

**THE COSTS AND BENEFITS OF
CHANGING AMBULANCE SERVICE
RESPONSE TIME PERFORMANCE STANDARDS**

**Janette Turner
Colin O’Keeffe
Simon Dixon
Kate Warren
Jon Nicholl**

with the assistance of Brigitte Colwell

**Medical Care Research Unit
School of Health and Related Research
University of Sheffield
Regent Court
30 Regent Street
SHEFFIELD
S1 4DA**

**Tel: 0114 2225202
Fax: 0114 2220749**

CONTENTS

	Page
EXECUTVE SUMMARY	1
1. INTRODUCTION	3
1.1 Background	3
1.2 Call prioritisation	4
1.3 Study aims and objectives	5
2. METHODS	7
2.1 Overview	7
2.2 Areas included in the study	7
2.3 Approval for the study	8
2.4 Data collection	9
2.5 Information recorded	10
2.6 Additional follow up of patients who died or were lost to hospital follow up	12
3. RESULTS – DESCRIPTION OF CASES	14
3.1 Introduction	14
3.2 Characteristics and clinical casemix	14
4. RESULTS - RESPONSE TIME PERFORMANCE	23
4.1 Service Developments	23
4.2 Changes in response time performance	25
5. RESULTS – OUTCOMES	30
6. RESULTS - RESPONSE TIMES AND SURVIVAL	33
6.1 Methods	33
6.2 Number of cases	35
6.3 Factors associated with outcome	35
6.4 Crude mortality	37
6.5 Intended service analysis	38
6.6 Service received analysis	41
7. RESULTS - CLINICAL GROUPS AND OTHER OUTCOMES	44
7.1 Introduction	44
7.2 All clinical groups	44
7.3 Out-of-hospital cardiac arrest	45
7.4 Ruptured aortic aneurysms and other serious haemorrhage	50
7.5 Trauma	50
7.6 Summary	51
8. ECONOMIC EVALUATION	52
8.1 Case studies	52
8.2 National survey of costs and response times	55
8.3 Patient-level costing of hospital care	57
8.4 Discussion and conclusions	57
9. DISCUSSION AND CONCLUSIONS	68
REFERENCES	76
APPENDIX 1 The Acceptability of Emergency Medical Dispatch (EMD) systems to 999 callers	78
APPENDIX 2 AMPDS and CBD codes used for case identification	83

TABLES

	Page	
2.1	Ambulance service areas included in the study	8
2.2	All A- calls and included A- calls by study year	10
2.3	Proportion of patient report forms found by study year	11
3.1	Numbers of all included cases by year and service	14
3.2	Characteristics of all patients included in the study	15
3.3	Category A call groups by study year and service	16
3.4	Characteristics of cases followed up and not followed up	17
3.5	Clinical casemix of all included cases	18
3.6	Clinical casemix in each study year	19
3.7	Clinical casemix in each service	20
3.8	Comparison of ORCON A categorisation and confirmed clinical condition	22
4.1	Major developments at 4 study sites over 6 years	24
4.2	Change in Mean response time over 5 years for all calls, transported to hospital and left at scene	26
4.3	Change in Mean response time in 4 services for all calls, transported to hospital and left at scene	26
4.4	Median time to definitive care over 5 years	29
5.1	Outcomes for all included cases	30
5.2	Patient outcomes for each study year	31
5.3	Patient outcomes for each study service	32
6.1	Numbers included in the outcomes study	35
6.2	Association between characteristics and odds of death before discharge	36
6.3	Estimated change in odds of dying per year	39
7.1	Effect of slow response on survival by clinical group	45
7.2	Clinical diagnosis of out-of-hospital cardiac arrests	46
7.3	Survival by whether the arrest was witnessed by the crew	47
7.4	Survival by presenting rhythm	46
7.5	Bystander CPR	48
7.6	Bystander CPR in patients found in VF	48
7.7	Odds of survival in OHCA	50
8.1	Service developments in Service 1 aimed at improving response times in the year April 1997 to March 1998	58
8.2	Service developments in Service 1 aimed at improving response times in the year April 1998 to March 2000	59
8.3	Service developments in Service 2 aimed at improving response times in the year April 1997 to March 1998	60
8.4	Service developments in Service 2 aimed at improving response times in the year April 1998 to March 2000	61
8.5	Service developments in Service 3 aimed at improving response times in the year April 1997 to March 1998	62
8.6	Service developments in Service 3 aimed at improving response times in the year April 1998 to March 2000	63
8.7	Service developments in Service 4 aimed at improving response times in the year April 1997 to March 1998	64
8.8	Service developments in Service 4 aimed at improving response times in the year April 1998 to March 2000	65
8.9	Response time, cost and activity trends over time	66
8.10	Models of cost per case	67

FIGURES

	Page	
3.1	Age and sex distribution of included cases	15
4.1	Percentage of responses recorded as ≤ 8 minutes - all calls	25
4.2.	Percentage of responses within 8 minutes - calls where a patient is transported to hospital	26
4.3	Response time distribution for each study service, based on rounding to the nearest minute	28
4.4	Median time to definitive care over 5 years	29
6.1.	Proportion of patients dying by year	37
6.2.	Proportion of patients dying before discharge by year and service	38
6.3	SMR (and 95% confidence interval) by year for all services	40
6.4	SMR and response performance by year	40
6.5	SMRs by service and year	40
6.6	SMR and response time performance in services 2, 3, and 4 by year	40
6.7	Death before discharge by response time (rounded to nearest minute 1 =0–1.49)	41
6.8	SMR adjusted for characteristics by response time	42
6.9	SMR adjusted for despatch code as well as other characteristics by response time	43
7.1	Time of day of call for cardiac arrests	46
7.1	Survival in OHCA by response time	49
7.2	Survival in OHCA of patients in VF, by response time	49
7.3	Survival of OHCA patients found in VF who had bystander CPR by response time	49

EXECUTIVE SUMMARY

Following a review of ambulance service performance targets in 1995, new targets based on the clinical priority of 999 calls were introduced. Priority despatch systems for ambulance deployment were introduced in 1997, and by 2001 Ambulance Services were expected to achieve 75% of responses from call to a crew arriving on scene within 8 minutes for life-threatening (category A) calls. In order to examine the effects of these targets we have evaluated service changes, response times and survival outcomes in four ambulance services during the five years from 1997-2001.

We have examined 17,950 responses to patients at the scene following category A calls in which the patient was reported as unconscious or not breathing or with acute chest pain.

The main findings from this study were

1. Services made many changes to their operations in order to improve response to achieve the targets including for example developing new resources, better communications, and dynamic deployment.
2. During this period the proportion of responses achieved in less than or equal to 8 minutes increased by a smaller amount than expected, from 47.0% to 60.2%.
3. A total of 14,993 patients were successfully followed up. These patients were elderly (mean age 57) and predominantly male (59%). The largest single clinical group were patients with cardiac conditions which made up over a quarter of the cases.
4. The identification of life-threatening incidents was poor with over 40% of patients not needing admission to hospital.
5. Excluding patients who were not taken to A and E, as well as patients who were dead at the scene on the arrival of the crew, there were 12,521 patients in whom the effect of response time on outcome was studied. In year 1 16.3% of these patients died before discharge; in year 5 16.7%.

Taking into account characteristics such as age, time of day, clinical condition and ambulance service, there was no evidence of any change in outcome over the five years of the study. This was not unexpected given the small and patchy improvements in response times achieved.

6. We have therefore also examined the relationship between individual response times and outcomes.

For all patients together there was no reliable evidence of an improvement in outcome with faster response, and we estimate that the odds of dying were only 1.4% less with responses \leq 8 minutes compared to responses over 8 minutes.

7. We did find a statistically significant improvement in the odds of surviving to hospital admission, especially when response times were very short (less than or equal to 4 minutes).
8. We also found benefits in out-of-hospital cardiac arrest. Out of 1154 out-of-hospital arrests which had a cardiac origin and which weren't witnessed by ambulance crews, 19 (1.8%) survived. However, the estimated odds of surviving to discharge increased by 19% for each minute reduction in response time.
9. We couldn't find any benefit in other groups such as trauma, serious haemorrhage, or asphyxiation.
10. An economic evaluation estimated that it cost Ambulance Services £37,000 pa. for each percentage improvement in terms of the 8 minute response time target. We have not tried to calculate the cost-effectiveness of response time improvements because of very great uncertainties over the estimates of both costs and benefits, and because response times are substantially better now which will affect the cost of further improvements.

Conclusions

Our results closely replicate those found in contemporary studies in the US. Overall, rapid response in terms of an 8 minute target makes no discernible difference to survival to discharge. Nevertheless, we also know there are benefits – for the survival of a small number of out-of-hospital cardiac arrests, and in the short term in reducing levels of anxiety, pain and distress. Thus for a given level of resources response times clearly need to be minimised.

However, given that Ambulance Services are now responding to 75% of category A calls within 8 minutes, our results point to the conclusion that further developments in Ambulance Service performance should be focused on better targeting and better clinical care rather than further response time improvements.

1. INTRODUCTION

1.1 Background

Response time performance has been used as an indicator of ambulance service quality for many years. Standards for performance have been in place in England since 1974. These standards specified that 50% of all calls should be responded to within 8 minutes and 95% within 14 minutes in urban services and 19 minutes in rural services.

The standards applied to all calls regardless of clinical urgency. However, the rationale for using response time as a performance standard is based in research evidence on the relationship between time and patient outcome for very specific clinical conditions, predominately out of hospital cardiac arrest.

Survival from sudden cardiac arrest is dependent on a number of key factors¹:

- Early recognition and access to treatment
- Early cardiopulmonary resuscitation (CPR)
- Early defibrillation
- Early advanced cardiac care

The development of Emergency Medical Systems, portable defibrillators and pre-hospital personnel with advanced life support skills have moved these principles from the hospital to pre-hospital settings².

