CAS). Intended to improve the quality and consistency of care, cut down on long waiting times, and extend the range of personnel that could see and discharge patients, CAS failed on all counts, mostly for reasons that lay outside the control of the project team.

Cost:

The ongoing costs of NU-Care, were it to continue in its present form, would be around £0.65m annually, excluding the cost of the CAS system, telecommunications, training and other apportioned costs. As the report illustrates, these costs are additional to the A&E Department's budget as financed by the Trust, and so a sustainable budget to provide current efficiency levels would need to be at least £0.65m per year more (or approximately £5.65m a year in total, for the whole of A&E). (This assumes the continued employment of the same NU-Care model design, based on a mixed team of primary care and A&E clinicians.) This increase would need to be considered in the context of the value of timesaving to patients – around £1.4m annually, based on the minimum hourly wage and assuming current levels of throughput. The benefits, therefore, outweigh the costs by a factor of slightly more than 2:1, but at the price of an increased budgetary burden on the Trust, unless efficiencies can be found.

Verdict:

Our overall verdict is that NU-Care has been extremely beneficial to patients; the improvements seen would not have occurred without the focus and resources provided by NU-Care. Many of the improvements that took place were acknowledged by staff as well as patients and, therefore, despite serious professional differences, the principles behind NU-Care were basically sound. Patients clearly like the idea of a 'one-stop shop' and hence, an idea that is based on establishing a primary care practice in the hospital, that could switch to an integrated out-of-hours service in the evenings and at weekends would seem to satisfy patient wishes.

Still outstanding:

The key question requiring further consideration is whether the NU-Care model of merging primary and emergency care practice to meet patient need is practical or not; indeed, whether models that continue the separate management of primary and emergency care might provide equal or better patient benefit, with greater sustainability. A corollary of this is whether, realistically, there is a future for computerised clinical assessment tools in face-to-face settings. The results of this evaluation indicate that a good deal more thought is needed with regard to the integration of such tools within an A&E environment. The Northwick Park A&E Department has yet to achieve a stable pattern of operation, especially in the context of key issues such as streaming, triage, pre-assessment and clinical competence. It could be some time before a suitable tool is devised and employed.

A better short-term investment, from the patient's perspective, would be to improve the methods of collection and analysis of management information, enabling the better deployment of resources and the identification of shortcomings in A&E systems and procedures. The problem identified here is that management information is regarded as a burden, rather than a tool; however, better use of existing data would lead to better management, but not necessarily more accurate data, if our work is an indicator. Improved data capture around stage times, staff deployment**,** use of tests and procedures would quickly pay dividends with the right management support.

The findings of this evaluation indicate that patients are impatient for a better service, but that they appreciate the dedication and skills of the staff. By contrast, the same evidence suggests that several of the problems are self-inflicted through working practices and that more attention to management and better interaction between the professions would have universal benefits.

NU-Care has shown that changing people's perceptions of the NHS for the better is easier than is generally appreciated, providing management aligns its priorities to what patients want – which in this case was undoubtedly a faster more reliable service.

The authors

Leslie Mayhew is professor of statistics at Cass Business School, London. He was formerly a director in the Office for National Statistics, a Senior Civil Servant in the Department of Social Security, and Senior Principal Scientific Officer in the Department of Health and Social Security in the Operational Research Unit. He works on health and social security topics has been widely published, and he is an Honorary Fellow of the Faculty of Public Health Medicine and an Associate Research Scholar at the International Institute for Applied Systems Analysis, Laxenburg, Austria.

Eileen Carney-Jones is Lead Nurse with NHS Direct West London. She has more than 20 years experience in the field of accident and emergency nursing, of which twelve were spent in the role of Senior Sister. She is an Emergency Nurse Practitioner (ENP) and practices in several settings, including minor injuries and mainstream A&E departments. She has experience as a primary care nurse, conducting telephone consultations for two 'out-of-hours' primary care co-operatives, and has advised the Department of Health on unplanned care.

Glossary of key terms used in this report

Ambulatory patients: Walking patients (see Minors).

CAS (Clinical Assessment System): A computer-based decision support system, introduced into NU-Care to enable junior nurses either to discharge patients directly, by offering them self-care advice, or to refer patients to an appropriate clinician for further assessment, examination and treatment within a safe time interval.

Clinician: A member of medical staff with the authority to treat and discharge a patient without reference to another member of staff.

ENP (Emergency Nurse Practitioner): An experienced Accident and Emergency nurse who has undergone extensive training, supported by academic study at Level 3 (degree). ENPs examine, treat and discharge patients with minor injuries without reference to a doctor, but within agreed clinical guidelines.

Majors area: The Majors area is a designated part of the A&E Department, in which patients who require a patient trolley to be examined, treated and observed**.**

Majors: Majors are patients who are treated in the Majors area, and are likely to have moderate to severe illness or injuries.

Minors area: The Minors area is a designated part of the A&E Department, in which patients are predominantly ambulatory or mobile with minimal assistance, such as wheelchair use.

Minors: Minors are patients who are treated in the Minors area and are likely to have mild to moderate illness, or minor to moderate injuries. They can be considered synonymous with ambulatory patients.

NHSD: NHS Direct, a nurse-led 24-hour telephone-based clinical assessment, advice and onward referral service

Out-of-hours: Normally refers to times when GP surgeries are closed. Based on local arrangements, this means after 18:30 on weekdays until 8:00 the following day and 24 hours at the weekends and on Bank holidays. There are some GP surgeries that open on Saturday mornings and a local GP co-operative that provides remaining cover.

PCNP (Primary Care Nurse Practitioner): An experienced primary care clinician who has or is undertaking a level 3 (Degree) course to enhance and support their own practice. PCNPs manage patients with mainly minor illness or minor injury who request emergency appointments. They also manage some patients who live with chronic conditions, and may have a particular interest in certain conditions such as asthma or diabetes. In NU-Care, they independently manage patients with a range of ailments, including paediatric cases.

Pre-assessment: A primary assessment by a nurse, taking into account the history of presenting complaint, relevant past medical history and current medicines. Observations, such as blood pressure, pulse and temperature, are usually recorded. Other tests, such as blood sugar or urinalysis, as well as further investigations, such as the recording of ECG, might be undertaken. The nurse may also request X-ray and blood tests, and might refer certain patients to specialists within the hospital under prearranged protocols.

Resuscitation: Resuscitation is a designated area of the Department, which has specialized resources to manage severely ill or critically injured patients.

Throughput: This refers to the number of patients who register with A&E per unit of time. It can, therefore, include patients who leave before they have been seen or have completed their treatment, who are known as *absconders*.

Triage: A rapid assessment of patient condition based on presenting symptoms, which enables the nurse to allocate an appropriate level of priority and, thus, a safe timeframe within which the patient may wait for a treating clinician, usually in accordance with the Manchester system.

Trolley: A bed with a 10 cm pressure-relieving mattress that is variable in height and position to facilitate patient comfort, diagnosis and treatment. It has wheels to transfer patients to other units for investigations, or to wards, and has restraining sides to reduce the risk of patients falling out.

Evaluating a new approach for improving care in an accident and emergency department

The NU-Care project

Section 1: Introduction

The Government has pledged to improve the health service and, to this end, has committed extra resources to the NHS over the next few years. The vision that was set out in the ten-year NHS plan is to provide a high standard of care with services that are available when people require them, and to tailor this care to their individual needs[1]. In many cases, planned improvements are being linked to demanding service targets, and hospitals that do not achieve those targets could face financial and other penalties. In parallel, the NHS is experimenting with new ways of working that include mixed teams of professionals, expanding the scope of practice and the adoption of new technology to improve efficiency and patient outcomes.

This report evaluates a partnership initiative between primary and secondary care providers to improve Accident and Emergency (A&E) services at Northwick Park, one of two large acute hospitals within North West London Hospitals NHS Trust. Specifically, we consider the major strides that were made during 2002/2003 toward improving A&E services to patients, and how Northwick Park was the site for a major experiment, involving an integrated 'out-of-hours' primary care and A&E service. Known as the NU-Care project (Northwick Urgent Care), the aim was to introduce new skills to the Department and to improve links with other existing providers to, thereby, improve the overall patient experience.

Most people perceive that the medical condition of patients who attend an A&E department is too serious to be managed in other health care settings. In practice, there are numerous other motivations for patients to attend A&E rather than other care settings, including convenience, fear, lack of knowledge or understanding, and, in some cases, desperation. At the same time, many prospective patients increasingly expect round-the-clock access to health care services. The combined effect of these influences is that a high proportion of cases presenting in A&E could be more appropriately managed in an alternative care setting.

It was acknowledged that the ideology behind NU-Care could not be met within the capacity of current urgent unplanned care arrangements. For example, patients presenting at A&E typically have a range of symptoms; the practicality of matching patients to appropriate care pathways and clinicians with the authority to discharge lies behind the NU-Care concept. In effect, NU-Care envisioned a kind of 'one stop shop' so that, whether a patient's first point of contact is the GP out-of-hours service, the A&E department or NHS Direct (NHSD), the support and care given would be prompt and consistent.

Building the system around the patient was, therefore, a fundamental objective:

'*...developing an approach in which the proposed model of service meets the needs of the patient, rather than, as so often in the past, the patient being required to meet the needs of the model of service*'[2].

There have always been inappropriate attendances at A&E, many reasons for which have been given in the literature[3]. In the area served by Northwick Park, there are many more primary care centres than A&E centres, and so the fear that improving access to A&E would replace the primary care function falters on practical grounds. However, the converse fear, that primary care could encroach on A&E services, was perceived by A&E consultants to be a more serious threat, although, in this case, all parties agreed at the outset to work together towards a set of agreed aims. The more likely scenario was that providing extra A&E capacity would create additional demand for any given level of need; this was a testable hypothesis.

NU-Care was funded by a one-off grant of £1.7m from the 'Out-of-hours Review Exemplar Program'. This meant that any improvements in service had to be sustainable in the long term, within normally available resources. One reason why the NU-Care project report should be of wide interest was that, against many people's predictions, the A&E department managed to both achieve the demanding national service target and substantially improve levels of patient satisfaction. The issue remaining was whether that progress could be sustained and improved upon.

Despite the service improvements that are reported here, this is an evaluation in which some of the hoped-for 'NU-Care' objectives did not materialise or deliver the efficiency improvements that were expected. These included the use of NHS CAS, a computer-based decision support system for clinical assessment purposes, and closer working between mixed groups of professionals. Identifying the reasons for these failures is just as important as identifying the successes, particularly where the outcomes invalidate widely held views or hypotheses, or where similar initiatives are being considered.

The style of evaluation is 'evidence-based', using what health professionals refer to as a 'whole systems' approach, so that it ranges wider than just NU-Care itself to look at the impact on the local health economy. It is also unique because, unlike comparable research projects, it involved constant feedback and analysis, using specially developed techniques, as well as standard statistical methods and analyses[4]. We believe this style of research was beneficial to the project and to the A&E Department in dealing with difficult and complex issues, and, thus, will also be of interest to others involved in management, research and policy.

Background

The NU-Care concept emerged at a time when there were significant concerns about waiting times in A&E departments – a frequent and well-publicised cause of patient resentment. The Government first made its views known in the 1996 'Patients Charter' and, currently, national policy is progressing, based on the ideas that were outlined in another policy document, the 'Out-of-hours Review'[5]. A central feature of the Government's strategy was the breaking down of traditional barriers between the acute side of secondary care and other services that the NHS provides. By removing organisational distinctions that traditionally separate one service from another, the theory behind the strategy was that the NHS would be able to improve services to patients as well as increase efficiency.

Since this time**,** the Modernisation Agency has developed pilot sites to tackle waiting times and, in December 2002, it funded a program to improve waiting times in all major A&E departments in England. The aim was that, by April 2004, no major accident department would have patients waiting for more than four hours from arrival to discharge or hospital admission[6]. However, an interim target was also set, so that, by March 2003, 90% of patients should complete in four hours. This target represented the second fundamental parameter by which the NU-Care project would be judged; its contribution to radically shorter waiting times and improved patient satisfaction.

Until recently, many hospitals found themselves in a similar position to that of Northwick Park. In 2001, the Audit Commission confirmed that waiting times had not improved in England since 1996 (and, in some areas, had deteriorated) and that, on average, waiting times were longest in urban areas and, in particular, London[7]. They reported not only large variations in waiting times but, more significantly, that waiting times did not seem to be related to staffing levels. This is interesting because, with limited resources to provide for health care, long waiting times had, to some extent, been regarded as 'inevitable'.

The Audit Commission report concluded that 'achieving lasting and demonstrable improvements in A&E services is not easy. It requires much management skill, both in A&E departments and more widely in the NHS, to bring about improvements to capacity, efficiency and quality'. It suggested that better management and the application of techniques such as systems analysis could be used to improve the situation, and that the core issues are organisational, rather than resource-related. In this report, we test these and other hypotheses, and demonstrate how detailed and timely analysis can lead to improvements.

How the project began

It was recognized that a large proportion of A&E attendees at Northwick Park had conditions that fell within the traditional domain of primary care. Yet, there were no primary care-trained clinicians in A&E (although the Harmoni GP 'out-of-hours' co-operative had a centre located barely 150 m away, in the same building). Attendance at this centre, however, was by 'appointment only', based on referrals from NHSD – it did not accept patients who were referred from A&E. The purpose of the NHSD telephone advice service is to direct patients to appropriate levels of care; thus, it seemed plausible that the same techniques that are used to stream patients here, could be applied in an integrated A&E and primary care setting.

Applications for funding were invited by the team supporting the Out-of-hours Review. At that time, A&E services at Northwick Park were regarded as 'peripheral' in terms of their perceived value in the health economy, yet they served a catchment of ~300 000 and were a central service for emergency care[8]. It was accepted that, although all of the components for a re-designed service were already available as a result of the presence of the Harmoni service, they were clearly not integrated. A particular gap was the 'out-of-hours service', which is supposed to operate when GP surgeries are closed at evenings and weekends, and which was thought to add to the load in A&E.

The NU-Care project was successful in its application for funding. A partnership board, involving all of the major partners steered the NU-Care project, led by Harrow Primary Care Trust, having taken over in April 2002 from the preceding Health Authority. North West London Hospitals NHS Trust hosted the A&E service, whereas, the project itself was managed by a dedicated team from outside of the A&E Department. Other partners in the project included 'Harmoni' and the London Ambulance Service. An evaluation team, which reported to the project board, oversaw the evaluation itself; this team included the project manager, senior clinicians and representatives from partnering organisations.

GPs participating in the project were all members of the Harmoni co-operative. All were self-employed contractors, retaining their own medical defence indemnity, and were paid at an hourly rate for their time spent on clinical shifts. Nurse Practitioners, with the authority to treat and discharge patients, were recruited locally from both primary and secondary care sources and were, similarly, paid on an hourly basis. All were concurrently working as primary care nurse practitioners in surgeries, or as Emergency Nurse Practitioners in A&E departments, or minor injuries departments.

The rationale for using computer-based clinical assessment was based on the observation that many patients using the emergency services do not require the expertise of highly skilled clinicians, but can be dealt with just as effectively and more quickly by less qualified personnel. The computer-based CAS that was selected for the project was already being used extensively in NHSD and in Walk-in centres. Assessing nurses who had the authority to discharge when using CAS came from various backgrounds, including GP practices, health visiting and NHSD. Paramedics, the other group of medically trained workers involved in the project, were seconded from the London Ambulance Service.

Figure 1 illustrates the different stages in the evolution of the project, starting with the pre-existing but separately organized A&E and Harmoni out-of-hours GP service, based at Northwick Park. Stage '0' is the pre-existing service in which unplanned

care was provided in two physically separate departments; Stage 1 is the intermediate stage, with NU-Care co-located with A&E and Harmoni, and; Stage 2 represents the final stage, with Harmoni fully merged into the new arrangement.

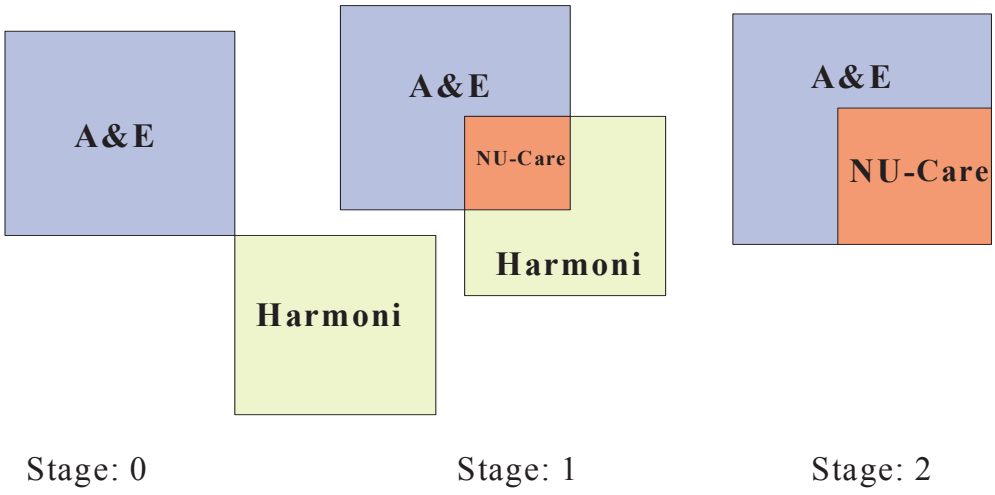

Figure 1: Stages in the planned re-organisation of A&E and out-of-hours GP services

Evaluation objectives

In evaluation terms, it was agreed that there were five key aspects of NU-Care that needed to be addressed:

- Workflow and response times

There should be a significant improvement in service levels and workflow with measurable progress towards the national target, in terms of completion times. Patients should be seen and discharged more quickly by clinicians who possess the appropriate level of competence and expertise.

- Patient satisfaction

Patients themselves should notice changes for the better, and the level of satisfaction with the service should also show a measurable improvement, regardless of severity of their condition.

- Staff endorsement

Staff should adapt successfully to the new arrangements, showing the ability to work side-by-side with colleagues who are not A&E specialists, but are drawn, predominantly, from primary care and the London Ambulance Service.

- Cost neutrality

The impact on the wider health economy should be broadly neutral in terms of cost, taking into account the possible care pathways available, and the behavioural responses of patients to changes in service configuration.

- Computerised decision support system

Staff using the newly introduced NHS CAS should be trained in its use, and the system itself should be cost-effective.

No system exists in complete isolation and this is especially true of emergency care services. In the course of the evaluation, we therefore found ourselves addressing topics relating to interfaces with the rest of the hospital and other services, which impacted on work entering or leaving the department and, hence, on service levels. Finally, our investigations extended to the use of amenities, space and admission procedures, which also ultimately contribute to service levels and efficiency.

Study design and data sources

As noted, the boundaries of the evaluation were drawn within the A&E Department, but included an evaluation of how the Department interacted with other services, both upstream and downstream. These included referral services, such as GP practices, NHSD and inpatient services, and community care, with links to Northwick Park. It excluded any related activity at neighbouring A&E sites. A key task was to measure, in detail, the activities and flows through the Department, capturing key data, such as completion times, but also recording patients' views in the process.

The evaluation also involved an investigation into the views of staff, data on costs, admissions, transfers, treatments, tests such as X-rays, onward referrals, official complaints and so on. Routinely available management information provided detail on each case, from arrival to departure from A&E, including discharge destination. Individual, hand-written patient records gave further detail about their diagnosis and the treatment and tests received. Together, these two sources form the basis for workflow and completion time measurements, as well as medical condition, and both were available on a monthly or *ad hoc* basis, throughout the evaluation.

None of these sources was able to provide information on costs or staffing levels, thus, these had to be obtained from other, less convenient sources, including the finance department, the Harmoni out-of-hours GP service, NU-Care, itself, and staff in A&E who were responsible for duty rotas. Two large surveys for

patients and staff were mounted; the first, in March 2002, just before NU-Care became fully operational on a daily basis, and the second, six months later. The purpose of these surveys was to obtain more factual detail that was not already contained in management sources, and to elicit views and comments. Finally, the CAS evaluation was based on a further survey of all staff who used or had trained on the system. This was coupled with a detailed analysis of a cohort of patients to ascertain who they were seen by, which tests and treatments they received and whether the patient could have been consulted via CAS.

Aside from routinely recorded data on patients' presenting conditions and dispositions post-A&E, including, for example, the number of deaths in the Department, a few other routine checks are regularly performed and audited within the hospital. These include 'door-to-needle time' for patients suffering from acute myocardial infarction and non-accidental injuries to children. Neither of these was of central importance to the NU-Care evaluation. Unlike patients who were admitted, data on clinical outcomes for ambulatory patients (our primary focus) was not routinely captured, the possible exception being X-ray audits (looking at recalls of missed injuries, which are relatively rare). However, we did measure the general frequency of repeat visits to identify any changes.

When a patient is discharged from A&E, they are usually advised to visit their GP, routinely, for follow-up care, or for further treatment if the condition does not settle or worsens. The patient might be given self-care advice and the course of recovery may vary, depending on the type of illness or injury from which they suffered. Similarly, patients might be advised to seek care from a community pharmacist. The method that was devised to obtain this information involved a telephone follow-up of patients who were seen at the six-month stage, to determine how they rated the service, if they would use the service again, and so on. Primarily for practical reasons, this obtained a low response rate and, therefore, was not pursued further; the evaluation relied essentially on data collected at the baseline, six-month stage and from other sources. Table I provides a complete summary of all the data sources.

Organization of the report

The report is organized into five further sections and a conclusion.

Section 2 provides a detailed analysis of workflow, completion times and dispositions, based on data from the patient information system. It includes details of progress towards national targets, and how workflow can be viewed and analysed to provide insights into how service levels can be improved. It illustrates the significant increase in workloads and the reduction in completion times.

Section 3 further disaggregates the analysis of section two and looks in detail at both the causes of delays and the solutions applied to some of them, and at the impacts and consequences. Here, we consider internal delays, the organization of pre-assessment and triage services, test and treatments, amenities and space utilization. It shows how there have been some dramatic improvements but that further efficiencies are possible.

Section 4 is a financial analysis of the impact of NU-Care on the wider health economy, resulting from changes in patient and provider behaviours. One of the stated aims of NU-Care was for it to be financially neutral, overall, in terms of its costs and benefits. This section confirms that this aim is met, but only if the value to patients, in terms of their time saved, is taken into account alongside the improvements in productivity that occurred.

Section 5 analyses staff and patient views, and reports on the increasing levels of satisfaction throughout the progression of the project. Interestingly, this section shows that patients, in particular, are able to accurately identify problems in A&E from their vantage-point and, hence, their views are extremely valuable in designing a better and more efficient service of the future.

Section 6 is an analysis of the CAS system – the extent to which it was used and valued by staff, how much it costs and its effects on the patterns of work. It is concluded that this was the weakest process of the whole NU-Care project and that the use of this particular system could not be justified on any reasonable grounds.

Section 7 provides a summary of our conclusions.