There is an extensive international literature on the impact of pre-hospital care on survival from out of hospital cardiac arrest that has supported these principles. Highest survival to discharge from hospital rates are documented in cases of arrest that are witnessed, where there is bystander CPR and where the presenting rhythm is ventricular fibrillation (VF) although survival rates widely differ from 26% in one US city³ 9% in Amsterdam⁴ 6.7% in Italy⁵ 6% in Scotland⁶ and 2% in Canada⁷ and England⁸. One study in Sweden identified 6 factors for increasing chance of survival. These were initial rhythm, delay to arrival of the rescue team, place of arrest, witnessed status, bystander CPR and age. Survival to one month was 0.4% if none of these factors were present and 23.8% if all were present⁹.

The relationship between time and outcome is also well documented. A number of studies have shown a linear inverse relationship between delay in resuscitation and survival¹. Defibrillation of VF arrests is associated with the highest survival and delay of only a few minutes without CPR is sufficient for reversible VF arrest to proceed to irreversible asystole⁹. Ambulance service response time is also a related factor. In one Scottish study shorter response time was significantly associated with increased probability of receiving early defibrillation and subsequent survival⁶. An Australian study demonstrated an inverse association between ambulance response time and survival¹⁰. A Canadian study examining

the relationship between time of defibrillation and survival from out of hospital cardiac arrest found a steep decrease in the first 5 minutes of the survival curve with the odds of survival decreasing by 0.77 for each minute of increasing response interval and suggested that standards for response intervals would produce additional survivors for every minute reduction¹¹. A number of studies have also reported improvements in survival when the cardiac arrest is witnessed by EMS personnel^{5,9,10} supporting the concept of rapid EMS response.

Survival from out of hospital cardiac arrest is dependent on treatment within a very short time frame – it is generally accepted that all people who collapse and are without a pulse for beyond 12 minutes with no intervention are unsalvageable. A priority then for emergency medical services is to target these cases and provide a rapid response.

In view of this evidence and concerns that clinical need was not reflected in ambulance service performance standards, in 1995 the Department of Health set up a steering group to review the ambulance service response time standards¹² (the ORCON review group). The group recommended that response to emergency calls should be prioritised according to the urgency and seriousness of the patient's condition on the assumption that a faster response to life-threatening emergencies could lead to an increase in the number of lives saved. The review group recommended three levels of response:

1. Category A - Life-threatening emergencies of which 90% should be responded to within 8 minutes
2. Category B - Serious conditions which should receive the same response as current standards (95% within 14/19 minutes)
3. Category C - An unspecified but appropriate response for calls with no immediate clinical need.

In the short term, two levels of response time standards were introduced - Category A calls with a target of 75% responded to within 8 minutes and category B+C which retained the previous standard of 95% within 14 or 19 minutes. Ambulance services were set a target to achieve these new standards by 2001.

1.2 Call prioritisation

The introduction of tiered standards means that some form of sorting or prioritisation of emergency calls is required. At around the same time of the response time standard review, UK ambulance services were beginning to introduce priority dispatch systems into their control centres. The purpose of these systems is to enable the rapid identification of life-threatening calls which require the fastest response and consequently deploy resources on the basis of clinical need.

Two systems, both developed in the USA, were introduced: Advanced Medical Priority Dispatch System (AMPDS) and Criteria Based Dispatch (CBD). Both systems use structured protocols that allow trained Emergency Medical Dispatchers (EMDs) to assess 999 calls and categorise them to different levels of urgency. Although there are some differences between the two systems the key processes are the same. These are:

1. An initial assessment that gathers information on patient details (name, age, location), key questions on clinical condition (to establish if the patient is conscious and/or breathing) and the presenting problem (chief complaint).
2. Further interrogation about the presenting problem using assessment protocols or guidelines for different clinical conditions or incident types. At the end of the process a dispatch code is assigned which reflects condition and urgency. Condition (or incident type) is indicated by the final category number and urgency is graded at four levels for AMPDS and 3 levels for CBD. These levels are based on the requirement for level of response (Advanced or Basic Life Support) and speed (lights and sirens or not).
3. The EMD may provide post dispatch instructions. This may be simple first aid and general advice (for example to send someone to look for the ambulance), or specific instructions on what to do in an emergency (for example, CPR, freeing an airway).

Initially there were some concerns about the application of call prioritisation to UK services, in particular the potential risk attached to under prioritisation of calls for a serious event. Consequently in the first instance these systems were introduced in “shadow” form, that is, calls were processed through the prioritisation systems but an immediate ambulance response still sent. During this period an assessment of the safety and reliability of the systems was conducted which found the risk of serious under-prioritisation to be low¹³. Call prioritisation in ambulance services commenced properly in 1997.

1.3 Study aims and objectives

The introduction of new response time performance standards and call prioritisation resulted in significant changes for ambulance services. The effects of this change in policy need to be assessed in order to determine what improvements in patient outcome are achieved, whether there are any lessons to be learned for prioritisation and response time standards, and to ensure that the costs of implementation are justified. The purpose of this evaluation was to measure the changes that result from implementing the new response time standards in four ambulance services. The broad aims were to assess the costs, benefits, acceptability and practical lessons of moving towards the new response time performance standards.

The original study objectives were:

1. To measure the effect of the introduction of the new response time performance standards on ambulance service performance times for calls of different types and

levels of urgency as assessed by two priority dispatch systems and the ORCON review groups categorisation.

2. To assess the effects of any improvements in response times for life-threatening calls (ORCON review category "A") on survival to hospital and to discharge, hospitalisation, and length of stay till discharge.
3. To assess the acceptability to 999 callers of the operation of the priority dispatch systems and pre-arrival instructions.
4. To monitor the nature of category 'C' calls including the reasons for the call and level of need, and the management of those calls including the response times, outcome and an assessment of alternative ways of managing calls.
5. To uncover and report on any practical lessons relating to the operation of priority dispatch systems and priority dispatching.
6. To measure the costs and cost consequences of the introduction of the new response time performance standards.
7. To make an assessment of the likely costs and health benefits of increasing the response time performance standards beyond the current proposals.

We subsequently omitted objective 1 from the study as ambulance service response time performance for different categories of calls is reported annually in Department of Health Statistical Bulletins.

Findings in relation to objectives 3 and 4 have been previously reported in an interim report¹⁴. In this report a summary of these studies is provided in the Appendix 1 with references to the peer reviewed publications on these items.

The primary purpose of this report is therefore to present the findings of the main study measuring the impact of changes in response time performance on patient outcome and the economic evaluation.

2. METHODS

2.1 Overview

Consecutive, life-threatening category A 999 ambulance calls were sampled on an annual basis for the 5 years 1996/7 – 2000/1 from 4 ambulance services. Of these, all calls where an ambulance arrived at scene and treated or transported a patient were included in the study. These cohorts of patients were followed up to discharge from hospital.

Details of incidents, patient characteristics, and clinical conditions were recorded. Processes of pre-hospital and in-hospital care, mortality and costs have been assessed and compared for each year and each service. Changes in response time performance have been measured and the relationship between response time performance and mortality for all cases and for different clinical conditions have been analysed over the 5 year study period.

A number of additional studies have also been carried out. These are:

- A descriptive study of the operational and organisational changes planned by the study ambulance services to enable them to meet the revised performance standards
- A before and after study of caller satisfaction with and acceptability of Emergency Priority Dispatch systems
- An assessment of the nature of category C 999 calls

The methods are described in more detail below.

2.2 Areas included in the study

Four ambulance services were included in the study. These were Royal Berkshire Ambulance Service (RBAS – service 1), Derbyshire Ambulance Service (DAS – service 2), Essex Ambulance Service (EAS – service 3), and West Midlands Ambulance Service (WMAS – service 4). The services were chosen on the basis that at the start of the study they had already implemented Emergency Priority Dispatch into their control rooms and could therefore categorise calls (but had not yet implemented call prioritisation), were planning to report response times for different categories of calls in the near future and that they represented the types of environment typically encountered in England and included urban, mixed urban and rural and very rural areas (table 2.1). In 1999 during the course of the study Derbyshire, Nottinghamshire and Leicestershire ambulance services merged to become East Midlands Ambulance Service NHS Trust.

Table 2.1 Ambulance service areas included in the study

	Service 1	Service 2	Service 3	Service 4
Total annual 999 calls with an ambulance arriving at scene				
Year 1	38,600	47,000	93,600	200,300
Year 5	46,600	(N/A merged)	114,700	217,800
Catchment population (millions)	0.76	0.93	2.14	2.67
% urban population	75	36	80	98
% rural population	20	59.5	19	2
% sparse population	5	4.5	1	0
Total area covered (miles ²)	491	1010	1500	406
Number of major A&E departments served	2	2	7	13

Services 1 and 3 used the Criteria Based Dispatch (CBD) prioritisation system, Service 2 the Advanced Medical Priority Dispatch System (AMPDS) and service 4 began the study using CBD before changing to AMPDS in the third year of the study.

2.3 Approval for the study

Approval for the study was obtained from 24 ethics committees covering the 27 hospitals that patients could be taken to within the geographical boundaries of each of the study ambulance services.

Following approval by the ethics committees, letters were sent to the Medical Directors and Chief Executives of all the hospitals involved and permission obtained to access the medical records of patients we wished to follow up.

The A & E consultants of all 27 hospitals were also contacted by letter to explain the nature of the study and request access to their records. Senior medical records managers and information technology managers were visited personally by the project researcher to obtain their co-operation and negotiate and agree the best methods of accessing records and computerised information. Permission was also gained to access the Patient Administration Systems to allow follow up of patients from A&E through to hospital admission.

Similarly the relevant control room and information managers were visited by the researcher and processes for providing ambulance control room data from the computer aided dispatch (CAD) system for 999 calls and retrieval of the patient report forms (PRFs) completed by attending crews were negotiated and agreed.

2.4 Data collection

Inclusion of cases

The evaluation has focused on 999 calls for potentially life-threatening conditions when a faster response may have some impact on patient outcome. To provide consistency in the reporting of category A response time performance once call prioritisation was introduced, the Department of Health produced a list of both AMPDS and CBD codes which were considered to correspond to the seven condition types identified as category A calls. We have included a sub-sample of all category A calls in which the patient was also reported as unconscious OR not breathing OR with acute chest pain. We have termed these A* calls and it is these calls that make up the cases included in our study. A list of codes used is given in appendix 1.

Exclusion criteria

A* calls where the patients were admitted to hospitals other than those included in our study (e.g. where the Ambulance Service transports a patient across its geographical boundary to a hospital in a neighbouring county) were excluded. Calls where no vehicle attended the scene (for example hoax, aborted calls) were also excluded.

Sample periods

Calls were sampled at five time points – baseline and one, two, three and four years after call prioritisation was introduced. The baseline time period was determined as immediately prior to implementation of call prioritisation and any major service developments designed to enable a service to work towards the new response time standards (for example station closures, new rostering systems). As a consequence the sampling periods vary for each service. The length of the sampling period for each service was determined by call volumes. Our aim was to select a time period that would allow us to sample approximately 1000 consecutive A* calls in each year.

The sampling procedure for the baseline comprised taking a start point of the nearest complete week that preceded any major service change and identifying all calls that corresponded to the inclusion criteria EMD codes. This was repeated, moving back through the consecutive weeks until the approximate target of 1000 calls was reached. An identical sampling period was then used for years 2 through 5. The actual sampling periods were 1/1 to 31/3 (Berkshire), 15/1 to 31/3 (Derbyshire), 1/4 to 15/4 (West Midlands), and 1/11 to 30/11 (Essex).

During 1999 West Midlands changed their EMD dispatch systems from CBD to AMPDS. In order to include calls identified by the AMPDS system we changed our sampling period to 12/3-25/3.

Case identification

At the end of each sample period in each of the five years of the study we obtained data directly from the Computer Aided Dispatch (CAD) systems from each of the four ambulance services. The dispatch information contained records for all calls made to the four ambulance services during each study sample period. We then identified our sample data (A* calls) by selecting the AMPDS and CBD codes corresponding to Department of Health category A calls and in which the patient was reported as unconscious OR not breathing OR with acute chest pain.

Any calls where a vehicle did not arrive on scene or where the patient was taken outside the study area were excluded.

During the 5-year period, there were 20347 calls identified from all category A- life-threatening calls made to the four ambulance services. Of these 17950 calls were included in the study for follow up (Table 2.2). Exclusions were made on the basis that calls were cancelled before an ambulance reached the scene and some patients were taken to a hospital not included in our study. The changes in the number of cases and included cases reflect the effect of the EMD system bedding in, changes in some services due to mergers and switching EMD systems, and the sampling period covering Easter in some services in some years but not in others.

Table 2.2 All A- calls and included A- calls by study year

	Year of study					Total
	1	2	3	4	5	
Number of calls	4192	4553	3746	3803	4053	20347
Number included	3887 92.7%	4026 88.4%	3154 84.2%	3288 86.5%	3595 88.7%	17950 88.2%

2.5 Information recorded

Pre-hospital

Two sources of data were used. The ambulance service CAD data provided information on the patient (name, age, sex), location of incident, grid reference for the incident, time of call, timings of all vehicles dispatched (passed, mobile, on scene, left scene, at hospital) and priority dispatch system category codes. This information was then used to identify the paper ambulance service patient report forms (PRFs).

We attempted to obtain a PRF for every case in our study. From the PRF, information was abstracted about the patient (name, date of birth and address), an incident description, the patient condition on arrival of the crew including presence of vital signs, details of treatment given, disposal of the patient (whether left on scene, or transported to hospital) outcome at

this point (alive or deceased). If the patient was taken to hospital details of name and address allowed us to identify their A&E cards and medical notes in order to ascertain their clinical outcome. If the patient was not taken to hospital then the PRF was used to determine the outcome of the incident.

If the patient did not go to hospital and no PRF was found, then the dispatch information was all the information we had on these incidents. For the outcomes part of the study these incidents were considered lost to follow up. However, as the dispatch information included time of call and time on scene then they were included in the response time part of the study. Table 2.3 gives the proportion of PRFs found in each year of the study.

Table 2.3 Proportion of patient report forms found by study year

	Year of study					Total
	1	2	3	4	5	
All included cases	3879	4013	3152	3279	3585	17908*
PRFs found number (%)	2933 (75.6)	2898 (72.2)	2190 (69.5)	2545 (77.6)	2725 (76)	13291 (74.2)

*excludes 42 cases where no patient was found at scene

In hospital

Every effort was made to trace each patient sampled who was transported to hospital to a matched A&E and inpatient record. Matching criteria were the name of the patient, date and time of incident, and type of incident. When a PRF was available this process was relatively straight forward. When no PRF was available or when neither the CAD data nor the PRF contained a name, then the CAD details had to be used to try and match incident date, time, and type with an A&E register entry. This was generally successful. However, there were some cases in which no matching case could be found, although the CAD data indicated the patient had been transported to hospital. Similarly there were a few cases where there was no record of A&E attendance of a named patient. In these cases the PAS system was checked to see if that patient had been admitted to hospital at the corresponding date and time. If an admission record was found these cases were followed up. When they had not, the case was considered lost to follow up. It is likely that for some cases where no hospital record was found for a named live patient they had a relatively minor condition and left A&E before being registered. At some hospitals when a patient was dead on arrival they would be certified by a doctor outside the department and not entered onto an A&E register.

Where cases were successfully followed up hospital information was obtained from A&E records, inpatient notes and PAS systems. Information was recorded for A&E events, inpatient events and final outcome.

Accident and Emergency events

Information recorded included time of arrival and discharge from A&E, patient condition including vital signs, cardiac rhythm (for cardiac patients), preliminary diagnosis, condition on leaving A&E and disposal (admitted, transferred, discharged, died).

Inpatient events

Details were recorded of where admitted to (speciality), length of stay, acute and long stay episodes, any operations or major investigations (e.g. CAT scans), final diagnosis and disposition (discharged home, discharged to continuing care or died). For any patient who died details were recorded of the date, time, place and cause of death.

For trauma patients a full description of all injuries sustained and their Abbreviated Injury Scale (AIS) codes^{ref} were made using A&E and inpatient records and post mortem reports. AIS codes indicate threat to life and range from 1 indicating a minor injury to 6 indicating a non-survivable injury. Injury mechanism was classified as blunt or penetrating.

The injury descriptions were coded using the AIS90 dictionary^{ref} and Injury Severity Scores (ISS) calculated^{ref}. ISS scores are calculated by summing the squares of the AIS scores of the most severe injuries in up to 3 body regions. ISS scores range from 1 to 75. Injury coding was carried out by 3 researchers (JT, KW, CO'K). JT and KW had considerable coding experience from previous studies. Training for CO'K was provided in house by JT. Any difficult cases were discussed and coding agreed between raters.

2.6 Additional follow up of patients who died or were lost to hospital follow up

Cause of death

We wanted to ascertain the cause of death for all patients who died in our study. If the patient died at hospital then cause of death was usually found in hospital records. However, if the patient died at scene and was taken directly to a mortuary then these cases were followed up at the appropriate coroners to ascertain cause of death. With the permission of a coroner the researcher accessed death certificates from the relevant coroner files.

In some instances researchers did not obtain the permission of coroners to view their records. In these cases the NHS Central register (part of the Office for National Statistics) was contacted and approval given to access their national register of deaths and obtain a death certificate. Lists of patients were drawn up and sent to NHSCR who then sent a copy of the death certificates to us.

Outcome

Over the course of the study there were also a few hundred patients recorded as being taken to hospital by ambulance dispatch information and for whom we had identifiable information (e.g name, date of birth) but no trace was found on A&E or inpatient systems. In order to find

out if these patients had died at the end of this incident or had survived we sent lists of these patients' details (name, address, date of incident) to the NHS Central Registry to cross-reference on their databases. If the patient was traced on the register then they were currently alive and therefore had survived the incident in our study. If the patient was registered as having died then the date, place of death and death certificate was obtained. From this information we were able to ascertain if the patient had died as a result of the incident in our study. Those patients for whom there was no trace on the NHSCR were considered lost to follow up.

3. RESULTS – DESCRIPTION OF CASES

3.1. Introduction

A total of 17950 calls were included in the main study sample. From these 14993 patients were followed up to discharge from hospital or traced through the Office of National Statistics register to establish if they had died or survived. The remaining 2957 (16.5%) could not be followed up as there was insufficient information due to missing ambulance service patient report forms and no name and age being recorded in the ambulance service control room CAD system. The proportion of cases followed up is similar in each study year and ranges between 82.5% and 84.5%.

The number of included cases for each year in each service is given in table 3.1.

Table 3.1 Numbers of all included cases by year and service

Included calls	Year1	Year 2	Year 3	Year 4	Year 5	Total
Service 1	956	809	694	673	562	3694
Service 2	922	1302	956	995	1356	5531
Service 3	968	945	725	743	695	4076
Service 4	1041	970	779	877	982	4649
Total	3887	4026	3154	3288	3595	17950
Followed up number (%)						
Service 1	829 (86.7)	735 (90.8)	628 (90.5)	605 (89.9)	489 (87.0)	3286
Service 2	698 (75.7)	916 (70.3)	791 (82.7)	804 (80.8)	1085 (80)	4294
Service 3	789 (81.5)	790 (83.6)	601 (82.9)	618 (83.2)	620 (89.2)	3418
Service 4	970 (93.2)	881 (90.8)	633 (81.2)	706 (80.5)	805 (82)	3995
Total	3286 (84.5)	3322 (82.5)	2653 (84.1)	2733 (83.1)	2999 (83.4)	14993