Table I. Sources of data used in the evaluation

	Aspect	Source	Frequency	Comments
1	Workflow, completion times and patient dispositions	Patient information system	Monthly	Used for producing monthly reports and performance tracking
2	A&E patient records	A&E department	*Ad hoc*	Used for identifying presenting complaints, treating clinicians, tracking pathways, diagnoses, treatments and tests, CAS evaluation etc
3	Patient provided data	2 × 1 week survey of patients passing through A&E	Baseline-stage and after six months	Used for assessing patients' views, checking the accuracy of the patient information system.
4	Staff views	Postal survey of staff attitudes	Baseline stage and after six months	Included those employed in A&E, and agencies and other services in frequent contact.
5	CAS users	Postal survey	One-off	Staff trained on CAS
6	Official complaints	Letters sent to the hospital Chief Executive	One-off	Used to cross-check trends obtained in the patient survey
7	Miscellaneous	Special surveys or measurements	*Ad hoc*	Measuring triage, pre-assessment, streaming and triaging procedures
8	Staffing levels	Duty rotas	*Ad hoc*	Harmoni, NU-Care and A&E
9	Costs	Finance departments		There was no integrated financial information covering all aspects of A&E and information was collected from various sources.
10	Harmoni GP 'out-of-hours' service	Harmoni	One-off	Patient perception and activity data
11	CAS archive records	CAS	One-off	To check frequency and mode of use

Section 2: Monthly workflow and completion times

Introduction

To provide a general overview of key trends and the issues involved, the first part of the evaluation considers monthly changes in workflow, completion times and dispositions over the evaluation period. For completion times, we use, as our main point of reference, the national target to be achieved by March 2003 – completion of 90% of cases within four hours (at the time of writing, the target for 2004 is to complete 100% of patients in this time). Completion times are defined as the elapsed time between arrival and departure from A&E. The national target provides a convenient and robust basis for measuring trends and variability.

For monitoring purposes, we used data source number 1, as listed in Table I. This provides a comprehensive record of the time that each patient arrived at and left A&E. It does not, however, provide data on the amount of time spent in different stages of the A&E process. This analysis, and an account of changes occurring within the day, relies mainly on data sources 2 and 3, in addition to source 1, and is discussed in section 3. In the following section, two notational conventions are used to denote completion times; for example, 2:50 hours, here, equates to two hours and fifty minutes, as opposed to the decimal form, where 2.50 equates to two hours and thirty minutes. Generally, the first format is preferable to the second, unless completion time is used as an equation variable. A 24-hour clock is used throughout.

We begin with an analysis of throughput changes during the year, before turning our attention to completion times. Certain features of workflow, such as the relationship between 'absconders' and service levels, both 'in hours' and 'out-of-hours', are then analysed. Absconders are defined here as those who leave A&E at any stage in the process before being discharged by a clinician. Absconders are a key indicator of the performance of the service at a point in time. They are included in the figures for total throughput because they had been registered, although they did not complete their treatment. Finally, we analyse the mix and variation in service levels, according to dispositions; that is, their final destination, post-A&E.

An underlying 'constant' throughout this section is the nature of workflow, which adheres to certain basic mathematical principles. Technical Annex A describes a queuing model that gives a good description of the overall system and provides some useful results. It seems likely that the regular parametric behaviour of workflow would allow the model to be employed within most A&E departments, not just at Northwick Park. For example, the model can link performance, as defined in the national target, to other useful performance measures in A&E. In section 3, these principles are developed further and the range of analysis is extended to provide additional useful insights.

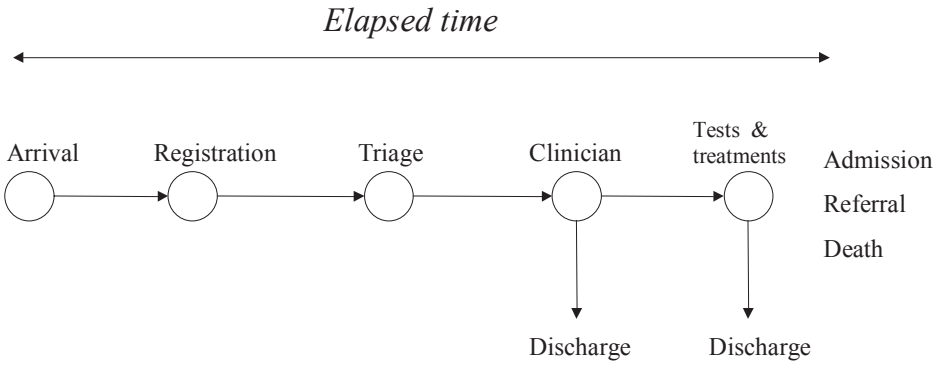

Figure 2: A typical pathway through A&E

Typical pathway through A&E

Figure 2 shows a typical pathway through A&E. Patients are categorised as either Minors or Majors. 'Minor' patients come to A&E of their own volition or are referred by somebody else – this could be a GP, the NHSD advice line, another health worker, pharmacist, relative or friend. They are ambulatory or require minimal assistance to move around, although some are brought in by ambulance and may be assigned to Minors, following pre-assessment. On arrival, they are registered on the system by a receptionist and are advised to take a seat, before being called to a designated 'Minors' area of the Department. NU-Care patients fall into this category.

It is customary for all patients to undergo nurse-assessment, or triage, as it is more frequently known, the aim of which is to identify patients with urgent needs as quickly as possible. Following triage, they wait to be seen by a clinician who might treat and discharge, order diagnostic tests and then see the patient again once the results of the tests are known. At this stage, the

clinician might decide to discharge the patient with the appropriate advice and medicines, or refer the patient to a specialist clinician for an opinion or to admit the patient to a ward.

'Major' patients are extremely ill and require a patient trolley, as well as a high degree of observational support. Generally, they are brought in by ambulance or transferred across from the Minors' area of the Department, following initial assessment into a designated Majors' area. On average, ~60% of patents were established as Minors and 40%, as Majors. Approximately 70% of patients were discharged home, most of these being 'Minors', although, obviously, the two categories are not a perfect match. The remaining 30% were placed into one of ~40 disposition categories, ranging from admission to a ward in the hospital, to a specialist clinic, or to another hospital. Of a total monthly throughput of roughly 7000 cases, an average of 20 (0.3%) were either brought in dead or died in the Department.

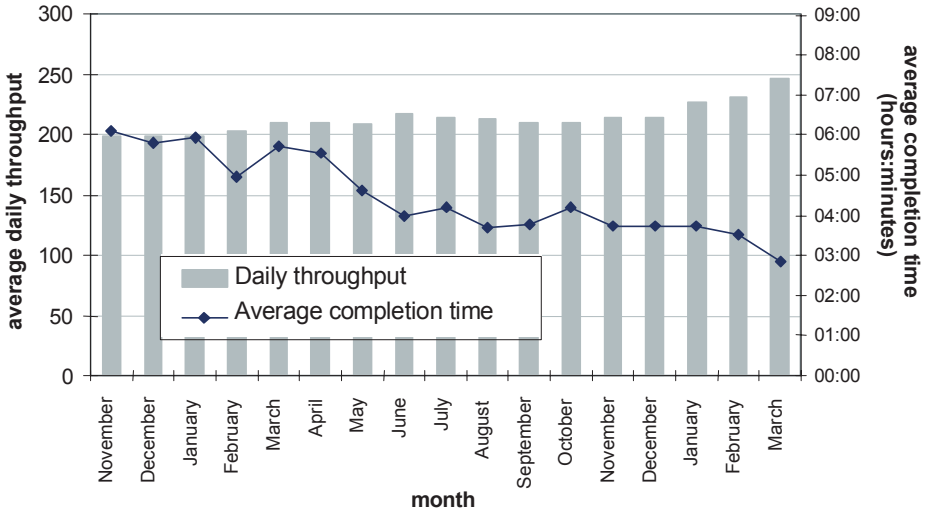

Figure 3: Monthly changes in throughput and completion times from November 2001 to March 2003. Data source, 1.

Figure 3 shows the overall monthly pattern of activity from November 2001 to March 2003. At the beginning of the period, throughput was 200 a day but this gradually increased over the subsequent months, apparently accelerating in the first three months of 2003, to a level of 250 a day. It should be noted that the fully operational NU-Care service did not begin until April 2002, although it had been available on some weekends in the preceding months.

Between 2001/02 and 2002/03, throughput increased from 71 800 to 79 500, equating to a 10.7% increase in activity; however, because monthly throughput is continuing to increase, it seems doubtful that activity has peaked. Shortly, throughput levels will be shown to be partly a function of completion times and this may be a more robust measure of where throughput will eventually settle than a standard statistical forecast.

Monthly changes in completion times

Figure 3 also illustrates trends in completion times and indicates a remarkable improvement over the period, falling from an average of approximately six hours to less than three. Averages, of course, can mask extensive variability. This issue will be addressed later, but for the moment, we need to break these figures down further.

Table II shows throughput and completion times for patients that are 'admitted or referred', and 'discharged home'. The home-discharge category is further broken down into 'out-of-hours' and 'other hours'. 'Out-of-hours' is defined as the period of the day and week when NU-Care is operational. This ranges from 19:00 each evening until 8:00 the following morning, and from midnight on Friday until 8:00 on Monday morning.

For home discharges, over a 12-month period, an increase can be seen in the proportion of patients that were seen 'out-of-hours', in comparison to 'other hours'. It is also clear that the 50% improvement in completion times was achieved equally, regardless of the time of day or the category of patient. In short, activity levels have increased and completion times have improved across the board, not just in 'out-of-hours', when NU-Care was active.

Absconding rates

The other key feature of Table II is the steady fall from March 2002 to December 2002 in the monthly number of absconders. In the 12 months from March 2002, the percentage of patients absconding fell by 59%, from 547 to 223 cases. Further analysis shows that absconding was closely related to perceived waiting and completion times, particularly if people saw many people waiting in front of them.

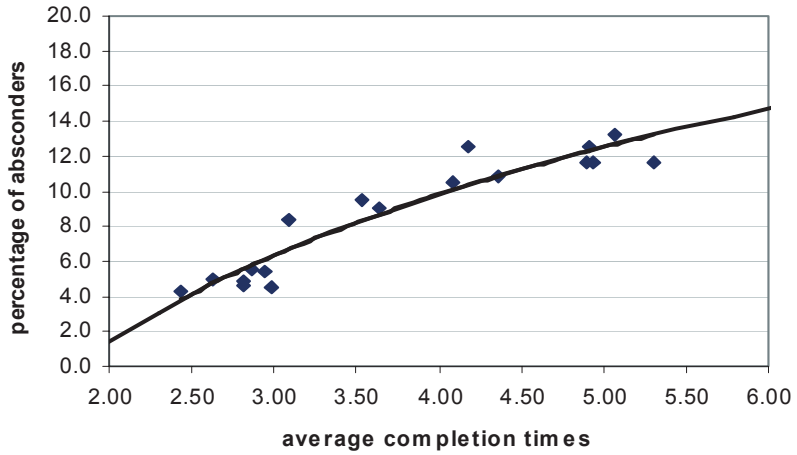

Figure 4: Statistical relationship between completion times and absconding rates. Data source, 1. Completion times are expressed as decimals (e.g. 4.50 hours = 4 hours, 30 minutes).

This effect is clearly demonstrated in Figure 4, which shows the relationship between the percentage of absconders and monthly average completion times for home discharges. Absconding rates tend to increase at a declining rate as completion times increase[9], which is logical, because the cases that remain are likely to be the most urgent. Based on data from October 2001 to March 2003, the absconding rate fell from around 13% to 4% and completion times fell from 5:30 hours to 2:26 hours.

Further calculation suggests that, if the national completion target were to be achieved, the estimated absconder rate would settle at around 3.2%.

Table II: Quarterly comparison of throughput and completion times between March 2002 and March 2003. Data source, 1

	Mar-02	Average completion time (hours: minutes)	Jun-02	Average completion time (hours: minutes)	Sep-02	Average completion time (hours: minutes)	Dec-02	Average completion time (hours: minutes)	Mar-03	Average completion time (hours: minutes)
Admitted/ referred	2146	07:04	2200	04:44	2176	05:11	2193	05:09	2489	3:37
Discharged home	3797	04:55	3909	3.32	3904	02:57	4257	02:59	4938	2:26
-out-of-hours	2129	04:59	2277	03:33	2282	02:57	2626	02:44	2886	2:27
-other hours	1668	04:50	1632	03:30	1622	02:57	1631	03:22	2052	2:24
Absconded	547	n.a.	408	n.a.	222	n.a.	202	n.a	223	n.a
Overall	6490	05:42	6517	03:59	6302	03:45	6652	03:43	7650	2:50

Underlying reasons for increases in throughput

We considered whether throughput increases were due to underlying changes in population need, or were the result of restrictions or closures to other health care facilities in the area. We also considered whether increases in volume might be due to patients returning for another visit – perhaps, because they were dissatisfied with the advice or treatment given on the first visit. No evidence was found for either hypothesis.

The level of repeat visits, while increasing slightly, was not confined to Minors but was seen in Majors too. In a comparison of all patients seen in the period April to September 2001 with the same period in 2002, each patient was tracked to identify repeat visits in the period. In that time, the percentage of repeats increased by 2.1% for patients who were discharged home and by 2.9% for patients who were admitted or referred. We concluded that this was a general effect and not one that was specifically attributable to NU-Care activity.

We also examined the interval between visits to see whether that had changed. Repeat visits can be planned or unplanned, and small differences in the advice given to patients by GPs could result in changes to behaviour. However, Figure 5 indicates that any such effect was likely to have been negligible; it illustrates the percentage of repeat visits occurring in the given time interval over the periods analysed for patients who were discharged home. The pattern was substantially similar, with most repeats occurring within seven days of the initial visit.

The most likely factors responsible for increases in throughput are a combination of referral practices by GPs and NHSD (examined later) and, also, the steady improvements in service. This notion is reinforced by the results in Figure 6, which show a non-linear relationship between throughput and average completion times for patients who were discharged home. As a rough rule of thumb, if average completion times lower or increase by 10%, throughput rises or falls by around 3.7%[10]. Figure 6 also shows throughput after allowing for absconders, with the vertical line, PQ, denoting the expected number of absconders for a given completion average. For low completion times of around two hours, a minimal number of patients abscond but, at higher averages, the numbers can be substantial.

This relationship was, however, less pronounced in patients who were admitted or referred, and so, were more likely to be urgent cases. Further analysis indicates that, if completion times were to equal the national completion time target for all patient categories combined, total throughput would be around 255 patients a day (of which ~150 would be home discharges and the rest, admissions), compared with an average of 200, pre-NU-Care. This finding could be useful to management, for planning purposes.

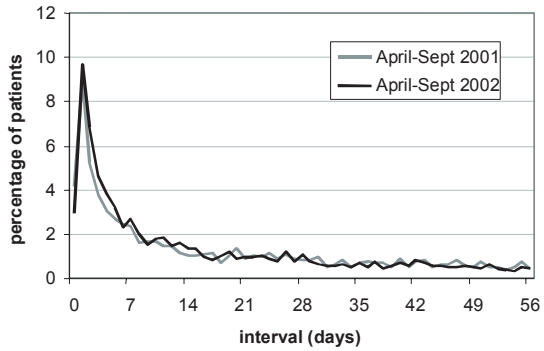

Figure 5: The percentage of patients making a repeat visit by length of interval between visits for April to September 2001 and April to September 2002. Data source, 1.

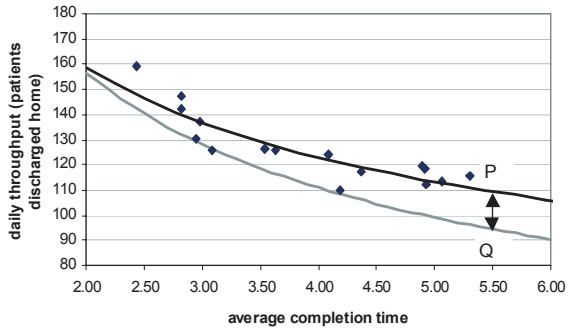

Figure 6: The relationship between daily throughput and completion times for patients discharged home. Data source, 1. The lighter curve shows throughput after allowing for absconders, based on results given in Figure 4 (see text). Completion times are expressed as decimals (e.g. 4.50 hours = 4 hours, 30 minutes).

Completion times and the national target

Thus far, completion times have been expressed as averages. However, the national target is expressed as the clearance of 90% of patients in four hours. Both are valid measures of performance, although the national target has the added advantage that it deals with the problem of very long waits that might be easily concealed within a simple average. Averages, by contrast, are much simpler to calculate, particularly if the information system is fairly basic, as it was in this case. In this section, we derive an empirical relationship between completion averages and the spread around the average. The result is a simple 'ready-reckoner', shown in Figure 7, that can be used interchangeably for either measure when monitoring performance. The ready-reckoner describes the relationship between average completion times, shown on the vertical axis, and the time taken to complete a given percentage of patients, on the horizontal axis. Annex A describes the queuing model that underpins the ready-reckoner. The sloping lines in Figure 7 indicate the percentages of completed patients: 10%, 20%, 30% … 80%, 85%, 90%. Superimposed on the diagram is the performance for March 2002, compared with March 2003. As an illustration, we have also overlaid the national target for

comparison and show that the target of 90% in four hours is equivalent to an average completion of 2:20 hours.

Looking at Figure 7, consider the performance in March 2002, when the completion average was 5:42 hours. Follow the dotted horizontal line corresponding to the average completion time, until it intersects the vertical dotted line corresponding to 4 hours on the abscissa. We infer that the Department was clearing slightly less than 50% of patients in 4 hours at that time, due to the dextral shift of the 50th percentile.

In March 2003, when the completion average was 2:50 hours, the rate of completion had increased to almost 80% in four hours, still short of the national target but a significant improvement, nevertheless. As a more extreme example, the ready-reckoner indicates that, in March 2002, it took 11:30 hours to clear 85% of patients, compared with 5 hours in March 2003. Annex A shows another, complementary ready-reckoner that is used for estimating the percentage of work that is outstanding after a given number of hours in the system. But how accurate is the ready-reckoner? The ready-reckoner was calibrated by analysing completion time distributions over a period and then using regression techniques to fit straight lines to each percentile. Experience suggests that the quality of fit is high (>95%) but that accuracy improves with more observations in the underlying component distributions.

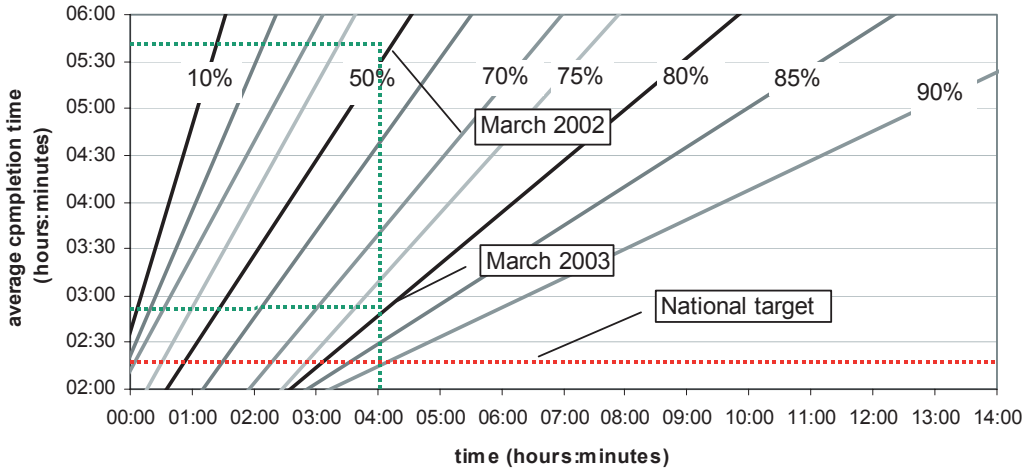

Figure 7: Ready-reckoner, showing the relationship between the average completion time (vertical axis) and the time taken to complete a given percentage of patients (horizontal axis).

We used weekly or monthly throughput for this purpose; typically, 6000 observations for monthly and 1500 for weekly throughput. A total of 18 observations were used to fit each regression line, based on 18 component distributions and around 100 000 observations in total. Figure 8 shows two of the 18 component distributions. The dotted lines show that, in January 2002, it took more than 13 hours to complete 90% of patients but, by January 2003, this had decreased to under nine hours. The results are valid for average completion times of between two and six hours. Outside of this range – for example, if completion times fall to below two hours – re-calibration is recommended. For further information on the form and specification of the component distributions, see Annex A.

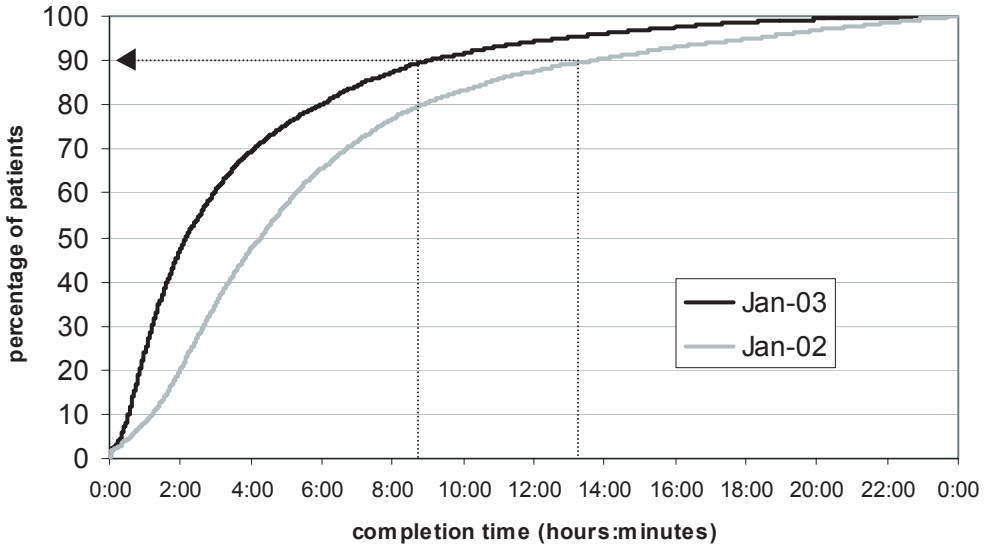

Figure 8: A comparison of the cumulative distribution of completion times in January 2002 and January 2003, comparing the times taken to complete 90% of patients. Data source, 1.

Completion times on matched days

Ideally, reliable and effective emergency care should be available at all times and on all days. Completion times that vary considerably from one day to the next might be viewed negatively by patients, despite monthly or weekly completion times being within target. We reviewed monthly performance on a daily basis throughout the evaluation; at the end of each month, a report was produced, identifying problems or issues over the period.

Figure 9, for example, shows average completion times on matched days in March 2002 and March 2003 for home discharges. The horizontal dotted line shows the 2:20 hour national target, as explained and derived previously. The vertical bars illustrate the change, usually an improvement between the same day in 2002 and in 2003. The detail is interesting because it shows that, by the end of March 2003, A&E was hitting its target on consecutive days and, furthermore, the day-to-day variability that was apparent in the previous year is lacking.