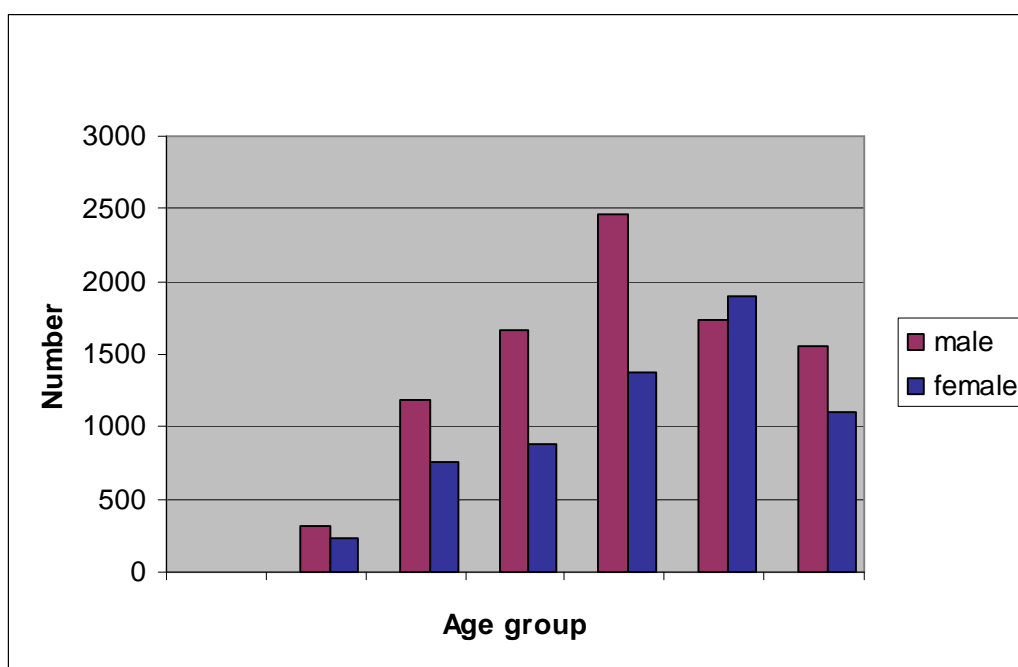
3.2. Characteristics and clinical casemix

The characteristics of included calls are shown in Table 3.2. Cases were predominantly male (58.9%) and aged 55 years or more (60%) although there were slightly fewer males in the 75 years or greater age group (figure 3.1).

Table 3.2 **Characteristics of all patients included in the study**

Characteristic	Values	Number	%
Age	0-14	555	4.4
	15-34	1950	15.5
	35-54	2544	20.3
	55-74	3851	30.7
	>75	3643	29
	Not known	5407	
	Total		17950
	Mean	57.34	
	Median	63.0	
Sex	Male	8927	58.9
	Female	6234	41.1
	Not known	2789	
	Total		17950
Orcon A category	Chest pain	6699	37.3
	Unconscious	11075	61.7
	Breathing difficulty	5	0
	Child < 2 years	171	1.0
	Total		17950

Figure 3.1 – Age and sex distribution of included cases



In terms of the classification of category A call made in ambulance control the majority of calls fell into the unconscious and chest pain categories. Only 5/17950 cases were included in the breathing difficulties category and only 171 in the child under 2 years of age category. The child under 2 category does not represent all of this group. Services using CBD had a specific category (27) for children and the number reported is those allocated to this code. However, if a specific clinical condition was identified, a call for an under 2 years child would be allocated to the category for that condition (e.g fits) rather than category 27. Services using AMPDS only allocated children to a clinical category and did not have a specific code for children. In total there were 267 (1.5%) children under 2 years of age included.

There were no cases reported as unconscious or not breathing and that also had EMD codes corresponding to the anaphylaxis, penetrating trauma or obstetric haemorrhage groups which are also part of the ORCON A categorisation. This is presumably because these are relatively rare events that require very specific diagnostic information that may not be available at the time of the 999 call.

Table 3.3 gives the number and percentage of calls in each category A group by study year and service.

Table 3.3. Category A call groups by study year and service

Category	Category A calls by type n (%)				
Year of Study	Chest Pain	Unconscious	Breathing Difficulty	Child = < 2 years	Total
1	1542 (39.7)	2331(60.0)	0	14(0.4)	3887(100)
2	1517 (37.7)	2439(60.6)	1 (0)	69(1.7)	4026(100)
3	979 (31.0)	2133(67.6)	0	42(1.3)	3154(100)
4	1236 (37.6)	2023(61.5)	1 (0)	28 0.9)	3288(100)
5	1425 (39.6)	2149(59.8)	3(0.1)	18(0.5)	3595(100)
Service					
1	690 (18.7)	2915(78.9)	0	89(2.4)	3694(100)
2	2944 (53.2)	2586(46.8)	1 (0)	0	5531(100)
3	1205 (29.6)	2821(69.2)	0	50(1.2)	4076(100)
4	1860 (40.0)	2753(59.2)	4(0.1)	32(0.7)	4649(100)
Total	6699	11075	5	171	17950

The proportions of cases falling into the ambulance service categories remained stable over the 5 year period with the majority of calls falling into the unconscious/fitting/unresponsive category followed by the chest pain category. Less than 1% of calls fell into other categories.

There is variation in the distribution of calls by category between the study services. This may be a consequence of the two different EMD systems used. Services 1 and 3 used CBD whereas service 2 used AMPDS and service 4 used both. CBD has a code for unconscious or not breathing for every condition category. This is restricted to a few conditions in AMPDS. As a consequence there is a much greater number of unconscious codes used in the sampling frame for services using CBD. As explained above, this system also has a separate condition category code for children under 2 years of age which AMPDS does not.

Of the 17950 included calls we were unable to follow up 2591 (14.4%) and record an outcome. We have examined the key characteristics of calls followed up and not followed up to determine if there are any major differences between these two groups that may influence the interpretation of the results. These are given in table 3.4

Table 3.4 Characteristics of cases followed up and not followed up

Characteristics	Followed up n (%)	Not followed up n (%)	Total n (%)
Age (years)			
0-14	550 (4.4)	5 (4.8)	555 (4.4)
15-34	1930 (15.5)	20 (19.2)	1950 (15.5)
35-54	2527 (20.3)	17 (16.3)	2544 (20.3)
55-74	3821 (30.7)	30 (28.8)	3851 (30.7)
>75	3611(29)	32 (30.8)	3643 (29)
Total	12437 (100)	104 (100)	12543 (100)
Sex			
Male	8541 (58.9)	375 (58.2)	8916 (58.9)
Female	5954 (41.1)	266 (41.3)	6220 (41.4)
Total	14495 (100)	644 (100)	15139 (100)
Orcon A category			
Chest pain	5772 (38.5)	910 (31.2)	6682 (37.2)
Unconscious	8969 (59.6)	1968 (67.5)	10937 (60.9)
Breathing difficulty	3 (0)	1 (0)	4 (0)
Child <2 years	291 (1.9)	36 (1.2)	327 (1.8)
Total	15035 (100)	2915 (100)	17950 (100)
Transported to hospital			
Yes	11773 (78.5)	1951 (66.9)	13724 (76.5)
No	3362 (21.5)	964 (33.1)	4226 (23.5)
Total	15035 (100)	2915 (100)	17950 (100)
Cardiac Arrest			
Yes	1230 (8.3)	17 (0.7)	1247 (7.1)
No	13622 (91.7)	2574 (99.3)	16196 (92.8)
Total	14852 (100)	2591 (100)	17443 (100)

There was no difference in the age or sex profile of the two groups. A slightly larger proportion of cases not followed up were categorised as unconscious and more of these cases were not transported to hospital reflecting the relatively minor nature of some calls left at scene. For both these groups less information is available to allow continued follow up. There was only a small number of cardiac arrest cases that were not followed up. The main difference between the two groups was in transports to hospital and as minor cases left at scene do not influence the mortality analysis presented in section 6 we do not believe there are any significant biases present in cases with missing data and hence outcome.

A more accurate description of the casemix is given by the clinical code we assigned to each case. This is based on the best diagnosis available using cause of death, diagnosis on discharge from hospital, A&E diagnosis, and incident description given by the ambulance crew. Where possible a verified condition has been used. Where this was not recorded a signs and symptoms description has been used.

Table 3.5 summarises the clinical codes assigned to all cases.

Table 3.5 **Clinical casemix of all included cases**

	Condition/Symptoms description	Number	%
1	Cardiac Arrest (no other diagnosis)	1105	6.2
2	Myocardial infarction (confirmed)	933	5.2
3	Other cardiac disease (confirmed)	1842	10.2
4	Non cardiac chest pain	1512	8.4
5	Respiratory disease (confirmed)	762	4.2
6	Respiratory symptoms	66	0.4
7	Asphyxia	53	0.3
8	Injury/trauma	927	5.1
9	Poisoning	1177	6.6
10	Serious haemorrhage	125	0.7
11	Cerebrovascular/CNS disease (confirmed)	740	4.1
12	Collapse, faint, unresponsive	1193	6.6
13	Fits/convulsions	758	4.2
14	Diabetes related	453	2.5
15	Mental Health/Psychiatric problem	287	1.6
16	Other diagnosis	1213	6.8
17	Non specific signs and symptoms (pain, fever, vomiting etc)	613	3.4
18	Dead at scene – no other details	743	4.1
	Known	14502	80.8
	Missing	3448	19.2
	Total	17950	100

Cardiac problems accounted for 21.6% of calls, respiratory problems 4.9% and collapse or unresponsiveness (fits, collapse, cerebrovascular disease) 14.9%. Almost a quarter (23.4%) of calls were for other medical problems, 5.1% for injury and 6.6% for poisoning.

Tables 3.5 shows the clinical codes for cases by study year.