The equivalent graph for patients who were admitted or referred is shown in Figure 10. This shows that the Department, although still well outside the national target, had also improved its performance. It is also worth noting that patients experienced longer delays on certain days of the week, rather than others; Sundays, Mondays and Tuesdays, in particular. This is generally known as the 'weekend' effect, during which there are unusual numbers of unplanned admissions but fewer corresponding discharges into the community, causing an access block into admission wards. Nevertheless, it is evident that there have also been improvements here during the study period.

Although the 2:20 hour target had been met on several occasions throughout the year, the longest sustained period of achievement was seen in March 2003. NU-Care had made the performance possible by placing extra staff on duty, but the primary motivation was the need to achieve the national target during the last week of March. Understandably, to achieve this level of performance, extra resources were drafted in and certain normal procedures were suspended, to a degree, to speed up the process. The question, as far as our evaluation was concerned, was how performance was achieved and if it was sustainable. During discussion, management had proposed different strategies. These included prioritising the 30% of patients currently staying longer than four hours to ensure that 90% could be completed within this time frame.

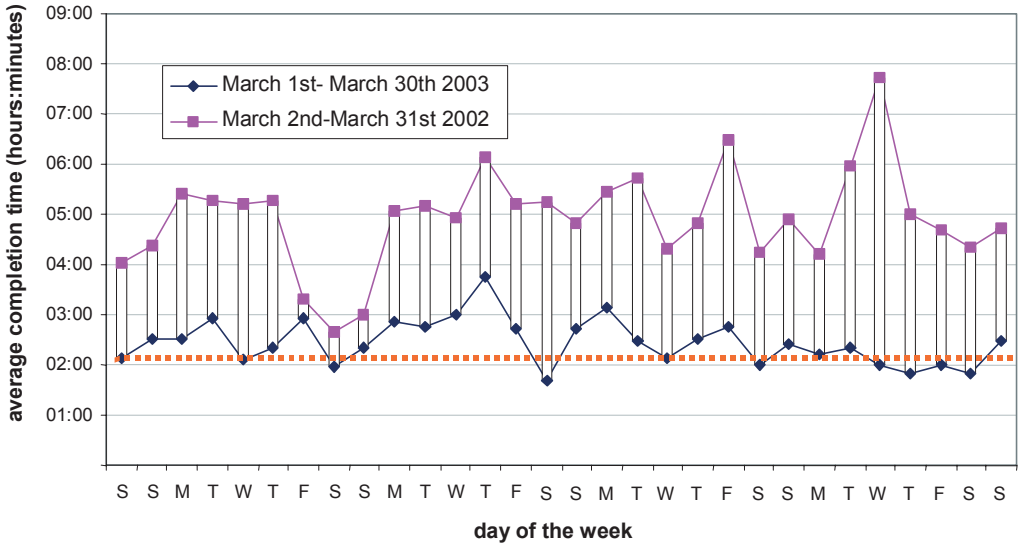

Figure 9: Home discharges**.** Average completion times on matched days in March 2002 and March 2003 for patients who were discharged home. Dotted line shows the national target. Data source, 1.

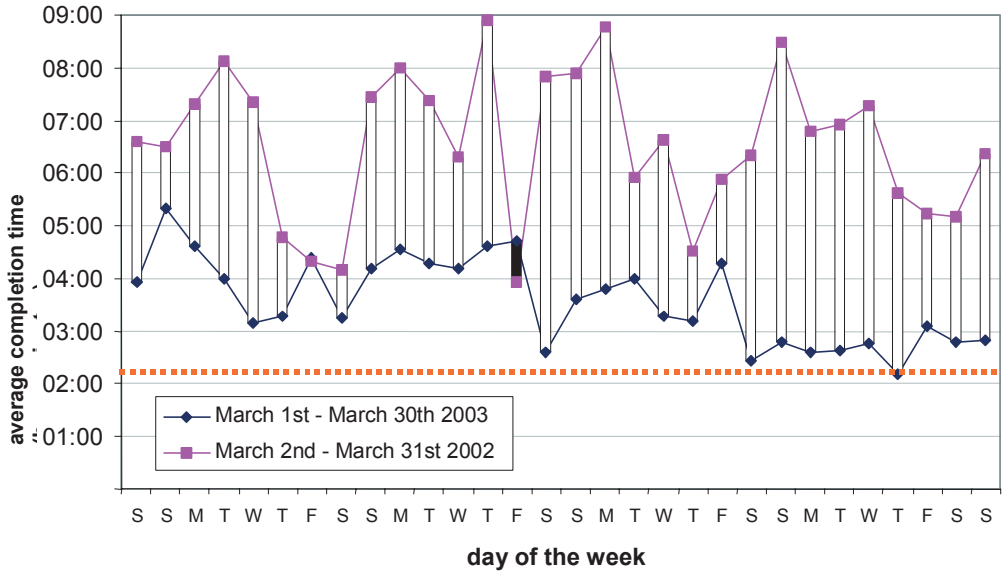

Figure 10: Admissions or referrals: Average completion times on matched days in March 2002 and March 2003 for patients who were admitted or referred. Dotted line shows the national target. Data source, 1.

The fundamental question is this: was the improvement achieved by giving higher priority to home discharges, or; were the improvements disproportionately due to patients admitted or referred, or; was it a mixture of several strategies? We applied the average completion times in the previous month to the workflow in the last week of March for every disposition category (e.g. admission to a ward, transfer to another hospital, home discharge) and calculated the effect on the overall completion time. The gap to be closed was 74 min – the difference between 3:30 hours in February and 2:16 hours in the last week of March.

Our analysis confirms that the goal was achieved through a combination of strategies. For example, we found that:

- 38 min out of 74 min (or just under half) were saved by speeding up the workflow relating to home discharges – mostly Minors. The NU-Care out-of-hours service can be applauded for some of this because it was designed to target this group.
- Speeding up the transfer of patients to the medical assessment ward, 'West Wing', saved a further 6 min (or 8% of the gap). It was notable, for example, that the percentage of all dispositions to West Wing more than doubled in the period compared with February, showing a clear change to normal referral behaviour, in an attempt to reduce referral and admissions delays.
- The remaining 30 min, which accounted for 40% of the gap, were saved by cutting completion times across a wide range of much smaller dispositions, each saving around one minute or less, indicating that a range of management solutions were deemed necessary.

Conclusions

A detailed analysis of routinely produced information indicates that there have been significant changes in workflow during the evaluation period. Our analysis of the data shows that overall

patient throughput was increased by 18% in March 2003 by comparison with throughput in March 2002, and this was, principally, a result of shorter waiting times (30% more patients, if only Minors are included). In addition, the absconder rate also fell from around 12.6% of Minors in March 2002 to 4.3% in March 2003. If the rate for March 2003 had applied throughout 2002/2003, around 4000 more Minors would have completed their treatments than if the rate in March 2002 had applied.

Admittedly, this improvement was partly due to the special circumstances that applied in March 2003, when the Department was being measured against the national target; however, the improvements have not been confined to the out-of-hours service and have generally affected all patient categories approximately equally. It is not entirely surprising that this should have occurred since NU-Care was co-located within A&E and because improved performance in one area will tend to have beneficial knock-on effects in another. The dramatic improvement in service levels outside NU-Care hours is a reflection of several factors, which will be explored in section 3. The sustainability of this level of performance, in particular, requires further analysis. Completion of 90% of cases in four hours is extremely demanding for Northwick Park; this analysis also casts doubt on the more ambitious national target for 2005, of clearing 100% in four hours.

What financial value should be placed on these improvements? There is no charge to patients for treatment in the NHS and so the answer partly depends on how one values people's time. This time includes not only the patients', but also, any accompanying person's time as well. Our surveys showed that, on average, one other person accompanies each patient. A conservative estimate would be to value people's time at the minimum wage, currently £4.20 an hour, although we must be careful not to value people who are extremely sick on an equivalent basis.

Thus, if the Majors are ignored and the Minors and accompanying persons, only, are included, we find that annual time-savings amount to ~54 years, at an estimated cost of around £1.4m. This figure may be contrasted with the £5m annual running costs of this particular A&E department. However, the fact that accompanying friends and family as well as patients move through the system more quickly would indicate that there are other potential categories for saving, for example, in terms of space occupancy and related amenities, because a shorter the completion time means fewer people in the system. We return to these issues in the following section. Finally, there might also have been better outcomes for patients, depending on their initial presenting conditions.

Footnote

Subsequent performance at Northwick Park in April and May 2003 worsened compared with March, but was slightly better than in February, resuming the long-term trend that is apparent in Figure 3. The average completion times were: February, 3:30 hours; March, 2:50 hours; April, 3:27 hours and; May, 3:16 hours. Achievement of performance levels close to the national standard is feasible, as shown by figures from Central Middlesex Hospital, which serves the same general area, where average completion times (all categories) were 2:33 hours in June and 2:28 hours in July 2003.

Section 3: Impact of NU-Care and related process changes on activity and service levels

Introduction

Section 2 analysed monthly and weekly changes in workflow and throughput. This section focuses on changes in activity during the course of the day, at a much greater level of detail. Ultimately, the performance of an A&E department is determined by the sum of its individual parts, including the processes and procedures adopted, and the level and deployment of resources. Owing to the interconnectivity between different parts of A&E, including NU-Care, it is essential to analyse each component part in detail, to understand how one process feeds into the next. To do this, patients must be further classified, not only according to whether they were discharged home or admitted. This should lead to improved understanding of the pressures and bottlenecks in the Department, and how they impact on patients.

The data used here were taken from sources 1, 2, 3, 7, 8 and 10 in Table I. The first part of the section deals with Minors' patients, and key aspects of the process, such as triage and diagnostic testing, are analysed in-depth. The subsequent part examines the Majors' side of the Department. Although Majors comprise only around one-third of all patients entering A&E, they have a powerful influence on the overall performance of the Department and how resources are used. Our aim was to show, in more detail, how the performance improvements that are discussed in section 2 were achieved, the scope for further improvements, and how changes in various areas have impacted on the Department and on NU-Care, in particular. First, we provide an analysis of the arrival patterns and treatment cycle for ambulatory patients who are treated in the Minors' area before being discharged home.

Patients who are discharged home

Arrival patterns

A key factor in the management of workflow is the pattern of arrivals. Figure 11 illustrates the average hourly pattern of arrivals in March 2002, September 2002 and March 2003, in the 'home discharge' category. Interestingly, the broad pattern has remained essentially the same throughout the evaluation. Between midnight and 8:00, activity falls to below four arrivals per hour. From 8:00 to 12:00, arrival rates rise steeply to more than ten per hour. Then follows a slow tailing off until around 17:00, after which there is a second peak of activity, followed by a further tailing off, which continues through the night. Note that this pattern is similar to the pattern that is observed in NHSD and by Harmoni, and is, thus, probably 'generic'. The most notable change during the evaluation was the increase in arrivals from late morning through to early evening; some of this is traceable to weekend activity, when NU-Care is continuously operational and patients start to arrive earlier in the day. The average increase is around one per hour, on a monthly basis, and two per hour at weekends, although, as will be seen, this tends to be concentrated at certain times of day.

Statistically, we found no systematic relationship between patient time of arrival and the complexity and severity of their condition, although there was some anecdotal evidence that it might be influenced by factors such as GP opening hours. Categorising patients into three groups, according to whether they were prescribed medicines, sent for further tests or investigations, or admitted, showed roughly equal proportions of each group presenting throughout the day. However, there was a greater tendency for cases arriving between midnight and 8:00 the following morning to be in the third category – those subsequently admitted or referred. Overall, the pattern did not raise any particular issues with regards to NU-Care with one exception. GPs were not routinely on duty on most weekdays after midnight, except on Friday, Saturday and Sunday nights when it was busier.

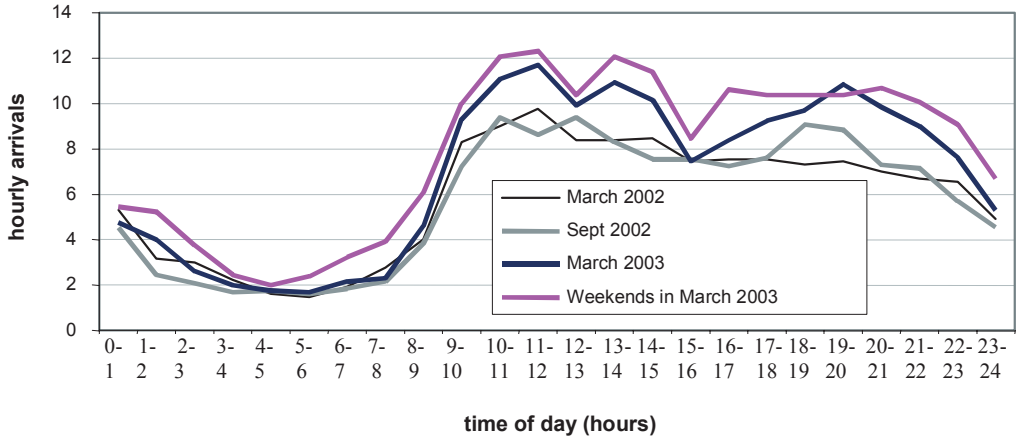

Figure 11: Average daily arrivals of patients by hour of the day in March 2002, September 2002, and March 2003. Data source, 1.

Analysis of duration by treatment stage

Completion times are the sum of time spent in each stage of the process. Data source 3 (Table I), based on patient surveys, tracked patients through the system, recording the times they spent in the system at different stages, from registration to triage, from triage to seeing a clinician, from clinician to tests and treatments, and then to discharge (Figure 2). A clinician is defined, for these purposes, as a nurse or doctor who has the authority to discharge a patient. All Minors are included in this part of the analysis, including those who were seen by NU-Care and discharged home**.** Majors are dealt with in a separate section later. The period covered by the survey was from 8:00 to 24:00, during which ~80% of daily activity is concentrated. In the following sections, we review some of the key changes that have occurred at each stage, commencing with an analysis of triage.

• *Triage waits*

Triage is a rapid assessment of patient condition, based on presenting symptoms, which enables a nurse to allocate an appropriate level of priority to a patient, and thus, a safe time frame within which the patient may wait for a treating clinician. An NHS circular[11] states that:

'If you go to an Accident and Emergency department needing immediate treatment you will be cared for at once. Otherwise, you will be assessed by a doctor or trained nurse within 15 min of arrival'.

Figure 12 shows the average wait for triage at Northwick Park from the start of registration, by hour of the day, between the first patient survey in March 2002 (the 'baseline'), and the second, in September 2002. At baseline, average waits increased more or less steadily from around 15 min in the morning to more than one hour, by the end of the day – well outside the required standard. However, by the six-month stage, there had been significant improvements, with the average falling to around 19 min, tending to peak mid-afternoon, rather than late evening; but, it should be stressed that this is only an average, and was achieved only at certain times of the day. Moreover, this figure is still outside of the expected standard.

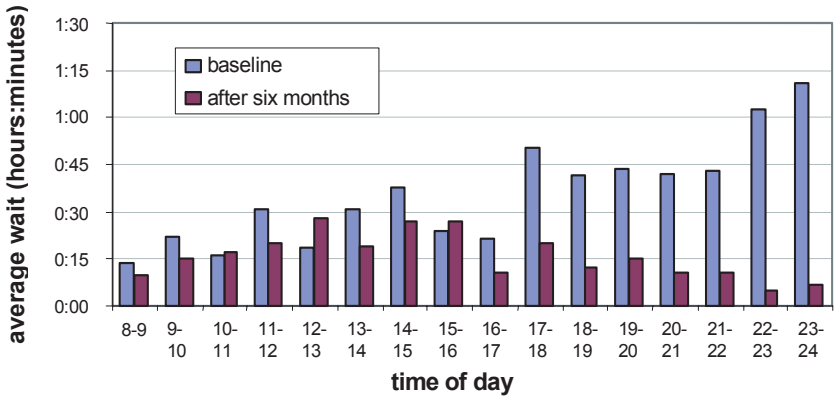

Figure 12: Average waiting time to see triage nurse by time of day during March and September 2002 (all patients discharged home). Data source, 3.

• *Clinician waits*

Following triage, a patient is re-seated and waits to be called by a clinician. Figure 13 relates to the interval from the beginning of triage to seeing a clinician. At baseline, we found that clinician waits could be over 3:00 hours, particularly during late afternoons and late evenings. However, by the six-month stage, this had fallen dramatically and was clearly a major contributor to the overall fall in completion times. This improvement correlated to the availability of more staff and to differences in productivity. To provide an idea of the relative utilization of NU-Care and A&E clinicians, with respect to home discharges, we found that NU-Care GPs accounted for 10% of total clinician hours, by virtue of their more restricted hours and numbers. By contrast, NU-Care GPs processed 1.8 patients per hour in comparison to 1.2 in A&E (43 compared with 29, over a 24 hour cycle). However, this was not a randomized controlled trial, and so, the differences might be due to patient selection, as well as differences in practice (see also section 6).

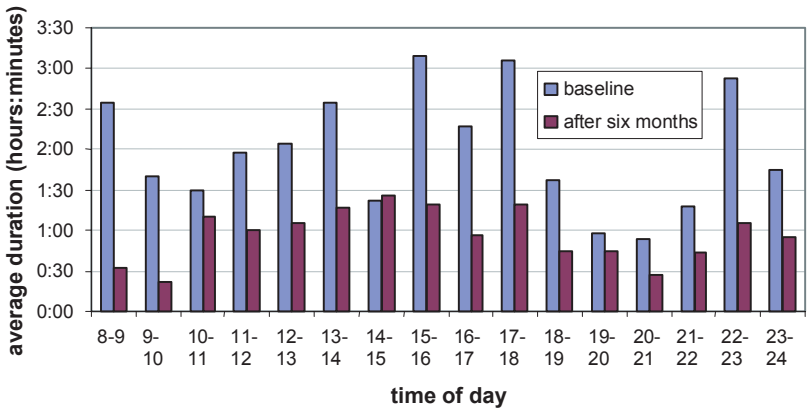

Figure 13: Average duration from seeing triage nurse to seeing a clinician, by time of day (all patients discharged home). Data source, 3.

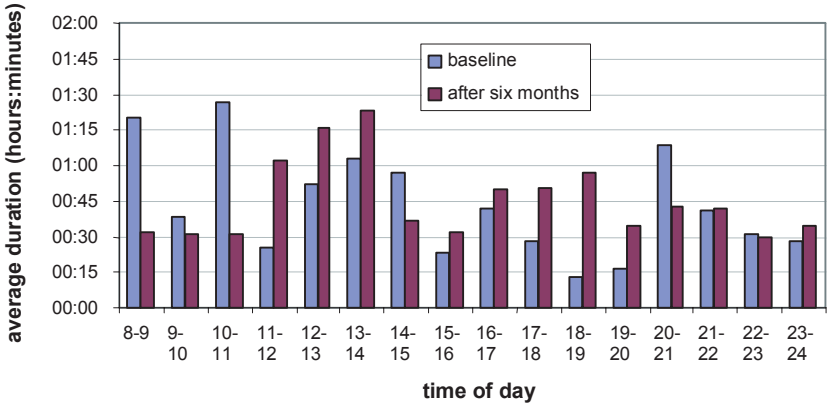

Figure 14: Average duration in A&E from first seeing clinician to discharge, by hour of day ('the tests and treatment' stage). Data source, 3.

• *Test and treatment duration*

After consultation with a clinician, patients may be treated or sent for further tests. Figure 14 illustrates the comparative difference in test and treatment duration, from the time of seeing the clinician to discharge, at the baseline and six-month stages.

In comparison to the previous stages, we observed relatively few systematic differences between the two surveys (baseline and six-month stage) by time of day, probably indicating little or no changes to procedures in the intervening period. The average duration in each survey was 54 min and 43 min, respectively, representing an improvement of 11min, overall. Figure 15 provides a summary of the improvements that occurred between these two points in time, at each stage in the process, and shows where time gains were chiefly made.

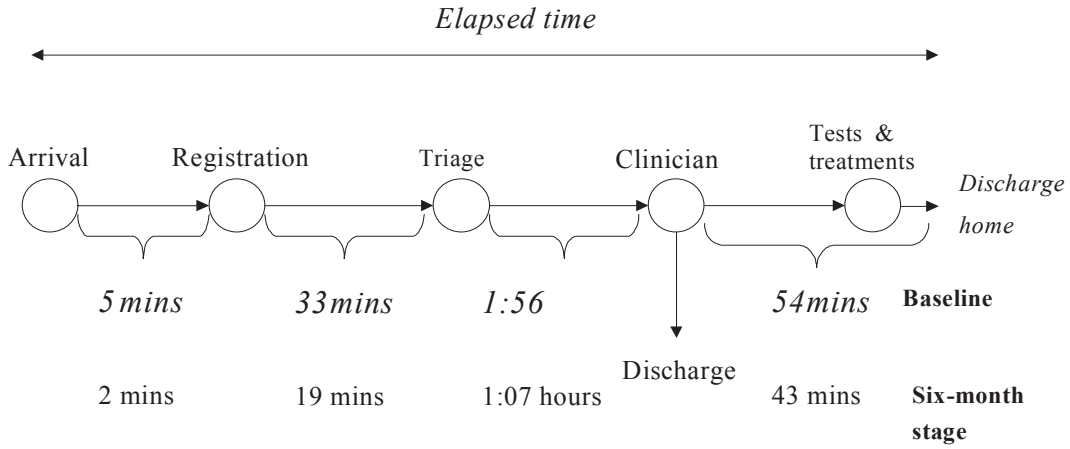

Figure 15: Typical pathway through A&E for patients who are discharged home, showing the intervals between key stages at the baseline and six month stages. Timings shown in the first line in italics refer to the baseline and in the second line, to the six-month stage. Data source, 3.

Absconding patterns

We wanted to establish if the fall-off in absconding rates that was observed in section 2 was a general effect or one that was more evident when NU-Care was active, because this might indicate that NU-Care was adding value by meeting a clear need at specific times of the day. We found that there was a distinctive absconding pattern, with the number increasing throughout the afternoon and reaching a maximum after 20:00, with no difference between genders. However, we also found that the same pattern persisted even when NU-Care was active, and that the absolute fall in absconders, post NU-Care, was similar over the whole 24-hour cycle. In practice, therefore, it was difficult to separate NU-Care effects from other positive changes in the service that were happening in parallel. Thus, each of the individual stages in the process had to be considered in more detail to understand the reasons for particular delays, starting with triage.

Managing patient flows

• *Triage as a system*

The results described previously show that, although waiting times for triage have improved, there is still a 'waiting' problem. What is understood and practiced under the name of 'triage' can vary greatly. According to the Manchester Group[12]:

'The main role of the triage nurse is the accurate prioritisation of patients. The triage nurse needs to become accomplished at rapid assessment that involves quick decision-making and suitable delegation of tasks. Long conversations with patients should be avoided, as should exhaustive history taking. Clinical observations, such as temperature/pulse, need to be delegated if not required to establish as they are too time-consuming. Rapid influxes of patients may require the triage nurse to seek assistance from another member of staff.'