Table 3.6 Clinical casemix in each study year

Condition/Symptoms	Year n (%)					Total
	1	2	3	4	5	
Cardiac Arrest	222 (5.7)	251 (6.2)	200 (6.3)	215 (6.5)	217 (6.0)	1105 (6.2)
MI (confirmed)	236 (6.1)	205 (5.1)	142 (4.5)	166 (5.0)	184 (5.1)	993 (5.2)
Other Cardiac disease (confirmed)	473 (12.2)	464 (11.6)	249 (7.9)	319 (9.7)	337 (9.4)	1842 (10.2)
Non cardiac chest pain	315 (8.1)	311 (7.7)	213 (6.8)	322 (9.8)	351 (9.8)	1512 (8.4)
Respiratory disease	165 (4.2)	165 (4.1)	128 (4.1)	128 (3.9)	176 (4.9)	762 (4.2)
Respiratory symptoms	12 (0.3)	19 (0.5)	15 (0.5)	9 (0.3)	11 (0.3)	66 (0.4)
Asphyxia	10 (0.3)	17 (0.4)	12 (0.4)	7 (0.2)	7 (0.2)	53 (0.3)
Injury/trauma	264 (6.8)	223 (5.6)	149(4.7)	145 (4.5)	146 (4.1)	927 (5.1)
Poisoning	259 (6.7)	232 (5.8)	233 (7.4)	209 (6.4)	244 (6.8)	1177 (6.6)
Serious haemorrhage	34 (0.9)	36 (0.9)	20 (0.6)	15 (0.5)	20 (0.6)	125 (0.7)
Cerebrovascular/CNS disease (confirmed)	176 (4.5)	185 (4.6)	112 (3.6)	138 (4.2)	129 (3.6)	740 (4.1)
Collapse, faint, unresponsive	194 (5.0)	221 (5.5)	201 (6.4)	251 (7.6)	326 (9.1)	1193 (6.6)
Fits/convulsions	211 (5.4)	167 (4.1)	147 (4.7)	118 (3.6)	115 (3.2)	758 (4.2)
Diabetes related	96 (2.5)	93 (2.3)	58 (1.8)	103 (3.1)	103 (2.9)	453 (2.5)
Mental Health/ Psychiatric problem	102 (2.6)	79 (2.0)	27 (0.9)	37 (1.1)	42 (1.2)	287 (1.6)
Other diagnosis	259 (6.7)	253 (6.3)	196 (6.2)	250 (7.6)	255 (7.1)	1213 (6.8)
Non specific signs and symptoms (pain, fever, vomiting etc)	67 (1.7)	88 (2.2)	122 (3.9)	122 (3.7)	214 (6.0)	613 (3.4)
Dead at scene	162 (4.2)	186 (4.6)	108 (3.4)	153 (4.7)	134 (3.7)	743 (4.1)
Missing	630 (16.2)	831 (20.6)	822 (26.1)	581 (17.7)	584 (16.2)	3448 (19.2)
Total	3887 (100)	4026 (100)	3154 (100)	3288 (100)	3595 (100)	17950

Although this clinical mix was fairly stable over the five study years, there was a change in distribution over the 5 year study period for some clinical categories. The proportion of cases with mental health problems and with fits and convulsions reduced by half suggesting the prioritisation process was reducing the number of calls for non life-threatening conditions. There were small reductions in the proportions of calls for myocardial infarction and cardiac disease and a small increase in the proportion of cases with non-cardiac chest pain. It is difficult, of course, at the time of the call to discriminate between cardiac and non cardiac chest pain and so both types will be included as category A calls. Overall, there was a small

reduction in the proportion of cardiac and chest pain cases over the 5 years which is one of the specific groups targeted for improved response time performance.

There was an increase in the proportion of calls for reported collapse or unresponsiveness which was also a target group for improved performance, however there was also an increase in the proportion of calls for generalised signs and symptoms not specific to any target category. This perhaps illustrates the difficulties of trying to obtain accurate information during an emergency call.

There were also differences between services in the relative proportions of calls within some clinical categories. Table 3.6 shows calls by clinical code for each service.

Table 3.7 Clinical casemix in each service

Condition/Symptoms	Service n (%)				Total
	1	2	3	4	
Cardiac Arrest	359 (9.7)	275 (5.0)	235 (5.8)	236 (5.1)	1105 (6.2)
MI (confirmed)	130 (3.5)	439 (7.9)	176 (4.3)	188 (4.0)	993 (5.2)
Cardiac disease (confirmed)	225 (6.1)	752 (13.6)	421 (10.3)	444 (9.5)	1842 (10.2)
Non cardiac chest pain	150 (4.1)	579 (10.5)	239 (5.9)	544 (11.7)	1512 (8.4)
Respiratory disease	122 (3.3)	276 (5.0)	143 (3.5)	221(4.8)	762 (4.2)
Respiratory symptoms	8 (0.2)	24 (0.4)	14 (0.3)	20 (0.4)	66 (0.4)
Asphyxia	13 (0.4)	22 (0.4)	7 (0.2)	11 (0.2)	53 (0.3)
Injury (specified)	281 (7.6)	113 (2.6)	262 (8.4)	271 (6.5)	927 (6.4)
Poisoning	270 (7.3)	334 (6.0)	282 (6.9)	291 (6.3)	1177 (6.6)
Serious haemorrhage	32 (0.9)	37 (0.7)	30 (0.7)	26 (0.6)	125 (0.7)
Cerebrovascular/CNS disease (confirmed)	189 (5.1)	155 (2.8)	214 (5.3)	182 (3.9)	740 (4.1)
Collapse, faint, unresponsive	264 (7.1)	304 (5.5)	258 (6.3)	367 (7.9)	1193 (6.6)
Fits/convulsions	274 (7.4)	102 (1.8)	167 (4.1)	215 (4.6)	758 (4.2)
Diabetes related	122 (3.3)	98 (1.8)	79 (1.9)	154 (3.3)	453 (2.5)
Mental Health/Psychiatric problem	51 (1.4)	54 (1.0)	62 (1.5)	120 (2.6)	287 (1.6)
Other diagnosis	181 (4.9)	414 (7.5)	257 (6.3)	361 (7.8)	1213 (6.8)
Non specific signs and symptoms	69 (1.9)	264 (4.8)	100 (2.5)	180 (3.9)	613 (3.4)
Dead at scene	192 (5.2)	64 (1.2)	181 (4.4)	306 (6.6)	743 (4.1)
Missing	762 (20.6)	1225 (22.1)	949 (23.3)	512 (11.0)	3448 (19.2)
Total	2932 (100)	4306 (100)	3127 (100)	4137 (100)	17950

Service 1 had a much higher proportion of calls identified as cardiac arrest than the other services. However, if all the cardiac related categories are combined then excluding missing cases service 2 has the highest proportion of this type of case with 34.1% compared to 24.2 %, 26.3% and 20.9% in services 1, 3 and 4 respectively. This suggests that, if the clinical

code is right then service 2 is better at targeting appropriate calls than the other services. The high proportion of cardiac related cases in service 2 may partly explain why there is a smaller proportion in other categories, particularly injury and fits and convulsions. There were also fewer cases where no information other than the patient was dead at scene was available although this may simply be a consequence of more successful follow up in this area. There were some categories (injury, cerebrovascular disease, respiratory disease, non specific signs & symptoms) where there appeared to be differences between services using CBD compared to AMPDS.

There are a number of possible explanations for these differences

- Two different EMD systems were used to categorise 999 calls. There may be subtle differences in the prioritisation process that results in differences in casemix.
- EMD systems are a tool used to categorise and triage emergency calls and, on the basis of information provided, it is the Emergency Medical Dispatchers in the ambulance service control rooms who allocate a condition and therefore identify calls coded as A- . There are differences in the training provided for each system and may also be local differences within the same system, for example in protocol compliance, that can result in differences in the accuracy and consistency of call prioritisation in different services.
- There may also be genuine casemix differences between different services depending on the type of geographical area and population served.

Although the clinical casemix of calls is fairly stable on a year on year basis the differences between services has implications for evaluative research and ambulance service performance measures as any comparisons between services has to take into account the casemix differences between services.

Many conditions, for example diabetes related problems, cardiac arrests and poisonings (particularly alcohol intoxications which account for 42% of this group) would have originally been categorised as unconscious by the ORCON classification of category A on the basis of the information given by the 999 caller. This is illustrated in Table 3.7 which compares the initial ORCON category with subsequent clinical condition where this is known.

Overall, the broad classification provided by the ORCON categories seems to accurately reflect the subsequent clinical casemix. Almost 90% of cardiac related cases were classified in the chest pain category with the exception of cardiac arrests which were correctly allocated to the unconscious category. The main anomaly is that no cases with respiratory problems were classified as breathing difficulty at the time of the call.

Table 3.8 Comparison of ORCON A categorisation and confirmed clinical condition

Condition/Symptoms	ORCON A Category n (%)				Total
	Chest pain	unconscious	Breathing difficulty	Child <2years	
Cardiac Arrest	51 (4.6)	1042 (94.3)	0	12 (1.1)	1105 (100)
MI (confirmed)	826 (88.5)	107 (11.5)	0	0	993 (100)
Cardiac disease (confirmed)	1601 (86.9)	241 (13.1)	0	0	1842 (100)
Non cardiac chest pain	1443 (95.4)	69 (4.6)	0	0	1512 (100)
Respiratory disease	475 (62.3)	268 (35.2)	0	19 (2.5)	762 (100)
Respiratory symptoms	41 (62.1)	21 (31.8)	0	4 (6.1)	66 (100)
Asphyxia	4 (7.5)	45 (84.9)	0	4 (7.5)	53 (100)
Injury/trauma	42 (4.7)	868 (93.7)	0	17 (1.6)	927 (100)
Poisoning	44 (3.7)	1132 (96.2)	0	1 (0.1)	1177 (100)
Serious haemorrhage	23 (18.4)	102 (81.6)	0	0	125 (100)
Cerebrovascular/CNS disease (confirmed)	52 (7.0)	685 (92.6)	0	3	740 (100)
Collapse, faint, unresponsive	93 (7.8)	1098 (92)	0	2 (0.2)	1193 (100)
Fits/convulsions	21 (2.8)	694 (91.6)	3 (0.4)	40 (5.3)	758 (100)
Diabetes related	11 (2.4)	441 (97.4)	1 (1.2)	0	453 (100)
Mental Health/Psychiatric problem	79 (27.5)	208 (72.5)	0	0	287 (100)
Other	695 (57.3)	496 (40.8)	1 (0.1)	21 (1.7)	1213 (100)
Non specific signs and symptoms	406 (66.2)	203 (33.1)	0	4 (0.7)	613 (100)
Dead at scene	7 (0.9)	735 (98.9)	0	1 (0.1)	743 (100)
Missing	785 (22.8)	2620 (76.0)	0	43 (1.2)	3448 (100)
Total	6699	11075	5	171	17950

The large proportion classified as unconscious in ORCON reflects the wide range of medical conditions subsequently identified although final outcome and some types of conditions suggest that “unconscious” is not a very accurate description of some cases. This may be a consequence of the key question in the prioritisation process which asks the caller if the patient is conscious and a yes or no answer is recorded. There were 11075 calls with EMD codes corresponding to the ORCON unconscious category. However, of these 4345 (39.2%) were recorded by the ambulance crew as conscious on arrival, 3679 (33.2%) as unconscious and for 3051 (27.5%) there is no record of state of consciousness. Whilst in some instances a patient may be unconscious at the time of the call but have recovered consciousness by the time the ambulance crew arrived this is unlikely to be the case for more than half of the cases in which state of consciousness is recorded. The outcome data presented later also supports the view that a substantial proportion of cases were not of a serious nature. There may therefore be some difficulty in relying on the interpretation of the term “conscious” by callers to the ambulance service as a means of identifying life-threatening medical decisions.