In theory, nobody is discharged immediately following triage, because triage nurses do not have the authority to do so. Most cases are referred to a clinician, although a small proportion might be referred to specialists, in accordance with agreed protocols, for example, in ENT, gynaecology or paediatric departments. Similar protocols enable the triage nurse to request some investigations, such as X-rays or take blood for analysis, with the potential effect of increasing triage times. The triage process is frequently criticized, based on the reasoning that it represents an unnecessary cause of delay for patients with minor conditions and, therefore, adds little value to the process. Using data source 7, we established that, excluding waiting time, the average time per triage is 12 min. This implied, for example, that the expected waiting time for a person who is fifth in the queue would be 1:00 hour (allowing a full 12 min for the patient currently being triaged). To put this into context, it represents just under half of the *total* completion time implicit in the national target of 2:20 hours.

For an A&E department that is interested in reducing triage waits, there are, essentially, three options: i) introduce more triage nurses or hold one or more in reserve (e.g. for times when the triage nurse is occupied and a new patient arrives; 2) reduce the time taken to triage and/or replace it with a simple 'rapid assessment', as implied above; 3) change the system altogether (e.g. by increasing the number of clinicians with authority to discharge or by placing one in triage).

The difficulty with the first option is demonstrated in Figure 16, which shows the relationship between the number of patients

in the queue, assumed, for illustrative purposes, to be 5, and the expected waiting time. As noted previously, with one triage nurse on duty, the expected waiting time for the 5th patient in the queue would be one hour, but only 15 min if there were four nurses on duty. Placing four triage nurses on duty makes no sense if the queue length is typically only three or four patients, although it is interesting that up to four were operating during some afternoons in March 2003.

The triage process, as practiced at Northwick Park, was perceived from the start as a potential obstacle to the aims of NU-Care and so an alternative was considered – 'streaming'. Streaming entails the use of a simple manual (paper-based) decision support tool by receptionists to 'stream' patients with a minor illness or injury to a clinician working in NU-Care. The tool also assists in the identification of those patients whose symptoms might indicate a high level of concern and empowers the receptionist to take a patient directly to Majors. Streaming is one of several initiatives that are being tested in the NHS to improve workflow and reduce delays to patients whose needs are greatest. Another example is 'See and Treat', in which senior clinicians are enabled to intervene at a much earlier stage.

Under the streaming option, the first medically qualified person to see the patient may be a GP, an assessing nurse using CAS, an Emergency Nurse Practitioner (ENP), a Primary Care Nurse Practitioner (PCNP) or a Senior House Officer (SHO). The single queue of patients is managed by a coordinator, on a first-come-first-serve basis, provided the case falls within the competence of the clinician. A recent study[13] has shown that streaming can be extremely effective at reducing waiting times. Consequently, the evaluation team considered the streaming option in more depth, to see if it could be made to work effectively.

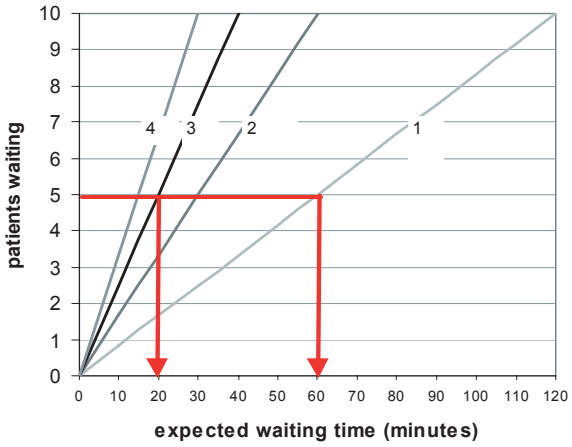

Figure 16: Guide to the relationship between queue length and expected waiting time for a given number of triage nurses (graph assumes triage nurse is free to serve the next patient). Assumed triage time: 12 minutes

The essence of streaming is that non-medically qualified reception staff separate patients into 'streams', either for triage or direct to a clinician, using simple algorithms to aid their decision. Pilot studies were carried out on random days to see what effect streaming would have on stage and completion times. The pilots were split into three categories: times of day with both NU-Care and streaming; times with NU-Care but no streaming; and times with neither.

The resulting impact on stage and completion times is shown in Table III; as can be seen, the effects can be dramatic. However, in spite of its effectiveness, streaming is still not an established part of the daily routine in the Department. Despite experimenting with different combinations of standard triage procedures and streaming, management failed to solve the issue entirely – namely, how to direct patients down the most appropriate care pathway. The main reasons for this are twofold: a continued perceived risk to patients that do not have an initial assessment by a nurse, and a lack of organizational and conceptual clarity about the purpose of triage. By the end of the evaluation, the issue of whether to triage, assess, stream or use one of the alternative options such as 'See and Treat', as noted previously, was left unanswered.

However, in the view of the evaluation team, triage for all patients is a waste of resources and, inevitably, leads to bottlenecks.

The key is to identify those patients for whom a full nurse assessment will add value, particularly those for whom diagnostic tests might be required to enable test results to be available at an earlier stage.

Table III: Impact of streaming on average triage, clinician and completion times. Data source, 7

	Average time from arrival to triage (A)	Average time from triage to clinician (B)	Average time from arrival to clinician (A+B)	Total time in department
No NU-Care and no streaming				
A&E	00:39	01:21	02:00	03:32
NU-Care	n.a.	n.a.	n.a.	n.a.
NU-Care with no streaming				
A&E	00:34	01:27	02:01	03:15
NU-Care	00:44	00:43	01:27	01:44
NU-Care with initial streaming				
A&E	00:20	00:41	01:01	01:46
NU-Care	n.a.	n.a.	00:22	00:44

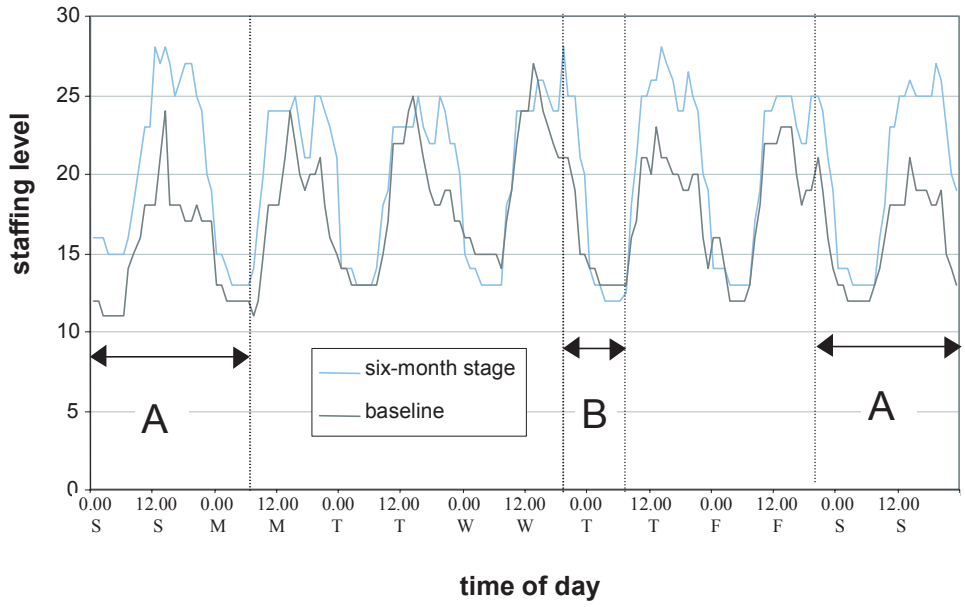

Figure 17: Hourly counts of staff on duty at the baseline and six-month stage in A&E, including NU-Care staff. Key: A = NU-Care hours during weekends; B= NU-Care hours during weekday. Data source, 8.

- *Profiling staff to meet demand*

The availability and deployment of staff hugely influence the management of workflow. Figure 15 shows that the biggest improvement in performance was a result of reducing the delay following triage to seeing a clinician, during which there could be ten or more patients waiting. The analysis in this section shows that both the increased number of staff, especially doctors who have the authority to discharge, as well as improved profiling during the peaks and troughs, were the main reasons for this. Note that for data purposes, a distinction was drawn between staff that were on duty and actively working in A&E, and staff that were on duty according to the duty rota. The difference is important because of staff breaks, training sessions and other miscellaneous absences.

Figure 17 shows hourly staffing levels over a seven-day period at the baseline and six-month stages (Sunday to Saturday). It demonstrates how staffing levels were adjusted during the course of the evaluation and, in effect, were directly responsible for

some of the performance improvements achieved. It also shows the hours that NU-Care is active at weekends (A) and the active period on weekdays (B), starting at 19:00 and continuing until 8:00 the following day.

Close examination of the graph indicates three key differences between the baseline and six month stages. At the six-month stage: 1) more staff were active at the peak time of day, as indicated by arrival patterns, the early afternoon, in particular; 2) more staff were on duty in the late evening and after midnight, particularly at weekends and; 3) morning shifts began more promptly. The differences are, primarily, the result of NU-Care staff being available, but are also a result of staggering of breaks and shifting of training sessions during core A&E hours.

Based on an eight-hour shift pattern, there were 51 whole time equivalents actively working in A&E at the baseline stage. At the six-month stage, this had increased to 60. Of the extra personnel, five whole time equivalents were NU-Care personnel, one was an A&E doctor, two were nurses and one was a receptionist. The overall difference in completion times between the cases that were sampled in the two evaluations was 75 min, although, obviously, the attribution of the saving to individual staffing levels tends to be problematic. It should be noted that there were no planned staff changes in the diagnostic or testing services during either period, linked directly to the NU-Care project.

While the results suggest a clear link between staffing levels and completion time, as theory would predict, this has to be on the assumption that procedures remain stationery and do not change. Changes to procedures, for example, with respect to triage, are obviously an important factor. To prove this point, in the last week of March 2003, the imperative was to achieve the national completion time target. The number of staff on duty and actively working in A&E was only 56 shift equivalents, yet the 2:20 hours completion average was achieved, both for home discharges and admissions. We conclude, therefore, that performance is a function of staffing levels, but it can be substantially influenced by management action and skill mix.

Tests and treatments: completion time effect

Previous analyses indicated that the time spent in the Department after consultation with a clinician made a significant contribution to overall completion times. However, only relatively small improvements at the six-month stage could be attributable to tests and treatments, and it is important to understand the reasons for this. To keep our analysis manageable, we divided the additional post-clinician stages to include X-rays, blood tests and urine tests. We distinguished between complex interventions that would be performed by a clinician operating at a high level of competency, such as sutures, incision and drainage, catheter insertion, dislocation and fracture reduction, and simpler interventions, such as dressings, plaster of Paris applications and strapping. We used a ‘bar code’ to track and quantify individual pathways and time intervals. The relative occurrence of each pathway and the average time interval was then analyzed and tabulated to identify particular sources of delay.

Table IV shows the results for the pre-baseline NU-Care stage (to be sure of sampling a ‘normal’ A&E caseload, rather than one that might be influenced by the presence of a GP). The bar code consists of a series of ‘1s’ and ‘0s’, depending on whether the given test or treatment was included in the pathway (key given under table). The results show that almost half of all Minors received no further tests or treatment (although 57% departed with a prescription or medicines). Potentially, this means that, of 80 000 patients who pass through A&E each year, 36 000 have no specific need to be there and could have their care managed elsewhere, by a GP or at home[14].

Patients in this category left the Department, on average, 42 min after seeing the clinician. For all other, less frequently occurring pathways, there was great variation in the time interval. Simple intervention cases, for example, were dealt with promptly, but any pathway involving a combination of blood or urine tests, particularly if combined with X-ray, took the longest time, often more than three hours. This is partly due to blood and urine samples being sent to a pathology laboratory, rather than being carried out at the point of care.

Table IV: Pathway analysis of the time interval from post-clinican to leaving the Department

Bar code M X B U S C	% of pathways	Average time post clinician (hours:mins)
1 0 0 0 0 0	45.4	00:42
1 0 0 0 1 0	13.4	00:21
1 1 0 0 1 0	12.0	00:59
1 1 0 0 0 0	7.9	01:27
1 0 0 0 0 1	3.7	00:31
1 0 1 1 0 0	3.2	01:52
1 0 0 1 0 0	2.8	02:00
1 0 1 0 0 0	2.8	00:35
1 1 1 0 0 0	2.3	03:06
1 1 1 1 0 0	1.9	04:21
1 1 1 0 1 0	0.9	01:30
1 1 0 0 1 1	0.5	00:56
1 1 0 1 0 0	0.5	04:05
Other	2.7%	
Total	*100*	*00:54*

Key: M=Minor; X=x-ray; B=blood test; U=urine; S=simple intervention; C=complex intervention. Data sources, 2 and 3, main pathways only.

Our suggestion to management at this time was to consider 'near-patient' testing as a way of accelerating workflow; although accepted in principle, it had not been implemented or trialled by completion of the evaluation. An air-chute system dispatches blood and urine specimens to the appropriate destination and so the speed of delivery is not the issue here. Currently the system operates on a batch-run system and a specimen that just misses the batch has to wait some time for the next processing. Some tests, however, take longer to complete than others and so, to an extent, delay is inevitable. We understand that staff, known as 'path pals', have now been employed to courier results on an immediate basis. However, it is hard to believe that a more efficient and long-term solution cannot be found.

Our overall conclusion in this section is that, if completion times for home discharges are to be lowered to levels that are consistent with a national completion time target of 2:20 hours (as shown in section 2), stage time intervals also have to be reduced. The evidence, to date, suggests that this had only partly been addressed at the six-month stage, although some progress had been made. The above analysis suggested two key bottlenecks, solutions to which are available. These are triage, and blood and urine tests, and until the issues surrounding these stages are finally resolved, a national target time is likely to prove unsustainable.

Patients who are admitted or referred

Patients who are admitted to a ward or referred to a specialist or other hospital are mostly cared for in the Majors' area of the Department, where there are different issues to Minors that impede or accelerate workflow. These include waiting to be seen by a specialist or waiting for a bed to be allocated after the decision has been made to admit. Also, the patients, themselves, are more unwell and are held temporarily on trolleys, under observation. In these cases, completion times might be only loosely related to turnaround times on tests, particularly, if the patient is deliberately being kept in for observation or is waiting to be admitted to a ward.

Although a totally separate workstream from NU-Care, there are two reasons for in-depth analysis of Majors**.** The first is that Majors compete with other resources in the A&E Department. For example, using data source 3, we found that, as the daily arrival rates for Majors increased, completion times for home discharges lengthened. The second is that the national completion target does not discriminate between home discharges or admissions, and so achievement of that target would necessitate a holistic approach to management and resource deployment.

Arrival patterns

Figure 18 shows that the arrival patterns for patients who are admitted or referred tend to follow a similar pattern to patients who are discharged home The average hourly arrival rate in March 2003 was 3.3 per hour, an increase of 0.3 per hour in comparison to March 2002. This contrasts with somewhat higher rates of 6.9 and 5.8 per hour for home discharges between the same periods. Patients are held on trolleys or chairs in a separate area, although staff might alternate between Majors and Minors sections, as required. The key factors that determine completion times for Majors are the clinical condition of the patient and admissions' and related procedures, which can cause delays when the decision to admit has been taken.

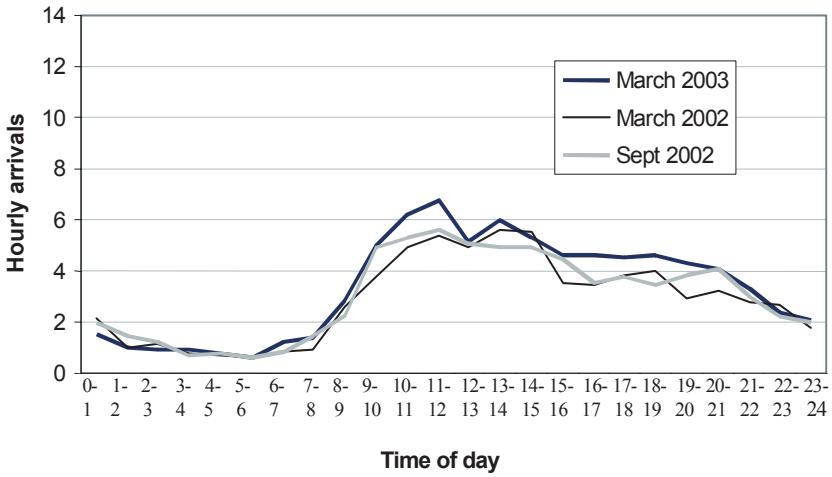

Figure 18: Hourly arrival pattern for patients who are admitted or referred. Data source, 1.

Completion times by disposition

Much of the variation in completion times was found to be a function of the disposition category – that is, where patients went on leaving the Department. Table V provides a breakdown of patient disposition, post-A&E, by principal destination, in the period March 2002 to September 2002. It shows the volume of patients, the average completion time by destination, the total time (expressed in days) and the proportion of total time spent in A&E. Destinations include, mainly, inpatient wards elsewhere in the hospital, but also referrals back to the patients' GPs, to other hospitals or specialist clinics.

During this period, more than 15 000 patients were admitted or transferred, spending a total of 3625 days, or ten person years, in A&E. As can be seen, average completion times are well outside the national target in all disposition categories. However, aside from target attainment, there are wider benefits in reducing A&E stays; fewer patients in A&E at a point in time reduces the nursing load and pressure on space. Also, the longer that patients remain in A&E, the higher the chances are that tests will need to be repeated in the ward, thus, leading to longer duration of inpatient stay.

The routinely accepted reason for longer completion times is the admission process itself, or bottlenecks in the receiving wards. The admission process is dependent on the availability of specialist doctors to take the decision to admit, as much as it is on the availability of vacant beds on the wards. One particular factor is delays at weekends, when discharges from the wards are put on 'hold'. This may explain the length of time in A&E but it does not explain the variability. For example, many of the longest waits were for patients who were admitted to medical wards such as 'Dickens' and 'Hardy', which are general medical wards. This is partly to be expected because they have more complex investigations undertaken in A&E, because the underlying cause of their symptoms is unclear and there is often no definitive diagnosis. Aside from home discharges, the most frequent destination is 'West Wing', which, as previously noted, is an assessment ward for GP referrals. When this ward is full, patients are routed through A&E, undoubtedly worsening completion times in the process.

Table V: Breakdown of patents who were admitted or referred and their completion times during the period March to September 2000. Data source,1

Destination	% of patients transferred	Average completion time in A&E (hours)	Total time in A&E by category (days)	% of total time in A&E
West Wing	10.0	5:38	361	10.0
Carroll	6.7	5:31	236	6.5
Dickens	3.5	10:21	234	6.4
Hardy	3.1	11:28	226	6.2
Fracture clinic	9.7	3:20	208	5.7
Gray	3.1	9:29	191	5.3
Jenner	2.5	9:43	155	4.3
GP	6.9	3:24	152	4.2
Herrick	2.1	10:59	149	4.1
Evelyn	2.6	8:01	133	3.7
Cavendish	6.1	2:57	116	3.2
Jonson	1.5	10:54	104	2.9
James	1.8	8:51	102	2.8
Haldane	1.8	8:38	100	2.8
Other	37.4	4:32	1027	28.3
Total	*100.0*	*5:38*	*3625*	*100.0*

Decision to admit by time of day

Another dimension of the problem is the timing of the decision to admit, because it can sometimes limit other care options. Figure 19, for example, demonstrates the rate of admission by time of day and clearly shows this decision building through the afternoon and peaking at around 18:00. As most decisions occur towards the end of the day, it was argued that this restricts the possibility of making alternative arrangements. For example, it was not apparent to us how this cycle fitted into the work patterns of other referral services, such as the community and rehabilitation teams that provide care packages for people in their homes.

A study at Addenbrooke's hospital showed that rapid reaction teams, providing domiciliary support, can reduce admissions, and the general idea of supporting people in their homes is supported by other studies[15]. However, if the occupational therapist's shifts finish before consultants have reached their decision, the domiciliary option will not work as effectively as it could. The later the decision is taken, the more likely it is to be skewed away from home care because of the difficulty in making the necessary arrangements at short notice. Moreover, the potential benefits of such a system should not be over-estimated, as the numbers in this category seem to be relatively small.

One suggestion that has arisen from the analysis is that performance of tests and treatment on arrival saves time later. It was argued that it would bring forward the decision of whether to admit, because most of the tests are routine anyway. In effect, this would remove one stage – the time spent waiting for test results, following clinical assessment. Another suggestion was for medical consultants to be on hand to assess admissions at key times of day, rather than towards the end of the day, although it was not clear to what extent this could be implemented. A third suggestion was that admissions' cases can often be identified at the arrival stage, with a high degree of probability. It would be simple to communicate the number of such cases to bed managers throughout the day to enable better planning.

In conclusion, although not the primary concern of this evaluation, admissions and referrals are clearly part of the wider picture, in that they compete for resources within the whole A&E setting, therefore, it is important that they are managed effectively and efficiently. Our main finding is that the processes that are currently operating are not harmonised or optimised for the benefit of patients or staff, and are partially the result of inefficiencies elsewhere in the hospital.

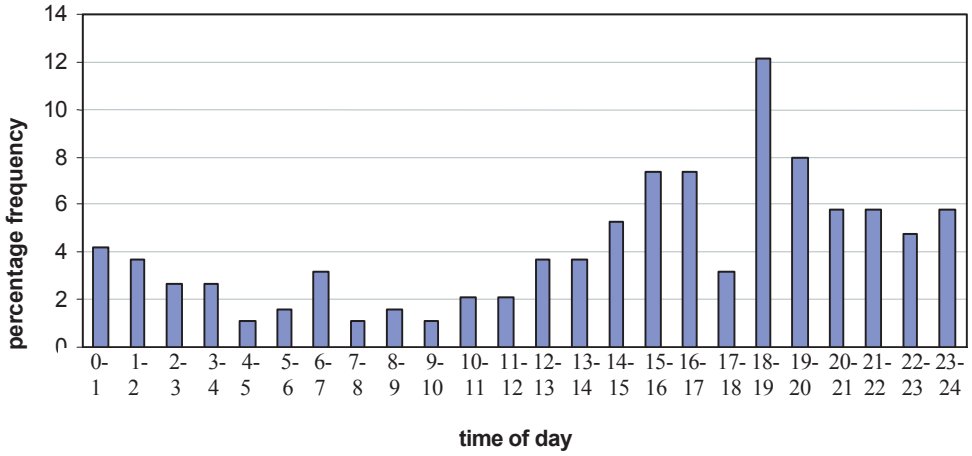

Figure 19: Percentage hourly frequency of the decision to admit.

Accommodating people in the system

During the year, part of the A&E Department was rebuilt to accommodate the re-shaped service and enlarge the area for seeing ambulatory patients. The perception had been that more space was already needed to accommodate existing patients and that the impact of NU-Care could be to increase that pressure further. The treatment and triage areas, in particular, were small, in relation to the volume of patents that passed through and to the areas occupied by other parts of the Department.

The Majors' area of the Department provides a large area for trolley patients in which those patients with high-dependency conditions are treated at the end nearest to the ambulance entrance. Those who require a trolley for examination are treated at the opposite end. Patients who may be assessed in a dedicated resuscitation area are frequently subsequently moved to the Majors' area for monitoring and further treatment, before transfer to the ward.

The waiting area for ambulatory patients had to accommodate patients and accompanying persons, waiting for triage and to see a clinician. There were concerns that the already overcrowded waiting area might not be able to cope if the treatment area was reconfigured, causing further loss of seating space. Based on our analysis of data (source 1) we examined the number of patients in the system at two periods in time - one week in November 2001 and another in September 2002, six months into the project.

By time of day

Using data source 3, we established, with some accuracy, the average number of accompanying persons per patient to estimate the total number of patients and visitors in the system. We also built a simple model to show how everybody would be distributed in the system, by waiting and treatment areas, and also added the number of staff on duty into the calculation.

There was no simple link between numbers in the system and arrival rates. Although November was less busy than September, we found that, during November, there were, on average, 68 patients in the Department. At the peak, almost 200 patients and accompanying persons were circulating, representing a considerable strain on space and staff. By September 2002, this decreased to 38 (76, if accompanying persons were included) with a standard deviation of +/– 15.2.

The issue for management is whether the system can deal with the peaks, because it is these, not the average, that determine space needs. The hourly pattern, showing the number of patients in the system, is given in Figure 20, with NU-Care hours of operation superimposed on weekdays and at weekends. The data show that weekday peaks occur during afternoons, as usual, but they are much less extreme than previously observed, having fallen by around 60%. It was worth noting that, at weekends, when NU-Care is fully operational, the Department seems to be quieter, despite an increased number of patients being seen. The busiest day, as measured by numbers of patients in the system (although, not necessarily arrivals), continued to be Monday, although the scale of difference was also apparently reduced.

These changes should be put into perspective. Queuing theory states that there is a link between numbers of patients in the system and average completion times. This was precisely the case here. It would be simple to demonstrate how many patients and accompanying persons there would be in the system, based on the completion times that were characteristic at the time.

Similarly, it is also easy to demonstrate how numbers in the Department can be made to fall dramatically if triage, clinician and admission waits are reduced to the kind of levels that are now being achieved. The results underline the difference between a functioning department that is busy, yet coping, in terms of space and other requirements, and one that is under strain and possibly being poorly managed.

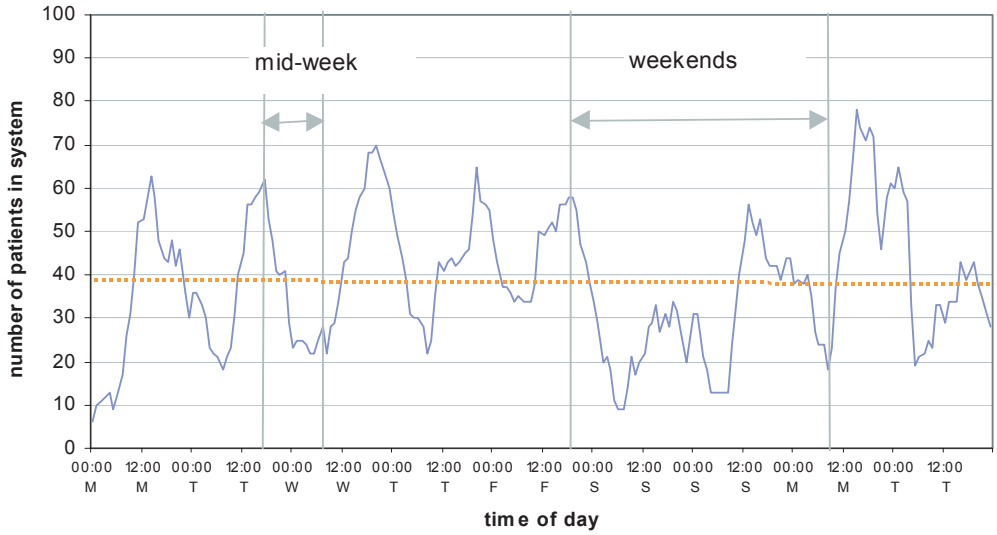

Figure 20: Numbers of patients in the system, by hour of the day between 21 to 30 September 2002. Dotted line shows the average number of patients in the system. Data source, 1.

It was this thinking that helped with the rebuilding program and the capacity planning of the waiting area. Much of the credit for this must go to NU-Care. With every improvement in completion time, the numbers of patients and accompanying persons in the system has decreased. Today, the waiting area is generally quiet, with plenty of spare seats; there are more unoccupied beds in the Majors' area, more patients are being treated every day, and there is improved access between areas. Estimates show that if the Department were operating at the national target of 2:20 hours, the average number of patients in the system would be 22 plus a similar number of accompanying persons. More precisely, the combined total would be 44 plus or minus 15 for 68% of the time. Further analysis of this issue in different scenarios is presented in Annex A.

The re-build, however, has not been a total success. The main difficulty, at present, is that the Minors' area does not have quite the capacity needed and some space is still being wasted for various reasons. A children's play area was lost in the rebuild, despite there being more young patients passing through A&E than previously, as discussed later. Considering the Department as a whole, the large area that is preserved for resuscitation cases, is adjacent to the Majors' area but it is hardly ever used.

There is, arguably, a need for an area to be designed as an observation ward for those patients for whom a protracted period of observation is required before making the decision to discharge. Such observational areas do not necessarily have to be within the main A&E environs. For example, patients with minor head injuries who have vomited, or who have had a brief period of unconsciousness, need to be observed for several hours to ensure that it is clinically safe to discharge them home. A more flexible approach to using the resuscitation area could provide some of that needed capacity. Although outside of our remit, our view is that space utilization should be examined again from a 'whole systems' standpoint, based on a full and stable definition of service.

Conclusions

Our conclusions from this section are mixed. On the positive side, there were welcome improvements in duration and waiting at key stages in patient paths through A&E, including waiting times for triage, and to see the clinician. More staff were available to meet demand peaks, but service has also significantly improved during 'out-of-hours'. Overall, the changes resulted in less pressure on space, quieter waiting areas and a sense that the Department was much more under control, from a management standpoint. Indicating that this is the case, management is now much more focused on workload and performance measurement, data quality and management, than previously.

However, the impression given is that the improvements, taken together, were due largely to the hard work of the staff and the additional resources that were made available. The Department has not become significantly more efficient through changes in process and procedures. Several key processes are still not working as efficiently as they might and further improvement is both desirable and possible. These include the way in which patients are streamed when they enter A&E, the triage/primary-assessment process, itself, and the procedures involved in blood and urine testing, where there are still unnecessary delays.

For Majors, there have been improvements in the admission process but the large differences in average ward admission times suggest there are bottlenecks downstream from A&E that require attention. Links to medical assessment function and the community care team also need further examination to reduce the numbers of patients occupying trolleys in A&E unnecessarily.

Overall, the redesign and rebuilding of the Minors' part of A&E have resulted in improvements but space is still at a premium, relative to levels of activity at busy times of the day. The Majors' area is of an appropriate size and will become quieter if some of the changes that are discussed here are implemented.

Section 4: Impact of NU-Care on the wider health economy

Introduction

When NU-Care was being set up, one of the concerns was whether, in creating much better access to out-of-hours care, it might also create behavioural change on a scale that, ultimately, would need to be reflected in the way resources were allocated to services throughout the local health economy. Equally, it might divert further inappropriate traffic through A&E and so, overwhelm the service. The issue for our evaluation was how to quantify and attribute this behavioural change.

It was evident that behavioural change could take several forms. For example, people that would have considered another A&E centre might go to Northwick Park instead because they had heard that the service there was better. Ambulances might switch to centres that are less busy for the same reasons that ambulatory patients alter their preferred destination. Similarly, patients that plan to postpone their visit to their GP until surgery reopens on Monday might decide to attend A&E instead, to be seen sooner. The evidence for significant substitution effects, however, tends to be contradictory or anecdotal[16].

On the provider side, NU-Care will almost certainly induce other services to make more referrals because it presents an increase in care options at certain times of the day and at the weekend. With differences at the margin in terms of service access, it is possible that some GPs might advise patients to use A&E, rather than wait for an out-patients' appointment. There is also the question of whether the observed increases in NU-Care throughput were related to unsatiated health needs or simply the widely made observation that an expansion in almost any health service tends to create its own demand.

Inevitably, our approach to these questions was not exhaustive, to the extent that we could not observe the entire range of direct and indirect effects, let alone separate them, unequivocally, at a point in time. We were able to observe, however, changes in referral patterns to A&E through a careful analysis of care pathways, to identify those which could be reasonably associated with the introduction of NU-Care and to make estimates of the cost.

The direct costs of A&E to the hospital are approximately £5m per annum, of which 60% of expenditure is on staff and the rest on materials, equipment and apportioned services. The 12-month cost for NU-Care in 2002/3 was £0.9m, excluding one-off costs that were related to the rebuilding work, NU-Care project team, IT equipment, advertising and publicity, and so on, which accounted for a further £0.8m. Of the £0.9m, salaries accounted for 70% and the remainder consisted mostly of telecommunications, IT, training, drugs and equipment. Direct costs are a blunt method for developing an understanding of true resource consumption because they tend to reflect budget, rather than demand, and are difficult to attribute across providers.

Patient pathways

Our method for analysing costs was to develop a patient pathways model. A pathway, in our definition, could be a call to a GP, who then calls an ambulance, which takes the patient to A&E, where the patient is eventually admitted to a ward. In our accounting framework, each stage in the pathway incurs a cost – to the GP, the ambulance service, or the hospital trust. The questions then raised are: what is the frequency of all possible pathways, how do they change, and finally, on whom do the costs fall.

Figure 21 is a conceptual representation of our aims. It shows a simplified 3D view of possible patient pathways through the health economy. Based on data sources 3 and 7, we were able to quantify the pathways that are depicted in bold in the diagram. All other pathways were excluded from our analysis and, by implication, we have assumed that their contribution to costs is neutral. It cannot be stated that this is a strong assumption, but in the analysis that follows, the costs tend to be dominated by one or two pathways.

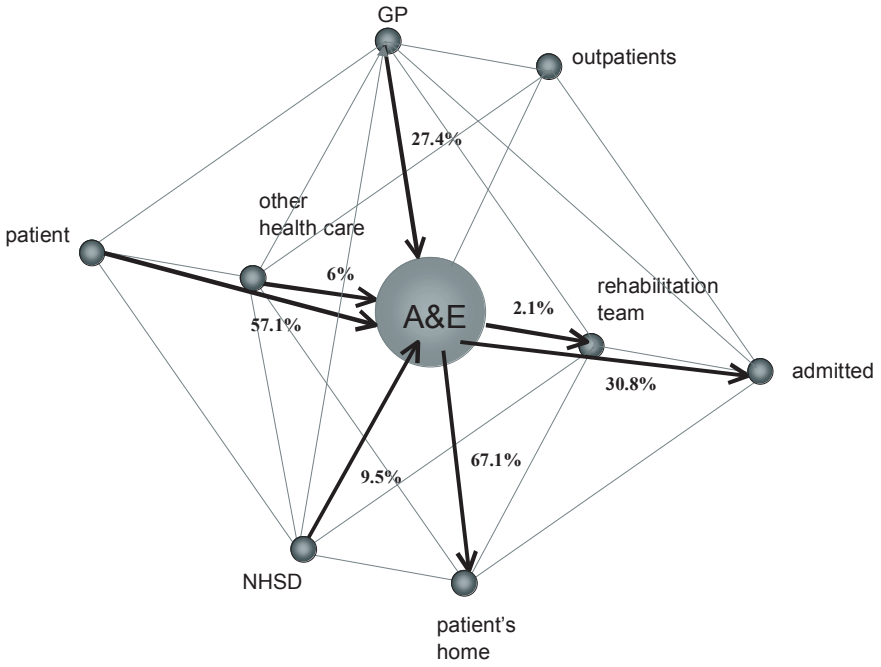

Figure 21: A schematic representation of patient pathways with emboldened lines showing the links for which we had data. Data source, 3. (Key: NHSD = NHS Direct).

Table VI, based on data source 3, shows the main referral sources to A&E at the baseline stage and at six-months. The category 'other health care worker' denotes mainly health visitors, midwives and community nurses. The category labelled 'other' comprises mainly pharmacists and opticians. As the table shows, there were no major shifts in the composition of prior contacts, except, perhaps, for slightly higher contacts with GPs and NHSD[17]. More than 50% of patients, the majority, have no prior contact at all before attending A&E.

Table VI: Prior source of contact before attending A&E – baseline and after six months. Data source, 3.

Source of contact	Baseline	Six months
None	58.8	57.1
NHSD	7.5	9.5
Own GP	25.9	27.4
Other health worker	5.6	5.0
Other	2.2	1.0
Total	100	100

In terms of destinations on leaving A&E, information was available for those discharged home, admitted or referred to the rehabilitation team. For evaluation purposes, some simplifying assumptions were made: first, the possibility of two or more contacts before attending (assumed to have only a minor effect) was ignored. Second, certain referrals from A&E, such as rehabilitation or ambulance journeys home, were not taken into account, due to the small numbers involved.

Each pathway is given a unique bar code, similar to the system used for tests and treatments as described in section 3. Pathway nodes are identified by a letter so, for example, *M* denotes 'Minor' or 'Major'; *A,* 'Admission' and; *G*, GP (see Table VII for key). Theoretically, there are 64 pathways in the schema, based on five 'nodes', 32 each for Majors and Minors.

Unit cost of pathway nodes

Each node incurs a cost and can be regarded as a cost centre, so that, for example, the average full economic cost of an ambulance journey is £104. For 'Other' contact, we assume a nominal £10 charge. There is no charge if there is no prior contact. The most costly path is admission to a ward, an average seven-day stay costing £2023. These costs, shown in Table VII, were assembled from various sources, including the NHS, NorthWest London Hospitals NHS Trust, and the London Ambulance Service.

Table VII: Average unit costs of different contacts with the health service. Data source, 9.

Abbreviation	Key	Unit cost (£s)
M	Minors	37
M	Majors	136
A	Admission	2023
G	GP	30
N	NHS Direct	15
O	Other	10
a	Ambulance service	104

Table VIII provides a breakdown of the main pathways for Minors at the baseline and six-month stages. Minors account for ~67% of all cases. The most common pathway to A&E involves no prior contact or referral to other health care providers without the assistance of the ambulance service. This accounted for 31.6% and 32.1% of all pathways, in the two periods, respectively. The next most common pathways involve prior contact with GPs, other health care workers or with NHSD, as might be expected.

The pathway categories that increased during the period included patients who had prior contact with NHSD and with other health workers, with GP referrals decreasing slightly. The percentage of all pathways that involved an ambulance journey can be estimated by adding the relevant pathways together. At the baseline stage, this was 8.3%, falling to 7.2%, six months later. The overall net increase in flow was 8.9 patients a day, the rise being roughly consistent with other data sources.

The conclusion that follows from this analysis is that Minors' pathways have changed only slightly by comparison with the pre-NU-Care service. In other words, concerns that NU-care might change the composition by skewing pathways towards more trivial cases, do not seem to have materialised. Therefore, the changes to Majors were examined as a comparison. The results are given in Table IX.

Table VIII: The percentage composition of Minors' pathways at the baseline and six-month stages, as a percentage of all pathways, plus average changes in the daily number of patients between periods. Data sources, 1 and 3. For key to barcodes, see Table VII.

Minors patients AGNOa	Baseline % of all pathways	Six-months % of all pathways	Difference in number of patients per day
00000	31.6	32.1	4.8
01000	12.1	9.6	-3.7
00010	5.9	7.2	3.4
00100	4.4	7.0	5.7
00001	3.2	3.0	-0.1
11000	1.3	1.4	0.3
10000	0.7	1.4	1.6
00011	2.9	1.4	-2.8
10001	1.3	1.2	-0.1
01001	0.9	0.8	-0.1
10100	0.0	0.6	1.2
11001	0.0	0.4	0.8
10010	2.0	0.4	-3.0
10101	0.0	0.2	0.4
10011	0.0	0.2	0.4
Total	*66.3*	*66.9*	*8.9*

Table IX: The percentage composition of all Majors' pathways at the baseline and six-month stages as a percentage of all pathways, plus average changes in the daily number of patients between periods. Data sources, 1 and 3. For key to bar codes, see Table VII.

Majors patients AGNOa	Baseline % of all pathways	Six-month % of all pathways	Difference in number of patients per day
10001	7.4	6.5	-1.0
11000	1.8	3.7	4.2
11001	3.2	3.6	1.2
00001	4.0	3.2	-1.1
01000	1.2	2.4	2.7
00000	2.1	2.4	0.9
10000	1.4	2.1	1.6
00010	1.2	2.1	2.0
10011	3.9	1.8	-3.8
01001	2.8	1.3	-2.7
10010	1.8	1.1	-1.1
10101	0.0	1.0	2.0
00101	0.5	1.0	1.1
00100	0.5	0.6	0.4
10100	1.1	0.3	-1.4
00011	1.2	0.2	-1.9
Total	*33.8*	*33.3*	*3.1*

Majors, which accounted for ~33% of pathways to A&E, show considerably more variability in terms of pathways, by comparison to Minors. This is not surprising because Majors are more likely to need complex interventions, tests or to be admitted to a ward. The most common pathway is admission, following arrival at A&E, having had no prior contact with the health service. Ambulance journeys were a feature in 23% of Majors' pathways at baseline, falling to 18.6% at the six-month stage. The main change appears to be an increase in GP referrals that are then admitted (up by 2%). The net change in daily flow is estimated to be 3.1 cases a day.

Overall cost

How does this analysis translate into cost? At the baseline stage, we estimated the total annual direct and indirect cost of A&E services to be of the order of £35.4m. Of this total, A&E, itself, accounted for £4.9m but, by far, the largest cost, £27.8m, was incurred by inpatients who were admitted through A&E.

The third largest cost was to the London Ambulance Service, at £2.2m.

When this analysis is applied to data at the six-month stage, we found that the net overall cost to the local health economy had increased by around £1.44m. Some of the changes, for example, to GP or ambulance services are negligible and can be regarded as *de minimis,* or experimental error. The two most notable effects are on admissions, which account for £1.21m of the total and higher A&E costs (£270 000). Full results are shown in Table X.

Estimates based on this methodology can only be approximate. A full analysis would take into account broader effects on other pathways that are illustrated, but not highlighted in Figure 21. Overall, however, we conclude that, although costs to the health economy have increased since the introduction of NU-Care (as a result of higher workflow and also some pathway changes), the main cost has been the rise in inpatient admissions, rather than additional demand generated by NU-Care itself.

Table X: Summary of changes in overall A&E costs to the wider health economy at the baseline and six-month stage. Data sources, 1, 3 and 9.

Category	Baseline (£ millions)	Six-months difference (£ millions)
A&E 'Minors'	1.7	0.12
A&E 'Majors'	3.2	0.15
Northwick Park	27.8	1.21
GP services	0.3	-0.02
NHS Direct	0.07	0.04
London Ambulance Service	2.2	-0.01
Other	0.08	-0.05
Total	35.4	1.44

This analysis deals only with provider costs, not with savings to patients and accompanying persons in terms of reduced waiting times. In section 2, it was noted in the conclusions that, under certain assumptions about 'time-value', this could be highly significant. Based on the same assumptions, we found that the value of reduced waiting times at the six-month stage was equal to £0.98m. Of this, £0.47m was achieved out-of-hours, £0.31m in hours, and £0.20m for patients who were admitted or referred. This showed that the improvements were achieved right across the board, not just when NU-Care was operational.

After 12 months, there had been further improvements in the service, by which time the annual value of time-savings had advanced to £1.4m. The value of the improvements to patients, therefore, appears to be approximately balanced by the increases in costs. Although, naturally, such estimates can only be an approximation, they seem plausible to a first order of magnitude.

Another way to show the distribution of costs is to rank pathways by costs and then plot the cumulative percentage of patients against the cumulative percentage of costs. If all patient pathways were to cost the same, then all the points would lie on a straight line. What we see from Figure 22 is that 20% of patients passing through A&E account for 80% of the costs and that there is a clear break point between those admitted and those discharged home.

In this context, the flow of patients through A&E consists of a large percentage of 'low cost' patients and a small, but dominant, number of 'high cost' patients. Put simply, a health service that wants reduce costs is more likely to succeed if it reduces admissions and lengths of stay, than if it cuts corners on Minors. Patients' views of A&E, pre- and post-NU-Care, are the subject of the following section.

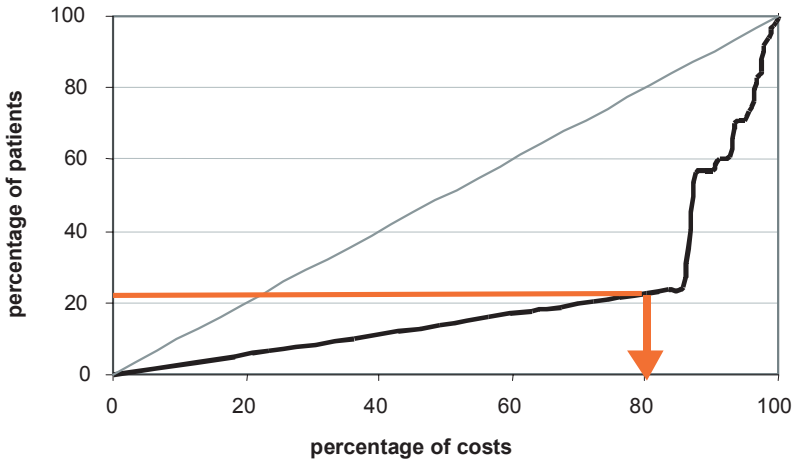

Figure 22: How costs are distributed between different patient pathways. 20% of patients account for 80% of costs. Data sources, 1, 3 & 9.

Finally, it is important to note the omissions from this analysis, of which there are two main areas of uncertainty. First, this analysis does not consider 'second-order' impacts on other services, the demand for which may have decreased (or increased), as a result of NU-Care. These could include, for example, surgery-based GP services, out-patients and community health services. Second, the analysis does not take into account the possibility of changes in unit costs or productivity (e.g. a significant increase in the cost of an ambulance journey), but this will only be significant if the relative costs have changed between the two evaluation points; this seems unlikely.

Conclusions

The economic impact of NU-Care has been most notably sustained by patients**,** who have experienced very significant improvements in service since the introduction of NU-Care due to time savings. Time-savings, generated through shorter waits, translate into economic savings if time is valued, as it should be, on such an appropriate basis. The additional financial costs of NU-Care, if 'one-off' and project management costs are ignored, have been just under £1m; however, this undoubtedly includes transitional difficulties and costs that should settle and disappear if some of the efficiency improvements that are noted elsewhere in this report are implemented.

To understand the importance of this finding, we need to go back to basics. NHS providers perform several roles, including diagnosing, treating, advising and caring. There is also a referral role that, in essence, is a form of 'handover' to sort patients into pathways until treatment is completed. In this sense, it is, therefore, the antithesis of a 'one-stop-shop' approach, although not necessarily a patient-centred approach. Higher levels of referring mean greater transaction costs, in terms of repeated information collection, time delays, unmet need, and unnecessary and wasteful conferral between providers in a pathway. This is, undoubtedly, why some patients provide this as an explanation for bypassing their GP in favour of A&E (see section 5).