4. RESULTS - RESPONSE TIME PERFORMANCE

4.1 Service developments

The introduction of call prioritisation and new response time standards for different categories of call presents a significant organisational challenge to ambulance services. Semi-structured interviews were conducted in all four services at the beginning of the study to determine how they were planning to meet the new response time standards. Progress was determined from an annual survey of services carried out for 6 years and described in more detail in the economic evaluation.

All of the study services made changes to facilitate improving response time performance. This includes major organisational changes including new capital investment as well as reorganisation of existing resources. These can be summarised as follows:

- Changes to ambulance station configurations including relocations, total numbers and initiatives to share premises (e.g with fire stations).
- A range of first responder schemes with the emphasis on single manned vehicles including motorcycles. Longer term initiatives include the development of community first responder schemes utilising personnel from outside the ambulance service itself.
- Developments to decrease total call time (receipt of call to vehicle clear for another call) include increased use of standby points and dynamic deployment, improved stocking procedures for vehicles which decrease the need for vehicles to return to stations and better arrangements with hospitals to enable patients to be taken to the most appropriate hospital rather than the nearest.
- Increased utilisation of IT developments including automatic vehicle location, predictive analysis and data transmission to vehicles (pre-alert systems).
- Improvements in demand management including demand analysis, predictive analysis, flexible crew rostering and the use of appropriately trained staff (e.g. managers) as first responders.

Table 4.1 summarises the major developments in the four study sites at the beginning and end of the study.

Table 4.1 **Major developments at 4 study sites over 6 years**

	Service 1		Service 2		Service 3		Service 4	
	Year 1	Year 6	Year 1	Year 3*	Year 1	Year 6	Year 1	Year 6
Number of solo paramedics	3	6	14	9	14	10	21	25
Number of other staff available for 999 response (managers etc)	4	12	34	11	7	25	25	23
Number of fast response vehicles including motorcycles	4	6	17	7	5	11	21	40
Number of ambulance stations	4	4	15	15	31	31	28	37
Number of static standby points	30	8	29	0	18	27	50	43
Priority dispatch system	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pre-alert system	X	Yes	X	X	Yes	Yes	Yes	Yes
Predictive analysis	X	Yes	X	X	Yes	Yes	Yes	Yes
Automatic vehicle location	X	Yes	X	X	Yes	Yes	Yes	Yes
Improved vehicle stocking	X	X	X	X	X	Yes	X	X
Improved communication with crews (e.g automatic data transmission)	X	Yes	X	Yes	Yes	Yes	X	Yes
Crew meal breaks taken on duty	X	Yes	Yes	Yes	Yes	Yes	Yes	Yes

* Service 2 merged with neighbouring services in year 4.

4.2. Changes in response time performance

One of the main objectives of the study has been to measure changes in response time performance over the 5 year study period as the services have moved towards the revised performance standard of responding to 75% of category A calls within 8 minutes. We have calculated the response time for all included calls using the response times recorded in the CAD systems. Where more than one vehicle was dispatched the shortest response time has been used in the analysis.

In some services in the early years of the study response times supplied by the AS CAD systems were given as whole numbers of minutes. We understand that this was because the event times (call, on scene) were only recorded in hours and minutes. This means that a response time reported as 8 minutes, for example, could actually be from 7.01 to 8.99 minutes. However, the response time recorded in the CAD system has been used in the calculation of means percentiles and other analyses.

Figures 4.1 and 4.2 show the percentage of responses within 8 minutes for each service over the 5 years. Tables 4.2 and 4.3 summarise mean response times for each service and each year for all calls, those where a patient was left at the scene and those where a patient was taken to hospital.

Figure 4.1 Percentage of responses recorded as ≤ 8 minutes - all calls

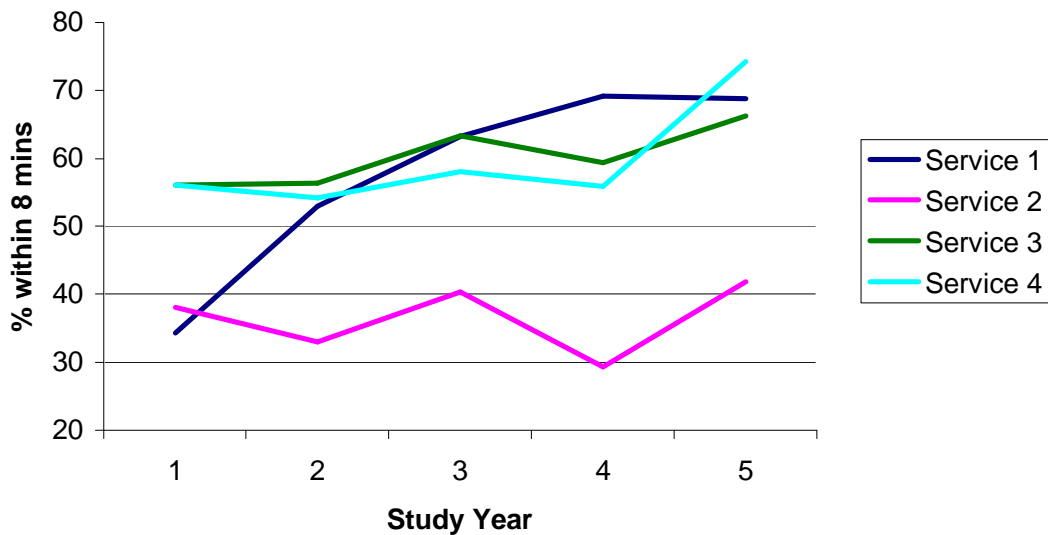


Figure 4.2. Percentage of responses within 8 minutes - calls where a patient is transported to hospital

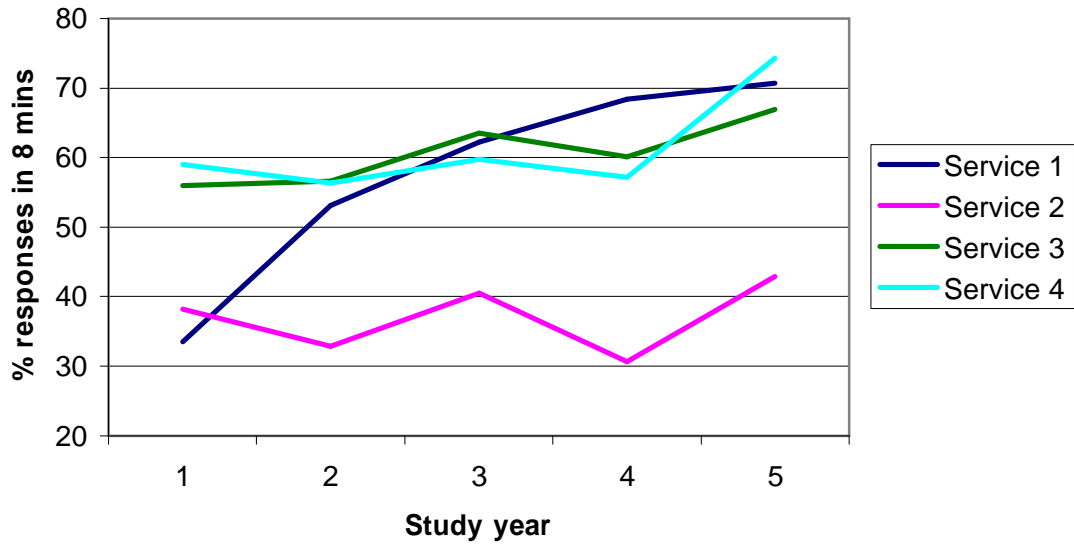


Table 4.2 Change in Mean response time over 5 years for all calls, transported to hospital and left at scene

	Mean response time (min:sec)		
	All calls	Taken to hospital	Left at scene
Year 1	09:21	09:19	09:29
Year 2	09:25	09:23	09:31
Year 3	08:49	08:54	08:36
Year 4	08:53	09:01	08:25
Year 5	08:18	08:22	08:05

Table 4.3 Change in Mean response time in 4 services for all calls, transported to hospital and left at scene

	Mean response time (min:sec)		
	All calls	Taken to hospital	Left at scene
Service 1	08:47	08:47	08:46
Service 2	10:25	10:26	10:21
Service 3	08:29	08:30	08:27
Service 4	07:50	07:53	07:34

Mean response time improved over the 5 years reducing from 9 minutes 21 seconds in year one to 8 minutes 18 seconds in year 5. However the percentage of responses within 8 minutes hardly changed. No service reached the 75% target although service 4 was close to this in the final year. Service 1 showed the biggest and most consistent improvement with performance increasing each year and median response time reduced by over 3 minutes in total. Service 2 made only a marginal improvement and 3 services had a reduction in performance before improvements began. With the exception of service 1 where the most substantial improvement was made in the first year of the study, the biggest change in performance was in the final study year.

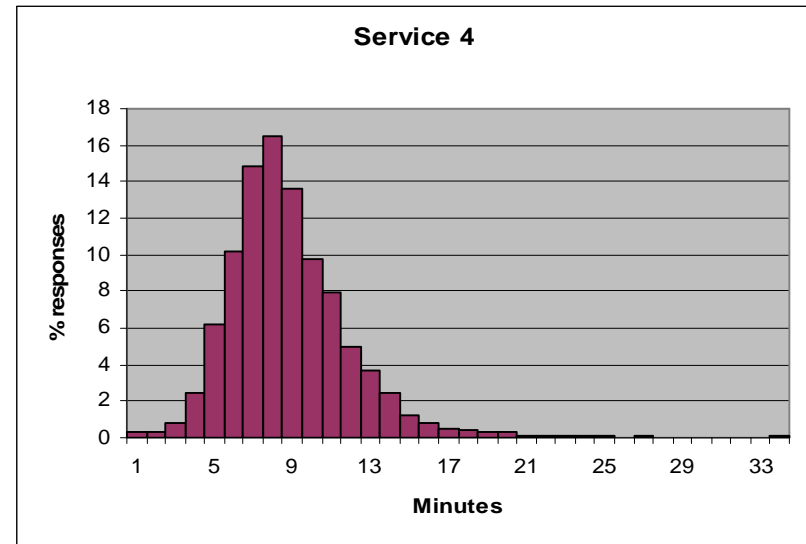
Overall, there was little change in response time distribution in years 1 – 4. However, there was a gradual increase in the proportion of calls responded to in very short times. The proportion of calls responded to within 3 minutes increased from 3.5% in year 1 to 6.5% in year 5 and within 5 minutes from 16.6% to 23.9% respectively.