For these reasons, the NU-Care approach remains valid, because patients can be streamed and treated *in situ,* where it is more convenient to do so. This, however, raises a more general point about extended pathways and the value of referral processes, particularly where the primary contact refers a majority of patients onwards and without treatment, with only advice. Although outside the scope of this evaluation, greater understanding of the added value and purpose of prior contact points would be beneficial, to prevent unnecessary proliferation and cost.

Section 5: Views of patients and staff

Introduction

For NU-Care to work effectively, it was important to have the support and endorsement of patients and staff. Ideally, patients would notice a significant improvement, not only in waiting times but also in all other aspects of the service, including the demeanour of staff, and the range and cleanliness of the facilities. We sampled patients' views at the baseline stage and after six months, using the results to assess how, and in what respect, the overall service had changed (data source, 3). The results, reported in this section, begin with patients.

Our patient questionnaire sought basic demographic details, such as age and gender, using a standard format, and views on a range of issues to do with the service. Space was also provided to allow patients to state a particular view or offer suggestions. The closed component of the questionnaire asked, first, if the patient was registered with a GP; second, their reason for attending A&E on that day and; third, if there had been any prior contact with another health care provider, such as a GP. General views on the general state of facilities were then sought; if they were clean and tidy, if there was sufficient privacy, the politeness of staff and so on. Patients were also asked how satisfied they were with the service, overall.

Patients were asked to record the exact times of when they were: 1) assessed by a nurse in triage; 2) seen by a clinician; 3) discharged and; 4) when they actually left the Department. A section of the questionnaire that was filled in by the investigators recorded the tests and treatments received, obtained by linking each completed questionnaire to the patient's medical record. The results were then used to analyse and understand the reasons for any delays.

The patients retained the questionnaire throughout their time in the Department and submitted them as they left. The period of the survey was from 8:00 until 24:00, with, generally, three investigators on duty in three- to four-hour shifts. The first survey was conducted in March 2002 and the second, six months later, in September 2002. Almost 1000 responses were collected, approximately translating as a 33% sample over the period of the surveys.

Patient responses were cross-checked with equivalent data collected through the patient information system to look for systematic bias or errors. Not all data could be validated this way but it was possible to check crucial measures, such as time of arrival and departure. Our overall conclusion was that there was a high degree of concordance between the two data sources but there were a few systematic errors in the patient information system, caused mainly by failures of recording, due to lost or mislaid medical records.

As shown by our results, the main concern among patients is waiting time. This, and the corresponding lack of information, attract the most criticism, but it is also clear that the issues are interconnected because, as waiting time reduces, complaints about lack of information also recede. It is equally clear from their comments that patients were better able to identify the causes of delays than were staff. Staff perceptions are consistent with patients', to an extent, but collectively, their perceptions demonstrate a lack of oversight of the system and what can be done to improve it. This might be because they only see part of it at any one time. Before considering the views in detail, the following section provides some relevant background detail on patients and their reasons for attending A&E.

Demographic and background details

Patient demography

Figure 23 shows a percentage breakdown of patients by age, seen at the baseline stage and after six months. The key differences between the two periods are increases in the percentage of infants and patients aged 20–30 years. The reasons for these changes and their degree of permanency cannot be confirmed; however, they would be consistent with the 'out-of-hours' pattern of younger patients attending at weekends and in evenings, thus, suggesting that NU-Care is filling an unmet need.

A comparison of these distributions with the general population distribution for Brent and Harrow would find 0–4 years, 25–29 years, and 70+ years to be over-represented. For example, 0–4 year-olds comprise 6% of the general population but accounted for 12% of patients at the six-month stage. At baseline, 60% of patients were male and 40% female; at the six-month stage, the gender split was even. No explanation for the differences was apparent from the data, suggesting this was probably a random effect.

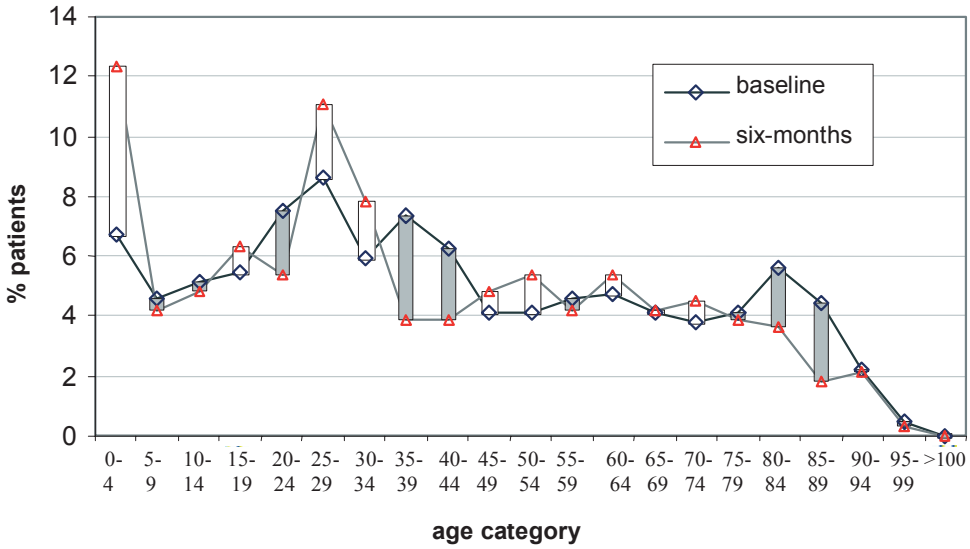

Figure 23: Age distribution of patients attending A&E at the baseline and six-month stages.

Accompanying persons

Persons accompanying patients are of interest because their number might be related to factors such as the age of the patient, waiting times and so on. As users of amenities, including seating, space-accompanying persons are also consumers of resources and so need to be factored into service specifications. The issue for our analysis was whether the number and composition of accompanying persons had changed since the introduction of NU-Care. At the baseline stage, there were, on average, 1.06 accompanying persons per patient but by the six-month stage, this had fallen to 0.92. The distribution of accompanying persons (1,2,3 etc) remained unchanged. However, we also found that the average number of accompanying children had increased from 0.08 to 0.13. Both results were statistically significant.

There are probably two underlying reasons for these changes. The first is the larger number of patients aged 20–30 years, arriving unaccompanied in the evenings. The second is that NU-Care probably drew some patients away from the Harmoni service, which tends to attract more children than A&E. No space issues are raised by the results because the numbers of persons in the system at a point in time had fallen by half; however, it is arguable that, with more infants in the system than previously, there are some implications for where children are seen and where they are seated.

Reasons for attending A&E

The reason for attending A&E, rather than another health care provider, is a potentially important indicator, because it could provide commentary on the service itself or on alternative services in the locality. At the baseline stage, 'need too urgent' and 'GP could not help' were the main reasons given by patients for attendance, accounting for 68% of the total. Access difficulties were a factor in 16% of cases, due to closed GP surgeries. At the six-month stage, urgent need had fallen to 38% of reasons given, and surgery access accounted for 13%. Overall, therefore, we observed a 'levelling-off' of reasons, as well as a fall in the percentage of urgent-need cases, both of which were consistent with the introduction of the NU-Care service. The results are shown in Table XI.

Table XI: Reasons given for attending A&E at the baseline and six-month stages. Data source, 3.

Reason	Baseline %	Six-months %
Need too urgent	49	38
Referred by my GP	9	18
Other	3	15
GP surgery was closed	16	13
GP can't help with this	19	12
Treatment not working	2	3
GP won't come out	2	1
Total	100	100

Views on specific aspects of the service

Amenities

Patients were asked for their views on the amenities. Table XII shows that their impressions had changed for the better between the two evaluation phases. This was partly due to some changes that were made following the first phase, but these were mainly modest and could not account entirely for the change. We believe the main reason was that the amenities were less crowded, so that privacy, for example, was less of a factor. Problems about lack of information in the first phase were caused mainly by the long waits, and thus, as these decreased, the demand for information fell away. Improvements in comfort and tidiness can also be related to reduced levels of activity.

Table XII: Views on general amenities at the baseline and six-month stages. Data source, 3.

	Baseline % good	% poor	Six-months % good	% poor
Clean and tidy	89.2	10.8	95.2	4.8
Comfortable	81.6	18.4	92.6	7.4
Information availability	46.6	53.4	86.6	13.4
Privacy	49.8	50.2	79.3	20.7
Other (toilets, refreshments)	58.7	41.3	86	14

Overall satisfaction

Patients were asked to record their overall satisfaction with the service received, based on a four-point scale, ranging from very satisfied to dissatisfied. The results are shown in Table XIII for the baseline and six-month stages. Data at the six-month stage is further broken down into Majors and Minors; Minors, in turn, are then subdivided into NU-Care and 'other'. As a further comparison, satisfaction levels with Harmoni, the current GP 'out-of-hours' service, are also included. Three key points emerge: first, between the baseline and the six-month stage, the proportion of patients that were very satisfied with the service doubled, from 22.5% to 45.7%; second, the levels of satisfaction were broadly similar between the three groups, Majors, NU-Care and other.

The third key point is that, despite the improvements seen, the proportion of patients that stated 'very satisfied' was still below that for the Harmoni service. This, however, is not altogether surprising because Harmoni patients arrive by appointment and so, waiting times are short and consultations, brief. In addition, they have been previously referred by NHSD and the survey does not record their satisfaction with that service, nor the time of original contact. However, it does pose a problem if full integration with A&E leads to a reduction in patient satisfaction.

Table XIII: Levels of satisfaction with the service received at the baseline and six-month stage, including a comparison with Harmoni current 'out-of-hours' GP service. Data sources, 3 and 10.

Opinion %	Baseline	Minors (primary care clinicians)	Minors (A&E clinicians)	Majors	All A&E	Harmoni
Very satisfied	22.5	46.5	48.6	42.9	45.7	76.0
Satisfied	40.2	37.2	41.8	41.5	41.4	19.0
Partly satisfied	24.9	14.0	6.7	9.9	8.8	4.0
Dissatisfied	12.4	2.3	2.9	5.7	4.1	1.0
Total	100	100	100	100	100	100

Specific comments and unsolicited views

We conclude that, with regard to the specified indicators, there were many positive improvements to the service and that the patient experience had also improved considerably since the introduction of NU-Care. The questionnaire also provided scope for patients to further comment, if they wished, on any part or element of the service that they received. We categorised their remarks into 'domains'. These were 'waiting,' 'information', 'facilities', 'privacy', 'politeness', 'overall service' and 'other'.

The 'waiting' domain attracted over one-third of all comments; the facilities and service, each around 20%; politeness and information, each 10% and; privacy, 2%. At baseline, there were few positive comments, and they mostly related to the politeness of staff. At the six-month stage, there was a significant transformation, although, even regarding waiting times, negative comments continued to outweigh positive comments. However, the overall improvement in all areas was highly encouraging and was significant.

It is appreciated that reliance on unsolicited or representative comments can be misleading but, in this case, the collective comments gave a consistent picture compared with our other analyses and also pinpointed areas of the service that caused patients the most difficulty. Some comments are repeated, more or less, at the six-month stage and this is disappointing because it shows that management might not have taken patients' concerns seriously.

The following selection of typical comments, taken from data source 3, illustrates the points dramatically. It should be noted that comments on the condition of the facilities are omitted, due to their specificity, but they have been passed on to the Department. These were, primarily, concerned with the condition of the toilets, general levels of tidiness, the need for drink dispensers, provision of reading materials and so forth.

Waiting

Baseline

- *'Terrible. Three hours waiting with a baby of one year-old is beyond belief.'*
- *'Been to A&E on two other occasions and waited too long (eight hours!)'*
- *'If you had more doctors, we wouldn't have to wait so long to be seen. First was four hours after arriving. Two hours later, the medical team came, and almost two hours later seen by ENT.'*
- *'While everyone who dealt with my mother was helpful and efficient, it was the sheer time that upset. Arriving at 15:00, we are still waiting for a bed to be allocated at 22:00. We are thirsty and hungry.'*
- *'Wait too long to be seen by doctor…waiting time can be cut enormously by not seeing triage nurse (1–2 hours!).'*
- *'Waiting time for treatment should not be longer than two hours on any one day. We pay a lot of National Insurance!*'

Six-month stage

- '*Service was very good and prompt. The ambulance was quick. All services were very good.'*
- '*I am happy to see a huge change in timing as I was seen sooner.'*
- '*Very good, apart from the waiting time in A&E to get a bed.'*
- '*Waited four hours for blood results!'*
- '*Patient happy with the service but unhappy with the blood results wait. Left department before psychiatrist came to review.'*
- '*Patient took own discharge before results of blood tests were available.'*
- '*My mum waited for seven hours. She is very ill and this waiting made her more ill and we would be grateful if this kind of thing wouldn't happen again.'*
- '*Waited too long to see doctor. Had previously contacted GP surgery but unable to get an appointment for several days.'*

Information

Baseline

- '*There was a lack of information about waiting times. I saw a man brought in and he was left in a chair for hours and ignored.*'
- '*Complete lack of communication. No information about waiting times or even why we were waiting or how the system works.*'
- '*Need for advice on whether it is worth waiting several hours especially where a child is concerned and bed rest is preferable.*'
- '*I noticed two people behind me. One of the patients didn't go to reception and was called before me. My son is one and a half years old and is still bleeding from the head. Reception told me we were 3 in the queue but 4 had already gone. How come?*'
- '*It would be a great help to people waiting in A&E if there were a visual display with their name and an estimate of the waiting time to be seen by a doctor.*'

Six-month stage

- '*More information would be nice so that they have not forgotten the patient. Patient doesn't mind waiting but not happy that she hasn't been told how long it will be.*'
- '*His piece of advice to us (staff) is not to tell the patient that the doctor will be with you and then disappear. The nurse should brief them on and off as to what is happening.*'
- '*Patient's notes lost. This is why he didn't see the doctor until 12:20.*'
- '*As the doctor in NHS Direct spoke to Doctors in A&E, they knew that we were coming and were seen straight away and they also knew that there would be a bed here.*'
- '*Though staff are well behaved it is annoying to listen to indefinite and vague replies to queries….*'

Overall service[18]

Baseline

- '*A nightmare experience of uncertainty.*'
- '*Very, very, very dissatisfied.*'
- '*It's too much like a third world country.*'
- '*In general, service poor. I hope the NHS improves for everyone.*'
- '*Very dissatisfied -14 month child with head injury. Waited two hours to see triage nurse.*'
- '*Sometimes you have to wait two hours, but I am pleased with the service. Staff always supportive and kind.*'

Six-month stage

- '*Patient very happy with service today, had to wait a long time but staff were very good.*'
- '*Patient's son is very impressed with the whole service. The attitude of staff both in A&E and ambulance was wonderful. No complaints whatsoever.*'
- '*What's the point of the triage nurse when after waiting an hour the sisters ask exactly the same questions then say exactly the same things. It seems like needless red tape.*'
- '*Not happy waiting and argued about the waiting time and therefore this lady has discharged herself.*'
- '*Having been here 2–3 times recently, I have found the A&E at Northwick Park much better than Ealing and Central Middlesex.*'
- '*Waiting times much better……. very nice doctors.*'
- '*All staff very polite and efficient, I am pleased with the service, many thanks.*'
- '*Patient's husband very happy with service. They don't bother with GP as GP is not very good.*'

Summary

Overall, we found that patients' views and attitudes were consistent with all other analyses. In addition, the patients' comments gave clear information on which aspect of the service caused them the most difficulties or pleased them most. When the data were presented to management at the baseline stage, some steps were taken to deal with specific comments – mainly, waiting times. However, it was also clear at the six-month stage that patients expected still further improvements to waiting times.

By the six-month stage, we concluded that the patient experience had improved for the better and that this was the result of a combination of factors, not least, the presence of NU-Care on site, which generated the momentum and pre-conditions for change. Although aspects such as amenities and information availability had not, fundamentally, changed at that point, patients were less concerned about them because they were now spending less time in the Department.

Staff views

In a parallel exercise, we sampled the views of service providers at the baseline and six-month stages. Our definition of 'service provider' included staff directly working in A&E, including GPs and other NU-Care staff; the ambulance service, which was in daily contact and; other service providers in and around the hospital environs.

In all, we received 166 responses, of which just under half were from within and around the Department, and half, from the ambulance service. The main issues addressed by the questionnaire were how A&E needed to improve and how, or whether, NU-Care had changed their role.

In answering the first question, we offered respondents 16 alternatives for improving A&E, inviting them to tick those they agreed with, plus an option to include their own suggestions. All responses at the baseline and six-month stage were tabulated, to identify the most applicable alternatives and to rank them. We also separated out the views of medically qualified doctors, as it became apparent that their perceptions tended to be different. The results of the survey are contained in Table XIV.

Several important insights were gained here, but overall, it is clear that staff felt that priorities had changed during the

intervening six months since the inception of NU-Care. Whereas, in the baseline, respondents felt more nurses and faster response times were needed, and efficiency needed improving and so on, after six months, the priority areas making the largest percentage gains were better training for staff and more information relevant to the job.

From the last column, which asks whether NU-Care had addressed their concerns, there was agreement that NU-Care had gone some way towards dealing with most of the key issues identified at the baseline stage. They included such aspects as better layout of facilities (64%), improved response times (50%), more support staff (47%), a better deal for patients (47%) and so on.

Interestingly, the belief that increased numbers of nurses were the answer to A&E's problems fell down the rankings and this is almost certainly due to the fact that the Department had become less 'busy' as a result of faster workflow. Clinicians, by contrast, voted for 'more clinicians', which could, of course, be construed as self-interest but, in fact, is probably the main single reason for the improvements seen in response times.

Finally, it is also interesting that, as the service has improved, staff have become more interested in aspects such as training and taking on greater responsibilities. Overall then, we may conclude that NU-Care has had the effect, directly or indirectly, of changing perceptions and priorities of staff about how the Department functions and operates, in many cases for the better. However, not all staff concerns have been addressed, and thus, there is further to go.

Staff were also asked whether NU-Care had changed their job for the better; 30% said it had, 40% said it had remained about the same, 6% said it had become worse and 24% did not know, or did not answer the question. While NU-Care can take a good deal of encouragement from these results, they are only part of the story. On a professional level, there were serious problems with cooperative working between GPs and A&E consultants, as is testified in some of the following comments, as taken from data source 4:

Reactions to NU-Care: some comments

- '*A great opportunity to improve patient care but at the moment it is a great vision not based in reality'*
- '*Some A&E staff feel that their territory has been invaded by NU-Care staff- notes on doors prohibiting entry to NU-Care staff or warning us to tidy up.'*
- '*Made me realize how unwelcome and badly received NU-Care has been by the A&E consultants.'*
- '*As a NU-Care GP who recently resigned I would like to add that for it to be a success NU-Care management and consultants need to work as a team. There is very poor communication. There is no floor management.'*

Table XIV: Staff views on how A&E services could be improved, at the baseline and six-month stages. Data source, 4.

	Subject of change in A&E	Baseline All (A)	Clinicians	After six months All (B)	Clinicians	B–A	% whose concerns NU-Care has addressed
1	More nurses	12.3	9.1	6.1	4.7	-6.2	29
2	Faster response times	9.5	6.5	8.7	8.2	-0.8	50
3	Better communications	8.4	7.8	7.4	7.1	-1.0	41
4	More efficiency	7.7	9.1	4.8	4.7	-2.9	9
5	More clinicians	7.1	11.7	5.2	5.9	-1.9	25
6	More support staff	7.1	6.5	6.5	5.9	-0.6	47
7	Better deal for patients	6.7	5.2	7.4	8.2	0.7	47
8	Friendlier staff attitudes	6.1	3.9	4.8	4.7	-1.3	27
9	Less time wasted	5.9	9.1	5.2	4.7	-0.7	25
10	Greater clarity of roles and responsibilities	5.7	2.6	5.2	4.7	-0.5	42
11	More privacy	5.4	6.5	5.7	7.1	0.3	31
12	Better training for staff	3.9	2.6	7.8	9.4	3.9	11
13	Better layout of facilities	3.8	9.1	4.8	4.7	1.0	64
14	More information relevant to your job	3.4	1.3	7.4	7.1	4	12
15	Clearer management structure	3.4	3.9	4.3	4.7	0.9	20
16	More responsibility to take decisions	2.6	2.6	7.4	5.9	4.8	24
17	Other	0.8	2.6	1.3	2.4	0.5	33
	Total	100	100	100	100		

Conclusions

In conclusion, we found that, as well as improving the patient experience, NU-Care has received partial endorsement from staff, in the sense that it had started to address several long-standing problems and for most staff, had either improved their job or not changed it. On the crucial issues of senior professional clinicians being able to work together, it has demonstrably not been a success and, clearly, this is a threat to the consolidation of the important gains made to date. From an evaluation standpoint, this would be a great pity, because patients have obviously benefited greatly and there are now clearer directions, in terms of service development. Thus, a key observation from this analysis is that it appears to be easier to improve patients' perceptions than to improve staff perceptions, and this should be considered in any future redesign of processes.

Section 6: CAS computer decision support software evaluation

Introduction

In this section, we report on the evaluation of the NHS CAS. This computer-based clinical decision support system was introduced into NU-Care to empower junior nurses, either to discharge patients directly, by offering them self-care advice, or to refer patients to an appropriate clinician for further assessment, examination and treatment within a safe time interval. An important distinction must be noted here – the system was not designed to diagnose but to assess risk associated with the symptoms presented.

Aside from its use in NHSD, as a telephone-based advice service, the system was also established in walk-in-centres to support nurse practitioners in face-to-face settings (although it was designed, primarily, for telephone use). It was the placement in walk-in centres that originally led the Nu-Care project team to select CAS for the NU-Care experiment. A face-to-face version of the software is believed to be in development, but was not available at any time while the NU-Care project was running.

The system was employed within NU-Care, as follows. A receptionist was assigned to note personal details of the patient and search the database for previous records, and the information was then electronically passed to the nurse or paramedic. The nurse or paramedic would then take sufficient history of the presenting complaint to direct the selection of the most appropriate algorithm. The CAS system worked independently of the patient information system in A&E although the long term aim was to integrate them.

The purpose of the algorithm is to elicit answers to a range of questions that would identify or exclude life-threatening conditions, through a decreasing range of priority to minimal risk. Each question is answered, yes or no. If 'yes' is selected, an outcome or disposition and time frame is provided in which a patient should be seen by another clinician. If 'no' is answered to all questions, the final disposition is likely to be self-care, thus, enabling the user to discharge the patient with advice only. The system then stores the dialogue. A report can be printed out and sent to the patient's GP.

In Nu-Care, both assessing nurses and paramedics eventually gained the authority to discharge patients after a CAS assessment; however, paramedics are required to discuss with a doctor or nurse practitioner all patients for whom a self-care disposition was the outcome recommended by CAS, before discharging the patient. In total, nine computer terminals were placed in the reception area, the nurse assessment room (triage area) and some of the consulting areas. At least twelve terminals were needed for the project so that there were enough to provide flexibility, depending on which areas were free, but the cost could not be justified within the budget. Each nurse and paramedic undertook a training period of five days, followed by a period of precepted consultations, until the individual was classed as competent.