There was no discernable difference in response time performance for calls where a patient was transported to hospital. One of the perceived advantages of EMD systems is that the assessment process makes more information about the call available. Control room staff can then pass this information to ambulance crews as they are en-route to a call. The availability of additional information may then potentially influence the speed with which a crew responds. Although response time for patients left at scene was marginally faster than for patients requiring hospital attendance there was some evidence that patients whose vital signs were compromised were responded to more quickly than patients without any recorded abnormal signs.

We have also examined the response time distributions for the services in terms of the proportion of calls responded to in one minute time intervals based on the rounded values. These are given in figure 4.3.

Response time distributions are similar for all four services although there are fewer response times greater than 12 minutes in service 4. This is the only urban service and probably reflects the more rural nature with longer distances of the other 3 services. Service 1 responded to 82.8% of calls within 12 minutes, service 2 73.9%, service 3 82.5% and service 4 93.2%.

Fig 4.3 Response time distribution for each study service, based on rounding to the nearest minute



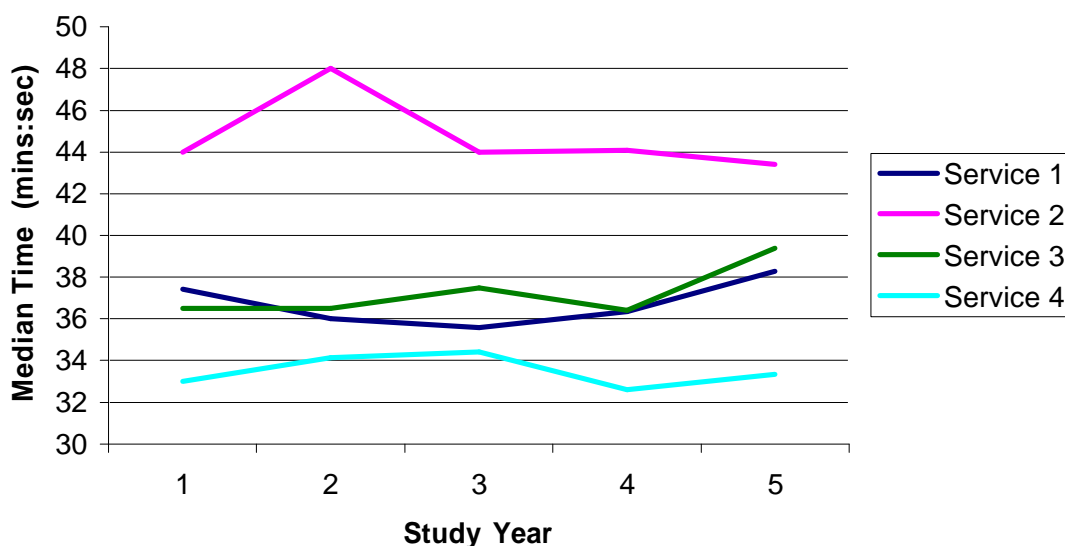
We have also examined the total time taken from the call to a patient arriving at hospital to assess if faster response results in a corresponding reduction in overall time to definitive care. The results are given in Table 4.4 and figure 4.4.

We have found no change in the median time to definitive care over the 5 year study period. Overall there is a small increase in this time. This may be because the reduction in response time is so small as not to have any impact on overall time to hospital, any gain in time by quicker response is lost by crews spending a longer time on scene or a combination of both.

Table 4.4 Median time to definitive care over 5 years

	Median time to definitive care (min:sec)				
	Year 1	Year 2	Year 3	Year 4	Year 5
Service 1	37:42	36:00	35:58	36:35	38:27
Service 2	44:00	48:00	44:00	44:10	43:40
Service 3	36:48	36:49	37:47	36:36	39:37
Service 4	33:00	34:12	34:41	32:59	33:34
All calls	37:41	39:00	38:00	39:03	39:12

Figure 4.4 Median time to definitive care over 5 years



5. RESULTS - OUTCOMES

Calls have been classified as deaths or survivors and whether they received pre-hospital care only, A & E or in hospital care. Table 9 summarises outcomes for all cases.

Table 5.1 **Outcomes for all included cases**

Outcome	Number	% of all calls
All cases		
Total survivors	12051	67.1
Total deaths	2942	16.4
Total	14993	83.5
Not known	2957	16.5
Survived		
Did not travel to hospital	1729	9.6
Discharged from A&E	4778	26.6
Discharged from hospital	5156	28.7
Total	11663	64.9
Not known when discharged	388	2.2
Died		
At scene or on arrival at A&E	1789	10.0
In A&E	513	2.9
In hospital	640	3.6
Total	2942	16.5

There was a high proportion of survivors (80.4% where outcome was known) given that the included calls were selected on the basis of potentially life-threatening signs. Of the survivors 1729 (14.3%) were left at the scene and 9935 (85.7%) were transported to hospital. Almost half of these (48%) were discharged from A&E on the same day with the remainder being admitted and discharged at a later date. Just over half of the calls for life-threatening emergencies required no or minimal hospital treatment.

Less than 20% of cases with a known outcome died and 58.7% of these were either dead at the scene or on arrival at hospital and 78.2% before admission to hospital. Only 640 cases died after admission to hospital (21.8% of deaths and 4.3% of all cases with known outcome).

Tables 5.2 and 5.3 summarise outcomes by year and by service.

Table 5.2 Patient outcomes for each study year

Outcome	Year					Total
	1	2	3	4	5	
Survived						
Did not travel to hospital	332 (10.1)	306 (9.2)	408 (15.4)	347 (12.7)	336 (11.2)	1729 (11.5)
Discharged from A&E	1051 (32.0)	1027 (30.9)	837 (31.5)	811 (29.7)	1052 (35.1)	4778 (31.9)
Discharged from hospital	1256 (38.2)	1151 (34.6)	802 (30.2)	976 (35.7)	971 (32.4)	5156 (34.4)
Discharged from A&E	1051 (32.0)	1027 (30.9)	837 (31.5)	811 (29.7)	1052 (35.1)	4778 (31.9)
Discharged from hospital	1256 (38.2)	1151 (34.6)	802 (30.2)	976 (35.7)	971 (32.4)	5156 (34.4)
Not known when discharged	32 (1.0)	131 (3.9)	85 (3.2)	56 (2.0)	84 (2.8)	388 (2.6)
Died						
At scene or on arrival at A&E	365 (11.1)	420 (12.6)	334 (12.6)	342 (12.5)	328 (10.9)	1789 (11.9)
In A&E	110 (3.3)	116 (3.5)	88 (3.3)	91 (3.3)	108 (3.6)	513 (3.4)
In hospital	140 (4.3)	171 (5.1)	99 (3.7)	110 (4.0)	120 (4.0)	640 (4.3)
Total died	615 (18.7)	707 (21.4)	521 (19.7)	543 (19.9)	556 (18.5)	2942 (19.6)
Total all cases	3286 (100)	3322 (100)	2653 (100)	2733 (100)	2999 (100)	14993

Table 5.3 Patient outcomes for each study service

Outcome	Service n (%)				Total
	1	2	3	4	
Survived					
Did not travel to hospital	556 (16.9)	194 (4.5)	502 (14.7)	477 (11.9)	1729 (11.5)
Discharged from A&E	904 (27.5)	1422 (33.1)	1105 (32.3)	1347 (33.7)	4778 (31.9)
Discharged from hospital	868 (26.4)	2007 (46.7)	1068 (31.2)	1213 (30.4)	5156 (34.4)
Not known when discharged	116 (3.5)	53 (1.2)	2 (0.1)	217 (5.4)	388 (2.6)
Total survived	2444 (74.3)	3676 (85.5)	2677 (78.3)	3254 (81.4)	12051 (80.4)
Died					
At scene or on arrival at A&E	544 (16.6)	352 (8.2)	472 (13.8)	421 (10.5)	1789 (11.9)
In A&E	146 (4.4)	101 (2.4)	105 (3.1)	161 (4.0)	513 (3.4)
In hospital	152 (4.6)	165 (3.8)	164 (4.8)	159 (4.0)	640 (4.3)
Total died	842 (25.7)	618 (14.5)	741 (21.7)	741 (18.6)	2942 (19.6)
Total all cases	3286 (100)	4294 (100)	3418 (100)	3995(100)	14993

The distribution of outcomes remained stable over the 5 years of the study. There were some differences between services. These are most apparent in service 2 which had a much lower proportion of survivors who were not transported to hospital and a higher proportion who were admitted to and subsequently discharged from hospital. In addition service 1 had a high proportion of both deaths and survivors who were left at the scene of the incident. One possible explanation is that the different EMD systems have different sensitivity in detecting those cases where there is a life-threatening condition that is amenable to treatment and there is some evidence of this in the fact that the two services with the lowest proportions of survivors who did not travel to hospital, and the lowest proportions of deaths (services 2 & 4) used the same EMD system (AMPDS). Other possible explanations are different policies between ambulance services as to who should be left at scene or different hospital policies on admission although the proportions discharged from A&E is similar for all services.

These outcomes are analysed in more detail in relation to response time in section 6 below.

6. RESULTS - RESPONSE TIMES AND SURVIVAL

6.1 Methods

Inclusion and exclusions

All patients attended following an A- call during the study periods have been included in the outcome analysis except

- i) patients found dead at scene in whom no resuscitation was attempted.
- ii) patients attended at the scene who survived but were not taken to hospital.
- iii) patients who could not be followed-up because of lack of details and whose outcome is therefore not known.