The personal and demographic details of all ambulatory patients were entered into the A&E system, whereas only those deemed suitable for CAS assessment were entered into the CAS system. In principle, CAS suitability was determined by a manual algorithm, based on a series of simple questions asked by the receptionist. Primarily, this distinguished the minor illness patients (streamed into CAS assessment), from the minor injury and potential Majors. Thus, inevitably, there was some duplicated effort in the way the system was set up.

The system was scheduled for delivery in February 2002, so that it would be fully operational and in use by the beginning of April 2002. However, only three terminals were installed, two months late and after NU-Care had been launched, and a further six terminals were not installed until June. The supplier failed to provide any support for the product, in terms of initial assistance for staff in the Department, and so, all necessary training was provided by NHSD. This was not completed until September and clinical approval for the use of CAS for discharge purposes was not given until January 2003. Thus, the CAS experiment staggered into life over a much more protracted period than had been envisaged.

Method and findings

Our aim was to understand the pattern of treatment during out-of-hours' periods, to judge the effectiveness of CAS. We considered not only the use of CAS in particular cases, but also, (by using expert clinical judgement in reviewing the case notes) we assessed whether it would have been appropriate to use CAS for other cases. The criteria for this judgement was whether the likely disposition was self-care, or referral to a 24-hour GP service or to a community pharmacist for advice on symptom management.

We also considered the use of CAS in relation to the working patterns for particular clinicians to see if they were more or less conducive to the operation of CAS generating a large enough pool of patients. Finally, we were concerned to see who authorised discharges, whether that was achieved using CAS alone, or CAS in conjunction with a clinician, or solely by a clinician.

Focus was placed on the 'out-of-hours' periods, when NU-Care was operative and, in particular, on ambulatory patients, for whom CAS was intended. Using the patient information system, 566 cases were sampled, inclusively, between 25 February and 2 March 2003, of which, 331 related to ambulatory patients who were seen out-of-hours. Details obtained for each patient included demographic information, time of arrival and departure, clinical information relating to each patient, the grade of the clinicians treating each patient, whether any tests were undertaken and the complexity of the intervention, and which grade of clinician discharged the patient[19]. The whole dataset was assembled and checked by a qualified clinician.

The views and comments of staff who had received training on CAS were sampled concurrently, and their subsequent experiences in using the system were recorded. We sampled 15 people who had been trained on CAS and were working in A&E. They were mainly female, Registered General Nurses or nurse practitioners of middle age. Of the sample, there was one daily user, five weekly users and the remainder were occasional users. The following sections record our findings.

We begin with an analysis of patient's records, covering both the use of CAS and the general pattern of work in the Department. A&E staffing levels for 'out-of-hours' were split into weekday and weekends. In terms of clinicians working a typical weekday, on average, there were 0.33 whole time-equivalent consultants, 2.5–3 junior A&E doctors, 0.5 GPs, and less than 0.5 PCNP and ENPs on duty. By contrast, at weekends, when NU-Care was operative over a 24-hour period, there were 0.5 consultants, 4 SHOs, and 1 GP, and so the mix was slightly different.

Patterns of Activity

• *Clinician interventions*

There were clear patterns of clinician engagement and interventions. For example, we found that consultants rarely engaged directly in the treatment and diagnosis of ambulatory patients, having a recorded involvement in only 1.8% of cases in the medical notes. We found that junior A&E doctors treated 30.8% of cases; GPs, 18.4%; ENPs or PCNPs, 10.9% and; specialists, 8.2%. However, a further 17.5% were treated by both a junior A&E doctor and a specialist, compared with 2.7%, by a GP and a specialist; 5.4% absconded before being seen or completing treatment. Other combinations accounted for only 4.3% of the total.

The small overlap between GPs, A&E doctors and specialists suggests that streaming had been effective at this level; however, the high proportion of patients seen by clinicians, all of whom had the authority to discharge, inevitably limited the pool of patients that were, or should have been, routed through CAS. For example, only 0.6% of cases were given a CAS assessment, 1.2% of cases were CAS assessed and seen by a GP, and 0.3% of cases were CAS assessed and seen by an A&E doctor.

Overall, we found that CAS was used in only 2.4% of cases, but CAS was actually deemed suitable for use on 17% of cases, based on medical notes and independent clinical judgement. These were defined as cases that were between one year and 75 years old, whose presenting complaint was minor and who were discharged, having had no urgent investigations, only advice or guidance to buy 'over-the-counter' medicines. To summarize from a discharge perspective, we found that CAS was responsible for only 0.5% of discharges, whereas junior A&E doctors discharged 39%; GPs, 30.5%; ENP or PCNPs, 17.2%; specialists, 9.0%; and other, 3.9%.

• *Tests and procedures*

The clinicians' behaviour in the commissioning and use of different tests and procedures, as well as the severity of the condition of the patient, is a factor that influences patterns of work and the consumption of resources. A&E doctors were found to commission tests at an average rate of one per patient; GPs, one every two patients and similarly, for ENP and PCNPs. Of the ambulatory patients seen by A&E doctors and PCNP/ENPs, 12.9% and 13.7%, respectively, required 'complex' interventions, by comparison to 8.7% of GP-seen patients. We found that 68% of patients were treated with simple interventions, 19% with complex interventions, 49% were administered drugs in the Department and 34% were given prescriptions.

These patterns contrast with the CAS-assessed patients, where, of the patients seen, only three diagnostic tests were subsequently carried out and only one intervention was performed. By any standard, this was a disappointing result. Thus, we conclude that the overall contribution of CAS, in clinical terms, was negligible to non-existent for the vast majority of cases.

• *Economic evaluation*

Because of the low level of CAS use, a fairer comparison is to base the economic evaluation on how it was intended to be used, rather than how it was actually used, given a fully trained complement of users. The annual cost of CAS was £98 000, before any training costs were taken into account; the average number of ambulatory out-of-hours patients is almost 100 per day, of which, it is assumed that 17% are suitable for CAS assessment (discussed previously). This gives a figure of approximately £15.8 per assessment, excluding staff costs.

We know from previous analysis that a GP sees, on average, two patients an hour, to the nearest whole number. We can assume that the cost of a GP is approximately £50 per hour, or £25 per case, whereas the cost of a CAS assessment nurse is £15 per hour (£7.50 per case). Using these figures, the total cost of a CAS consultation carried out by a CAS assessment nurse is, therefore, around £23.30 per case, before any further clinician opinion or intervention. At best, the system is, thus, borderline compared with a GP but only if a consultation leads to a discharge, which, looking at this sample of cases, is clearly the exception, rather than the rule.

If the evaluation were to be extended to 'all hours' on a similar basis to before, the cost per consultation would fall to around £15 per case at optimum levels of usage, which would be more acceptable; however, this figure still does not include the cost of a second opinion. It is not possible to give an exact 'breakeven figure', but it is unlikely to be above £10 per case, which might still be regarded as too great for a commercial software tool. Thus, we conclude that the system is uneconomic in its present form and rate of use, and does not provide value for money in any realistic scenario. Caution should be employed here, however, as this conclusion ignores the fact that a nurse and CAS might be easier to employ than a GP, so there could be some

potential hidden costs. However, this appeared not to be the case in this instance.

Staff views on CAS

The rate of usage of CAS was clearly extremely low, relative to the workflow and in terms of the patients that appeared, from case notes, to be suitable for CAS assessment. But was this a failure of the system, itself, or a failure of the NU-Care project to integrate it into the Department? Staff comments clearly highlighted what they saw as the main problems. The most frequent complaints were that CAS did not integrate into the workflow, there was uncertainty about when to use it, given that clinicians would review the patients anyway, the system was too slow and detailed, and the level of disposition recommended for patients was too high. However, a secondary issue, which was possibly the fault of the project, was that access to CAS was difficult, in terms of physical location and other competing uses for the terminal space.

Comments about CAS

- *'CAS takes too long to do if you are assessing and treating a patient. The time needed for a CAS assessment is not appropriate in an A&E department'.*
- *'I am sure that CAS is suitable and safe in an environment where the clinician cannot see the patient. However, in A&E, it is too longwinded and robs those using it of their skills and common sense'.*
- *'There is an awareness that no doctor is going to read what is produced so why bother in the first place? There is no pressure to use CAS'.*
- *'CAS adds no value as patients have to see another doctor anyway. Patients do not like to be asked the same questions twice, which happens with CAS'.*
- *'A nurse practitioner needs to take a succinct history and record what IS the matter with the patient. CAS makes you ask a list of things that the patient has NOT got'.*
- *'As a telephone advice system CAS may be OK but as a face to face tool it is a pointless exercise when the patient will have to be seen by another clinician anyway'.*
- *'It produces too much paper that no one wants to read and not only this the SHO's have no idea about what it is'.*
- *'……you don't want to use a system to produce information no one wants! Also if you can't discharge a patient without getting a second opinion from a doctor they might as well have seen the doctor first of all ….completely unsuitable for any injury or multiple symptoms or complaints*
- *'CAS has been a huge waste of money, there are far superior decision support tools on the market. How CAS could have been successful in a procurement process is beyond me'.*

Conclusions

There is no doubt that CAS has been the weakest part of the NU-Care project. While the CAS experiment does not invalidate the concept of using computer decision support software for assisting safe assessment, diagnosis and treatment in face-to-face settings, it is clear that this particular system is unlikely to ever be beneficial. In face-to-face situations, nurses are able to use all of their senses to assess, diagnose and treat patients, so it seems certain that there will be an element of redundancy in a system that was primarily designed for telephone usage. Although face-to-face versions were in development at the time of the NU-care project, none materialised in time to avert the failure of this experiment.

A recurring comment was that the system did not represent value for money. The above analysis confirms that view. Nevertheless, the reasons for failure were not limited the system, itself, but also its selection and implementation. The equipment was delivered late, and the project team did not receive the necessary support from the supplier. As the foregoing analysis demonstrates, the delays did not have an effect on the final verdict, in the sense that the product was clearly unfit for the purpose. However, with appropriate cooperation from the suppliers, it might have been possible to establish this at a much earlier stage, saving much expense and time.

However, it is also true that the vast majority of patients were seen and discharged by clinicians, for whom CAS was not intended. Moreover, the pool of patients that was routed through CAS was much smaller than the theoretical limit, which was around 17% of all out-of-hours ambulatory patients. If such an experiment were to be repeated, more attention would need to be focused on its integration within the system, taking into account the number and mix of clinicians working within the Department, and providing clear instructions to staff of the nature of the experiment and its aims. A future version, for example, might require patients to complete CAS, using a touch-screen computer, while waiting for pre-assessment. Finally, clear methods of separating and routing patients into appropriate streams must be outlined, if each element in an A&E system is to fulfil its potential.

Section 7: Summary of conclusions

The NU-Care project evaluation has been detailed and exhaustive. Inevitably, despite all best intentions, there remain some gaps, omissions and differences of interpretation. However, it has been possible to reach more or less definitive conclusions on each of the evaluation criteria that are listed in section one, each of which is now considered in turn.

Workflow and response times

Since the launch of NU-Care, there have been highly significant improvements in completion times and, by the end of March 2003, completion times were comparable to national targets. When the project began, they were more than double the required level. The improvements achieved have not been confined to the out-of-hours service and have generally affected all patient categories approximately equally. This is not entirely surprising because it was a likely result of the co-location of NU-Care within A&E and the registering of all patients within one system.

A detailed analysis of routinely produced information indicates that there have been significant changes in workflow during the evaluation period. There has been a substantial increase in throughput, together with the reductions in completion times, and evidence suggests that these effects are interconnected. The improvements that were achieved in March 2003 alone, were driven more by the imperative to achieve the national target for accountability purposes than by the efforts of NU-Care, as such. However, it is interesting to note that the previous trend was resumed in April and May 2003.

The overall improvements seen were the result of a combination of factors, primarily, the deployment of more staff and a better match with demand patterns, rather than fundamental changes in procedures or processes. Many suggestions were made during the project, regarding how individual processes could be streamlined or changed, but instigating changes in the organization or suggesting the conduction of sustained and fair trials of new methods was a significant impediment and frustration to the NU-Care team. This much was clear from the evaluation.

One important change for which NU-Care can take credit, has been to instill the management discipline of routinely analysing data, checking its quality, monitoring performance and using the available evidence to drive decisions. This has been a significant gain, in the sense that management are now better able to spot and rectify difficulties, as demonstrated in the way staff are deployed and used, how to analyse information and to maintain and improve its quality.

Another impediment is the patient information system, which operates retrospectively and tends to service the needs of the Trust, rather than those of the A&E Department. It is clumsy, and so not used consistently. Staff prefer to use paper records, and, hence, destinations and dispositions are entered retrospectively. Staff choose not to use the software to its full potential because there it is of little perceived benefit to them. It cannot, for example, deliver information for real-time patient tracking, prospective waiting times, blockages or delays, the status of tests and so on.

With the exception of registration, all information is collected and entered manually at a later stage, usually long after patients have left the Department. As our evaluation illustrated, this was also a source of human error, particularly in terms of recorded departure times, which had to be estimated when patients' notes went missing. In short, the system is a management tool rather than something that will improve the patient experience.

This criticism, of course, is a general one and is not specific to this hospital or Trust. NHS management information systems have a reputation of being expensive and hard to use. In this case, we believe it is something that could be solved quickly, for example, using a simple bar coding system and swipe pen, to monitor and track patients through the system. Not only would recorded times be more accurate, but management would have an instantaneous picture of where queues were stacking up and would be able to advise staff and patients accordingly.

Patient satisfaction

The harrowing patients' comments obtained in the baseline survey and presented in section 5 bear testimony to the parlous state into which the service at Northwick Park had fallen before NU-Care. Almost without exception, all of these comments were supported by copious statistical data, which confirmed their stories about excessive waits to see clinicians, unreasonable waits for triage, overcrowding and the failure to keep patients informed. Some of these problems were inherent in the organization and management of A&E and were due, for example, to lack of resources and competing needs from elsewhere in the Trust.

It is particularly interesting that patients' views and attitudes were consistent with all other analyses. Furthermore, it was also true that the patients seem to have a clearer picture of the problems in A&E and where improvements were urgently needed. At no time did we gain the impression that staff had the same overview and this is probably because they only ever saw their particular part of the process. By the six-month stage, it was clear that the patient experience had improved enormously and that this was the result of a combination of factors. NU-Care is partly responsible for this; indeed, it is doubtful that change on this scale would have occurred in the absence of NU-Care.

Between the baseline and six-month stages, the proportion of patients that were very satisfied, for example, doubled from around 22% to over 46% for both Majors and Minors, while the proportion that were dissatisfied declined from 12.4% to 4.1%. This is a remarkable improvement but there must be a word of caution here. Current levels of satisfaction continue to fall short of the satisfaction levels achieved by the existing out-of-hours Harmoni service, which scored 76% on an equivalent basis. However, comparisons between the two services are arguably

unfair, but they do show how far A&E has come and, also, how far it should aspire to go.

Staff endorsement

The specific criterion was that staff should adapt successfully to the new arrangements. This included being able to work side-by-side with colleagues who are not A&E specialists but are drawn, predominantly, from primary care and the London Ambulance Service. Prior to NU-Care, the A&E Department at Northwick Park was being carried by the hard work of the clinical and support staff in difficult circumstances and under critical external scrutiny. In this context, it is clear that the NU-Care project could have appeared to be very threatening, as it questioned the very people that held the service together.

As section 5 shows, when staff were asked their views on NU-Care, the results were generally positive and there was a fair consensus, in terms of priorities. Furthermore, as the project proceeded, priorities seemed to change in a logical way so that, by the six-month stage, several key issues had been addressed and others had emerged. Thus, it seems that the improvements were being recognized by some staff at least as well as patients, and the evidence supports this conclusion.

As the project developed, it became apparent that there were serious differences in approach and style between senior A&E clinicians and the NU-Care project. Despite efforts to remove the differences, they simmered and grew. This manifested itself in different ways. One example was the evidence of benefits to response times that were seen by streaming patients as they arrived at A&E. No clinical risk was posed in the pilots, but the streaming process was consistently blocked by the A&E consultants and remains deficient today. Our conclusion is that no initiative, such as NU-Care, will ever be given a fair trial if the goal posts are constantly shifted and project disciplines break down.

From a patient's viewpoint, it must seem extraordinary that professional and dedicated people could not find ways to overcome their differences and work together. The most likely reason for the disfunctioning is that all staff concerned with the project failed to recognize that the vision and direction of development agreed from the outset was interpreted differently by different people. With the benefit of hindsight, this could have been tested and worked on from inception, with a much clearer definition of how different procedures would be tested and trialled, more clarity around management issues, and roles and responsibilities. The extent of the problem emerged only after it was too late to remedy the situation.

An alternative thesis, and one with substantial implications for any attempts to remodel A&E, would be to accept that the basic philosophical approaches to emergency medicine and primary care medicine are different – evolving, quite logically, from the differing patient demands. Such an interpretation might conclude that trying to merge these approaches into a singular model is bound to result in conflict. Consequently, it might conclude that the only way to avoid this in future would be to run the different approaches in cooperation, but separate and in parallel, with a single gateway and a seamless transferability of patients between the two without patients having to join a new queue. A possible new NU-Care model would not be part of A&E, but would be adjoining it, and run as a primary care-oriented provider.

Cost neutrality

There are several ways to test 'cost neutrality'. The first is to consider only expenditure. This would show that the ongoing costs of NU-Care, were it to continue in its present form, are around £0.9m a year. This figure includes the cost of the CAS system, telecommunications, training and other apportioned costs. The direct staffing costs, however, are £0.65m and this is likely to be a more realistic cost, as CAS has now been discontinued, based on the findings detailed in this report. These costs are additional to the A&E Department's budget, financed by the Trust, and so a sustainable budget to provide current levels would need to be at least £0.65m a year more, or in total, approximately £5.65m a year. This assumes the same NU-Care model design, based on a mixed team of primary care and A&E clinicians.

However, the analysis changes if increases in throughput are factored in. For example, the numbers of patients seen in A&E in March 2003 was 17.9% higher than in March 2002, for roughly a 12.8% increase in expenditure. If this level of throughput is sustained, it would represent a 4% increase in efficiency or roughly £3 less per patient seen. In other words, based on 2002/3 figures, the comparable budget at the new levels of throughput would have to be about £5.89m and, thus, an annual budget of £5.65m could be seen as good value, based on these assumptions.

The above calculations do not account for any changes in the quality of service or possible changes in efficiency due to changed procedures. Quality changes primarily arise from two sources: reductions in completion times and reduced numbers of absconders. In section 2, we placed an annual value on time-saving of around £1.4m a year, based on the minimum hourly wage and assuming current levels of throughput. The absconder rate, meanwhile, fell from around 8.4% in March 2003 to 2.4% in March 2004. It is interesting to note that if the March 2003 rate had applied to throughput levels in 2002/3, ~4000 more patients would have completed their treatments than if the March 2002 rate had applied. Obviously, it is as difficult to place a financial value on this, as it is to place a financial value on the substantial improvements seen in patient satisfaction. Nevertheless, it must be judged as significant, in terms of the overall evaluation.

The wider test of cost neutrality entails the inclusion of adjustments elsewhere in the health economy. As section 4 argued, the major changes that occurred were the result of increased hospital admissions and were not directly related to NU-Care, as such. These changes have put increased pressures on existing budgets, which, presumably, have been absorbed elsewhere in the Trust through greater efficiencies or longer waiting lists. The exact effects, however, are outside the scope of this evaluation. We have been unable to ascertain views on the

indirect effects of NU-Care on other local health providers, including GPs, but we believe these are likely to have been small, for the reasons given in section 4.

If the case for extra resources is accepted, a debate must ensue about whether staff should have a primary care or an A&E background. The results of this evaluation show that the primary care team was relatively effective, in terms of productivity. They also referred patients less frequently to specialist colleagues and tended to be more conservative with regard to commissioning tests – both of which add to delays and, therefore, cost. Their contribution also appeared to have no impact on the increased likelihood of repeat visits. However, this was not a randomized controlled trial and it cannot be confirmed that an equivalent result would be obtained using only A&E qualified staff.

Computerised decision support system

The original aims of CAS were, essentially, to: improve the quality and consistency of care; cut down on long waits; extend the range of personnel that could see and discharge patients; improve patient satisfaction; and improve efficiency by having to make fewer referrals. CAS failed on all counts, although primarily for reasons outside of the project team's control. It was let down by the supplier, the system delivered was inappropriate for face-to-face consultations, the layout of A&E made it difficult to generate sufficient usage to make it cost-effective, and users strongly disapproved of various aspects of the software. As a result, their ability to discharge any patients on the basis of a CAS assessment was heavily circumscribed.

The process for streaming patients to CAS was never fully tested, and the system received a lukewarm reception from consultants, meaning that there was never any realistic chance of success. Thus, subsidiary aims, such as facilitating electronic patient record and information transfer were also never tested. The fact that there were fewer referrals or 'hand-offs' was mainly due to the influence of GPs working in NU-Care and had nothing to do with CAS, as such. Thus, the overall verdict is an extremely negative one and so, what lessons have been learned?

The system itself was very expensive, but this alone does not invalidate the use of computer-based decision tools and many are already in use elsewhere in the health economy. The first lesson is that the system needs to be fit for purpose and this system plainly was not. Greater pre-testing should have made this apparent. The second is that the experiment needed to be set up in such a way so that it could have a realistic chance of success in an environment for which it was intended. A fair trial would require a stronger commitment towards streaming from management, more structure, in terms of procedures and protocols about the scope of CAS, and finally, greater commitment from senior clinicians to allow the experiment to proceed. However, even if such project-specific factors are disregarded, this system is currently not suitable for use in an A&E environment.

Final verdict

Our overall verdict is that NU-Care has been extremely beneficial for patients and that the improvements seen would not have occurred without the focus and resources founded by NU-Care. Many of the improvements that took place were acknowledged by staff as well as patients, indicating that, despite professional differences, the principles were basically sound.

Difficulties arose because of flaws in the overall operation of the A&E Department that were obvious, even to patients, were not properly addressed or acknowledged. These arose at various points in the process, from registration through to streaming, tests and treatments, to discharge and admission, and indeed the question of who exactly is empowered to discharge, admit, stream and order tests. However, despite the evidence in this evaluation, there still appear to be substantial difficulties regarding changing routines and in obtaining the cooperation of staff with different professional backgrounds, at least in this environment.

At the level of the local health economy, there is a broader question about whether NU-Care principles should be extended to all hours, instead of simply 'out-of-hours'. This evaluation found that that the presenting symptoms of patients are generally similar during the day and evening, and therefore, a case could be made for this. However, this might create perverse incentives and encourage inappropriate use of the NHS, although this would need to be confirmed.

Patients clearly like the idea of a 'one-stop shop', so the concept of establishing a primary care practice in the hospital that could switch to an integrated out-of-hours service in the evenings and at weekends would seem to satisfy patient wishes. Perhaps, the key question requiring further study is whether the NU-Care model of merging primary and emergency care practice to meet patient need is possible or not. If it is possible, the model must be underpinned by sound medical justification, and accepted by patients**.** The evidence obtained from NU-Care suggests that patients are more likely than the system is to respond positively and more quickly to change.

Achievement of objectives

1. Response times – NU-Care delivered its objectives
2. Patient satisfaction – NU-Care delivered its objectives
3. Staff endorsement – NU-Care only partially delivered its objectives
4. Cost neutrality – NU-Care delivered its objectives
5. CAS – NU-Care failed to deliver its objectives

Annex A

Representing workflow as a queuing process

Part of the NU-Care project involved a detailed examination of patient flows, particularly the relationship between patient flows, resources, use of waiting areas and completion times. In mathematical terms, A&E workflow in an A&E department is a classic example of a queuing process - patients arrive, are treated and then leave.

In theory, a queuing model can help illuminate the relationship between resources and waiting times, provide a method for understanding and monitoring performance, identify bottlenecks, and be used as a general planning tool for estimating floor space and other requirements. In practice it might only be possible to do some of these things because of data and other limitations.

Queuing models vary in complexity, according to the arrival pattern, the order in which patients are treated, the existence of parallel or sub-queues (e.g. for X-rays or blood tests, and so on). Our aim, however, is to produce a simpler and more general framework that can be used by non-mathematicians in a range of A&E departments as a management tool for monitoring and managing performance.

One of the features of queues that is often surprising is the speed with which they can get out of control because there are too few resources to deal with them or they are being managed badly. Queuing theory shows that there is a narrow safety margin between queues that are under control and those that are not. The lesson from NU-Care is that queues can be brought under control and waiting times reduced with appropriate organisational and management strategies.

The first simplification is to imagine the workflow as a series of stages. These stages could include initial clinical assessment, diagnostic tests, including treatment, and then eventual discharge. In practice, we know that some patients experience only one stage and others, more than one. What constitutes a 'stage', however, is not always clear, because each can often be broken down into several sub-stages so that the point at which each begins and ends is blurred.

In this research, we found that there is a key difference between patients who are discharged home and those who are admitted as an inpatient or referred. This suggests a mathematical model with two queues or streams arranged in parallel. One stream, those discharged home, has one 'stage' and those admitted or referred, two 'stages'.

We found that splitting the queues in to further streams with different numbers of stages improved the statistical goodness of fit only slightly. A feature of this approach, therefore, is that we infer the number of stages and the workflow characteristics through consideration of the aggregate distribution properties of the data.

This method was, for example, successfully employed in an application to social security queues[20] – the main difference is that social security deals with benefits and an A&E department, with patients. Note that it is possible that two different queuing models, making slightly different assumptions, could provide equally good 'fits' to the data. Thus, we make no claims that this is the most accurate and most general model that exists, or that it correctly represents every aspect of the queuing process. The following sections describe the model in detail and the empirical fitting of the model to data.

The model

We consider a queuing model of the type in which there is one or more stages through which patients pass before they are discharged from A&E (Figure A1).

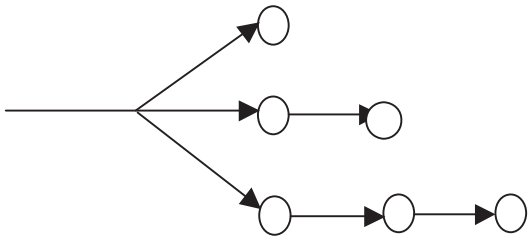

Figure A1: Depiction of a queuing system with different sub-queues and stages

Patients arrive and are, initially, sorted into queues, depending on the severity of their condition. The number of stages that patients pass through will depend not only on severity but also on standard clinical protocols, depending on the presenting symptoms. Some patients, 'absconders', leave before being seen or treated.

Over a period of time, workflows tend to follow a pattern and are quite stable features of the system. For example, the proportion of patients who are discharged home is in the order of 60% and those admitted or referred, around 40%. Up to 0.5% are dead on arrival or die in the Department.

Consider the total time spent in the Department by a patient and make two further simplifying assumptions: (i) the average time spent in each stage is the same; (ii) arrivals are random with inter-arrival times specified by a Poisson process. The probability of the total time spent in A&E equalling z may be considered to be the sum of s random variables, as follows:

$$z = \tau_1 + \tau_2 + \tau_3 ..... + \tau_s$$

Assume that the system is characterized by an exponentially distributed arrival rate with a parameter λ and exponentially distributed service times at each stage μ. The probability density function of z can be shown to be:

$$p(z) = \frac{z^{s-1}(\mu-\lambda)^s \exp(-z(\mu-\lambda))}{(s-1)!}$$

This is when the queue has reached a stable state, but if $\lambda > \mu$, the queue is unstable and grows indefinitely. Our main interest is average completion times and the distribution around the average for stable queues, therefore, we might write this equation more conveniently, in terms of t, the average completion time t.

$$p(z) = \frac{(\frac{zs}{t})^s \exp(\frac{-zs}{t})}{z(s-1)!}$$

$$\text{where } t = \frac{s}{\mu-\lambda}.$$

This p.d.f. has the cumulative distribution function:

$$P(z) = 1 - \exp(\frac{-zs}{t}) \sum_{i=0}^{i=s-1} \left(\frac{zs}{t}\right)^i / i!$$

Figure A2 shows the probability of different completion times, based on models with sequential numbers of stages (1, 2, 3…7) and completion time averages (1, 2, 3, …7 hours). For example, the curve furthest to the left is a one-stage model with a completion average of one hour, and the curve furthest to the right is a seven-stage model, with a completion average of seven hours. As can be seen, the model can deal with a widespread range of possible queuing behaviour. The empirical issue is to determine the appropriate number of stages by fitting the theoretical distribution to actual distributions of completion times and known averages. Before we do that, however, we need to consider how the information produced by the model will be used.

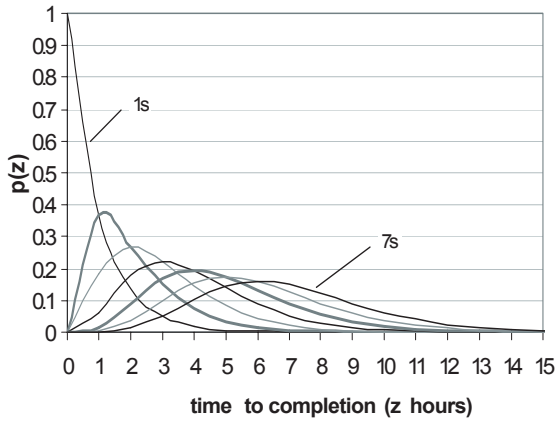

Figure A2: Distributions of completion times, based on different completion averages and numbers of stages.

Ready-reckoners

It has become custom and practice to express completion time targets, not as averages but as the percentage of patients to be completed in a given time. For example, the national standard in emergency care in March 2003 was 90% in four hours. This specification has an obvious attraction over averages because averages are sensitive to extremely long waits or completion times.

We, therefore, need a convenient method of moving between averages and distributions. An example would be one that links the target of *x%* clearance in *y* hours to an average *t,* or which relates the average t to the work still outstanding after a given time *z* in the system.

Consider a simple case in which there is only one stage (s = 1). The average completion time can be shown to be related to the cumulative distribution around the average by:

$$t = \frac{-z}{\ln(1-P(z))}$$

We may plot this equation for different values of t and z to obtain the result in Figure A3, which we term a ready-reckoner. By reading off the average (follow direction of arrow), we can determine the time taken to clear a given percentage of cases. In this example, a four-hour average equates to 70% of completions in just less than five hours.

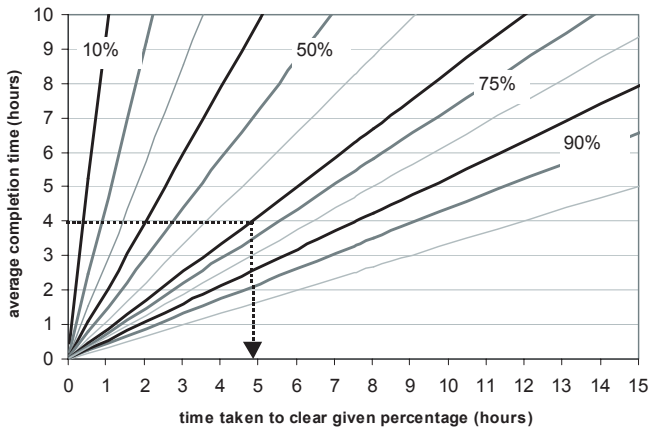

Figure A3: A ready-reckoner for a queuing system with one stage (s=1).

Although this ready-reckoner achieves its purpose, it is inaccurate to the extent that it represents only one of several possible sub-queues with different numbers of stages. In a typical day, only the number of patients is counted, not the numbers of stages they pass through. Therefore, when we observe the completion time distribution for all patients, we are really observing the aggregate effects of several queues conflated within one completion time distribution.

Thus, we need a model of a form that is a weighted probability distribution in which the

weights represent the proportion of patients in each queue. If there are two parallel queues, one with one stage and the other with two, the composite or hybrid probability distribution will be as follows:

$$P_c = pP_1(z) + (1-p)P_2(z)$$

To characterize and identify the correct distribution, we need to determine, first, how many processing stages are implicit in an observed distribution of completion times, and second, the value of the weights (in this case, *p* and *1-p*). We adopted the following simple procedure. Using the observed cumulative distribution of completion times and actual average completion time, we compared the predicted distribution, obtained by systematically varying the set of weights for a one-,two- and three-stage model. We then plotted the observed and predicted values to see how closely they matched over the z-range. A sample of the results is shown in Figure A4.

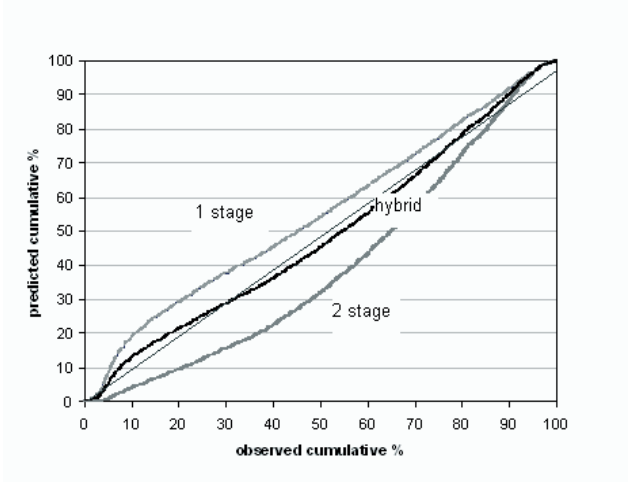

Figure A4: Comparison of the quality of fit as generated by a one-stage, two-stage and hybrid model. The best 'fit' is the hybrid model with 60% of flows through a one-stage queue and 40% with a two-stage queuing model. Perfect agreement would be represented by the diagonal line.

By experimentation, we found that the best results from this model are obtained using two queues in parallel with 60% of flows through a one-stage queue and 40% through a two-stage queue. It transpires that these weights are almost identical to actual percentage flows of patients, categorised into those discharged home and those admitted or referred. This model is labelled 'hybrid' in Figure A4 and the closeness of the fit to the diagonal line is an indication of how well the model fits the data.

If we plot the actual data and the predicted completion times, according to their relative frequency, we obtain the results that are shown in Figure A5, which is taken from completion times of over 6000 A&E patients in June 2002. The results indicate a reasonably good fit over the range, although the quality of fit is poorer in the 1–2 hour range. This difference, an over-estimate of up to one hour and an under estimate between one and two hours, is due to the 'triage' bottleneck, which patients must pass through, post registration.

Accepting that this was likely to be the best possible representation using this model, we recalculated the ready-reckoner, accordingly, using the hybrid model deriving two variants, which represent two sets of solutions to the equation.

$$P_c = pP_1(z) + (1-p)P_2(z)$$

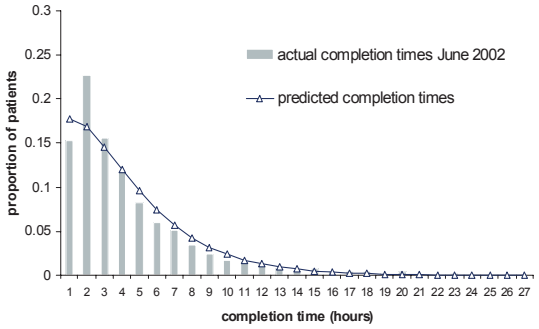

Figure A5: Comparison of observed and predicted completions times, based on hybrid model and June 2002 data.

The first variant establishes, for a given average completion time, the time taken to complete a given percentage of patients. The second variant establishes, for a given average completion time, the percentage of patients outstanding after a given time in the A&E Department. The results are shown in Figures A6 and A7.

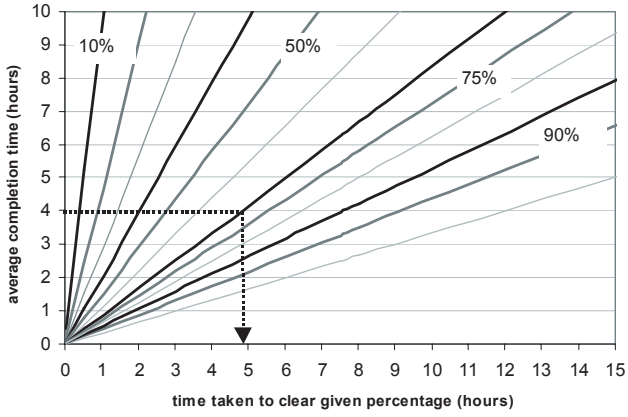

Figure A6: The time taken to clear a given percentage of patients, based on the hybrid model.

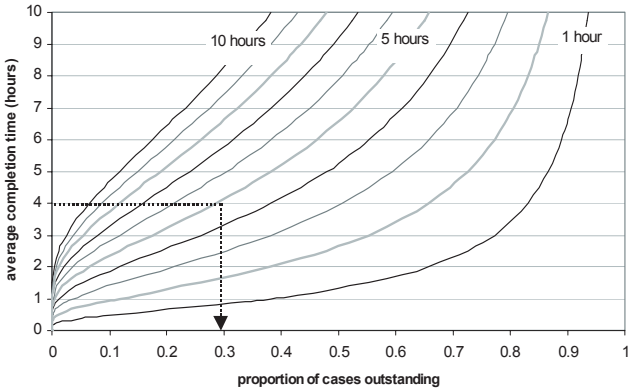

Figure A7: The percentage of cases still outstanding after the given number of hours in A&E, for a given average completion time. The dotted lines indicate the proportion cleared up after waiting one to ten hours, when the average completion time is four hours.

Figure A6 predicts that just over 70% of cases will have been cleared in five hours, whereas Figure A7 predicts that just under 30% will be outstanding after five hours. By comparison with Figure A3, the one-stage model, the time to clear the same percentage is, therefore, similar. Larger differences occur depending on the choice of average and percentile. For example, for a six-hour average, the hybrid model predicts ~2 hours and the one-stage model, ~1.25 hours.

Counting patients in the system

The number of patients in the system at a point in time is a function of the number of patients arriving per unit of time and the time it takes to process patients and discharge them. It is important to know the typical numbers in the system because it helps to determine space needed to process and treat patients, staffing and other requirements, such as beds and equipment. Several examples were given in section 3.

Exact estimates of these parameters are complicated by several features of the A&E environment and workflow pattern. Thus, using queuing models to estimate staffing numbers to produce required completion times is likely to be crude, at best, because management and other factors are more likely to be influential at this level. Simulation techniques are likely to prove more practical for detailed level analysis; however, some generalisations are possible.

From the formula for the average completion time, $t = \frac{s}{\mu - \lambda}$, it can be shown that the average number of patients in the system is $t\lambda$. This is 'Little's' formula and it states that the number of patients in the system is proportional to the arrival rate and completion time. Management has no direct control over the arrival rate or the clinical condition of patients but it does have a degree of control over the completion time. This will depend on the number of staff employed with the authority to discharge patients, and general efficiency considerations relating to management and organization of the Department.

It is not appropriate to estimate space requirements based on an average figure for patients in the system if the waiting areas are subject to periodic overcrowding. Mathematically, for a simple queuing process with one stage, the probability of there being N patients in the system is given by $p_N = \rho^N p_0$. We are more interested, however, in the probability of there being S patients in the system, where S>N. The cumulative probability of there being from 0 to N patients is given by $F_N = (1-\rho^{N+1})$, so that the probability of there being more than N in the system is, hence:

$$F_{S>N} = \rho^{N+1}$$

Using this formula and the relationship, $\rho=\lambda/\mu$, in conjunction with the formula for the completion time, we derive the following types of graph which have proved useful for examining a range of potential over-crowding scenarios within an assumed range of arrival rates and completion times.

The example given in Figure A8 is based on the probability of there being more than 40 patients in the system, which may be considered borderline in terms of crowding. The mean arrival rate is shown on the horizontal axis and the probability on the vertical axis for different values of *t* the completion time. During March 2003, the average arrival rate was 10.4 per hour overall, 14.4 per hour 'in hours' and 6.8 per hour 'out-of-hours', whereas, the average completion time was 2:50 hours. The results demonstrate that the probability of finding more than 40 patients was under 30% overall, 42% during 'in hours' and 20% 'out-of-hours'. At the national target of 2:20 hours and with a typical arrival rate of 10 per hour, the probability of there being more than 40 patients in the system is 20.4%.

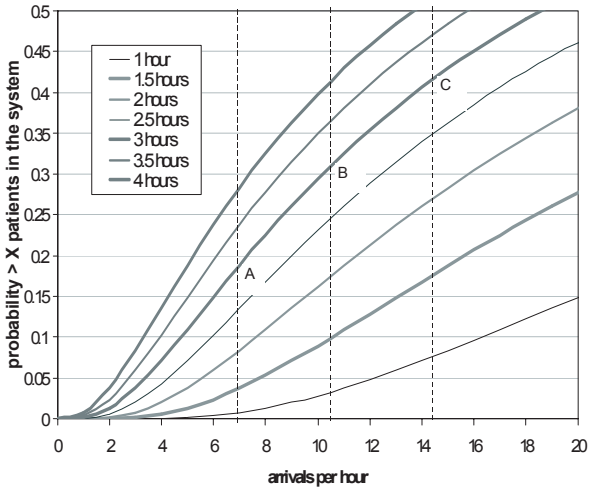

Figure A8: Relationship between patients in the system, arrival rates and completion times, showing the probability of there being more than 40 patients in the system at a point in time, assuming a steady state.

Footnotes and references

[1]The NHS Plan (2000). Command Paper 4818 – 1. The Stationery Office, UK.

[2]Bid for Exemplar Site, p9, paragraph 3.1 and; Raising Standards for Patients, DoH, Oct 2000.

[3]There are many papers on this topic. Recent examples include:

Murphy, A.W. (1998) Inappropriate attenders at accident and emergency departments I: Definition, incidence and reasons for attendance. *Family Practice* 15, 23–32

Sanders, J. (2000) A review of health professional attitudes and patient perceptions on inappropriate accident and emergency attendances: The implications for current minor injury provision in England and Wales. *J. Adv. Nursing* 31, 1097–1005

Carlisle, R. *et al.* (1998) Relationship of out-of-hours activity by general practice and accident and emergency services with deprivation in Nottingham: Longitudinal survey. *Br. Med. J.* 316, 520–3

[4]It is rare for published studies on A&E departments to take a whole-systems approach. For comparison, the reader is referred to the excellent:

Forsyth, G. and Logan, R.F.L. (1960) *Casualty Services in their Setting*, Oxford University Press for Nuffield Provincial Hospitals Fund

[5]Various (2000) *Raising the standards for patients: New partnerships in out-of-hours care*. Department of Health, London

[6]Various (2001) *Reforming Emergency Care.* Department of Health, London

[7]Audit Commission (2001) *Review of national findings: Accident and Emergency*. Audit Commission, London

[8]Northwick Park is one of many A&E centres serving the London area. For a London-wide analysis of the relationship between access and response times, see:

Hyman, G.M. and Mayhew, L.D (1983) On the geometry of emergency medical provision in cities. *Environment and Planning A* 15, 1669–1690

[9]The equation for the fitted line is y=12.095ln(x)-3.29. This produced a value of R^2, the coefficient of explanation of 90%.

[10]This argument is based on a best-fit equation to the data in Figure 6, given by $y=204.89x^{-0.3682}$, where y is expected daily throughput and x is the average completion time (R^2=79.8%). The power parameter in the equation, 0.3682, gives the elasticity of throughput in percentage terms, with respect to small changes in completion times, x. However, if average completion times decrease or increase by a much larger margin, say 50%, throughput rises 30% or falls 14%. To determine the effect of larger changes in x, insert the relevant values in the equation and compare values of y.

[11]NHS Circular EL(97)60, October 1997.

[12]Manchester Triage Group (1997) *Emergency Triage,* BMJ Publishing.

[13]Cooke, M.W. *et al.* (2002) The effect of a separate stream for minor injuries on accident and emergency department waiting times. *Emergency Medicine J.* 19, 28–30.

[14]This figure is an estimate and, almost certainly, an upper bound. See also:

Martin, A. *et al.* (2002) 'Inappropriate' attendance at an accident and emergency department by adults registered in local general practices: how is it related to their use of primary care? *J. Health Serv. Res. Policy* 7, 160–165

[15]Hardy, C. *et al.* (2001) Admission avoidance and early discharge of acute hospital admissions: an accident and emergency-based scheme. *Emergency Med. J.* 18, 435–440; Burns, E. (2001) Older people in accident and emergency departments. *Age And Ageing* 30 (Suppl 3), 3–6

[16]For example, see the following slightly adjacent examples:

van Uden, C.J.T. *et al.* (2003) Use of out-of-hours services: a comparison between two organisations. *Emergency Med. J.* 20, 184–187

Chalder, M. *et al.* (2003) Impact of NHS walk-in centres on the workload of other local healthcare providers: time series analysis. *BMJ (Clinical Research Ed.)* 326, 532

[17]Note that assessing levels of compliance with advice given by other providers is difficult, although available evidence suggests it is high, in the case of NHSD. For example, see:

Foster, J. *et al.* (2003) Do callers to NHS Direct follow the advice to attend an accident and emergency department? *Emergency Med. J.* 20, 285–288

[18]Apart from the issues listed in this section, it is worth noting that the number of official complaints (complaints made in writing, directly to the Chief Executive of the hospital trust) was 83 in 2001/2 and 85 in 2002/3 (Data source, 6).

[19]A simple intervention was defined as including plaster of Paris, or a dressing or strapping, whereas, a complex intervention was defined by use of such interventions as sutures, catheters etc.

[20]Mayhew, L. (1987) Resource inputs and performance outputs in social security offices. *J. Operational Res. Soc.* 38, 913–928.

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Cass Business School
City of London

106 Bunhill Row
London EC1Y 8TZ
T +44 (0)20 7040 8600
F +44 (0)20 7040 8880
www.cass.city.ac.uk