Groups i) and ii) have been excluded because we have assumed that they could not benefit from rapid response.

Outcome

For the main analysis deaths before arrival at hospital, in A and E, or in hospital after admission have been combined, so that the outcome being assessed is death vs. survival to discharge. However, we have also examined deaths before admission (ie. pre-hospital + in A and E) which may be more sensitive to response time changes.

Analysis

Crude Mortality has been modelled as a function of response time to estimate the (marginal) benefit in terms of the reduced risk of death of improving response time by one minute. There are three types of problem with this analysis.

Firstly, there are some missing response times, and these cases have to be excluded even though they may not be missing at random.

Secondly, cases with long response times may have different characteristics with a different inherent mortality risk than cases with short response times. For example, cases with long response times may be more often in remote, rural areas with different types of incident, population demographics and so on.

Thirdly, there is the possibility of reverse causality – in which the response times are a function of the risk of death rather than vice-versa. This could arise if it is possible for despatchers and drivers to act more quickly in response to calls (correctly) perceived to be higher risk. This is not likely to happen to any great extent in our data because all these calls were in the highest risk category, and small differences in how high the risk actually is are very hard to gauge prior to arrival on scene.

Three strategies have been adopted to overcome these problems

- i) Intended service analysis. Reverse causality and missing response time data can be avoided by using an 'intended service' approach which is analogous to the intention-to-treat approach in clinical trials. In this approach year is used in the analysis rather than actual response time since response times were expected to be improving year on year (the intended service). Analysing by year rather than response time means that cases with missing response time data can be included and there is no possibility of reverse causation. However, case-mix may change over time and it is still necessary to adjust for case mix differences. Furthermore since response times improved to a different extent in different services, analysis by service is necessary.
- i) Analysis by dichotomised response time. Since all the calls were classified as A calls they were all prioritised as needing response within 8 minutes. Considerable pressure has been put on AS to achieve this target for 75% of category A calls. Whilst calls might be attended to with more or less urgency if either they were going to be responded to in less than 8 minutes or more than 8 minutes, there was no flexibility around this threshold. Consequently it is less likely that there could be any reverse causality around response less than or greater than 8 minutes, and we have therefore also calculated the odds ratio of death or survival for responses ≤ 8 or > 8 minutes.
- ii) Case-mix adjustment. Both reverse causality and case-mix variation can be dealt with to some extent by adjusting the analyses for any differences in call and patient characteristics. We have therefore examined the relationship between outcome and
- age
 - sex
 - service
 - clinical category
 - in-hours or out-of-hours
 - weekday/weekend
 - distance from scene to hospital.

We have adjusted the analysis of mortality vs response time for those factors with a significant influence on outcome.

The case-mix adjusted analyses have been carried out by fitting logistic regression models to death or survival using those covariates identified as potentially significant influences on outcome. The fitted values from the models have also been used to calculate the expected number of deaths, and these have been used to calculate Standardised Mortality Ratios (SMRs) – that is the ratio between the observed and expected number of deaths. These SMRs have been graphed and tabulated to illustrate the results.

6.2 Number of cases

As reported above the outcome was known for 14993 (83.5%) of the 17950 patients included in the study dataset. Of these 743 (5.0%) were found dead at the scene and there was no attempt at resuscitation, and a further 2201 (14.7%) died before reaching hospital, in A and E or in hospital (Table 6.1). Of the patients known to have survived, there were 1729 who were attended at the scene but were not transferred to hospital because their condition did not warrant it. Excluding these patients and those found dead at the scene there were 12521 patients with known outcomes included in the study of outcomes and response times.

Table 6.1 Numbers included in the outcomes study

Outcome		N excluded	N included	%
Died	At scene, no attempt at resuscitation	743		5.0
	At scene, before A and E		1048	7.0
	In A and E before admission		513	3.4
	In hospital, before discharge		640	4.3
Survived	Did not travel to hospital	1729		11.5
	Discharged from A and E		4778	31.9
	Admitted		5156	34.4
	Not known disposal		386	2.6
Known outcome		2472	12521	100
Not known		2957		
Total		5429	12521	

6.3 Factors associated with outcome

The most important determinants of survival to discharge are the clinical condition and age of the patient. Given these two factors we have examined the influence of time of day, day of week, sex, service, and distance from scene to hospital (Table 6.2).

Table 6.2 Association between characteristics and odds of death before discharge

Characteristic		Estimated odds ratio	95% CI	df	Ddev ¹	p ²
Clinical condition (see section 5)				17	5980	<0.001
Age	0 – 54	Reference				
	55 – 74	3.57				
	75 +	6.86				
	Missing/NK	11.0				
Age ³	Per year	1.03	(1.03,1.04)	1	214	<0.001
Sex	Male	Reference				
	Female	1.02	(0.86,1.18)	1	0.0	p>0.5 ⁴
	Missing	4.03				
Time of day	0800 – 1759	reference				
	1800 – 0759	0.84	(0.73,0.98)	1	5.4	0.02
Day of week	Weekday	reference				
	Weekend	0.90	(0.76,1.05)	1	1.9	0.20
Distance from scene to hospital ⁵	< 10kms	reference				
	10 - 20kms	1.13	(0.92,1.43)			
	20 kms +	1.02	(0.81,1.27)			
	Missing	1.03		2	1.2	0.8
Service	1.	reference				
	2.	0.53	(0.43,0.65)			
	3.	0.95	(0.78,1.17)			
	4.	0.49	(0.40,0.61)	3	77.4	<0.001

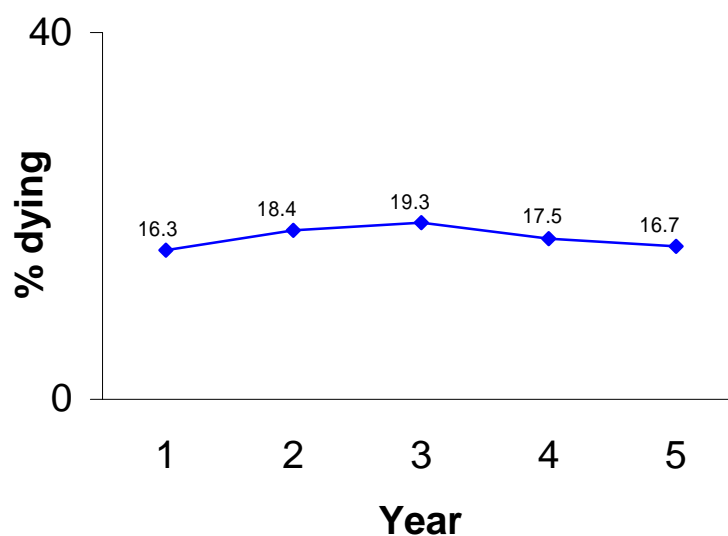
1. Δdev = change in deviance, approximately distributed as χ^2_{df} if there is no association with outcome.
2. p-value assuming $\Delta dev \sim \chi^2$.
3. 8% of cases have missing age. The average age of the known cases in the same clinical group and service and year was imputed for them.
4. Male vs. female excluding the cases with missing sex.
5. Patients who died at the scene have been excluded from this analysis.

Given clinical condition and age, there was some evidence that there were still differences between the services in outcome, but little evidence of other effects. A weak association with time of day was found with a smaller chance of dying out-of-hours than in-hours. The small association with sex was only due to a difference in outcomes between patients with known sex and those with missing data, and consequently sex hasn't been used to adjust the outcomes for casemix.

6.4 Crude mortality

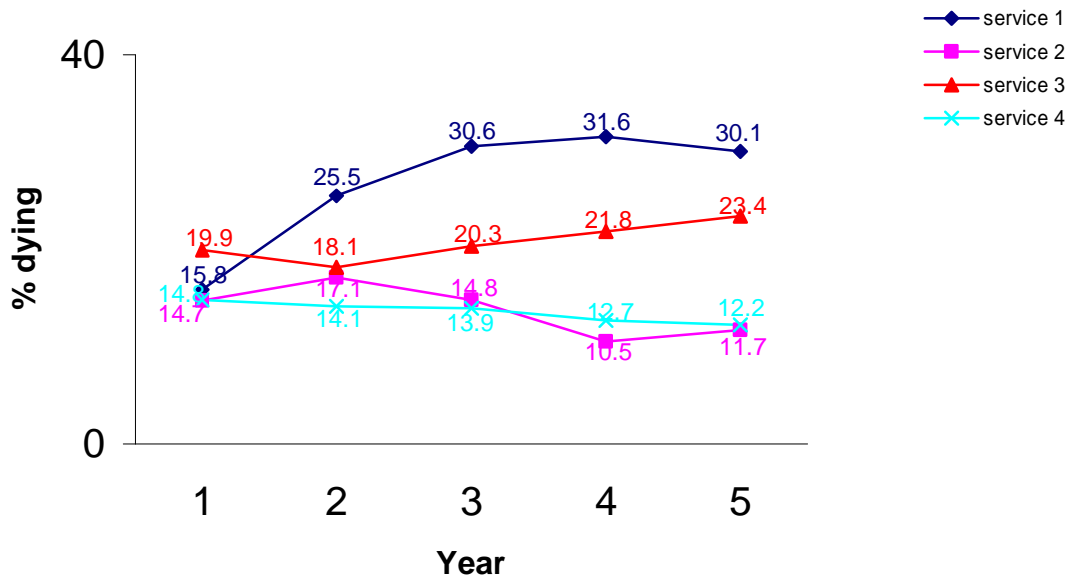
Of the 12521 patients included in this analysis of response time effects 2201 (17.6%) died, approximately half of them before reaching hospital. The proportions dying before discharge in each year were similar with no obvious trend (Fig 6.1).

Fig 6.1. Proportion of patients dying by year



The proportions who died differed between services ($\chi^2 = 77.4$, $df = 3$, $p < 0.001$), probably reflecting a different casemix included in the A- calls reported to the study. There was no evidence of an improvement in crude mortality over time as response times improved (Fig 6.2). Indeed in service 1 there was a dramatic leap between 1997 (15.8%) and 1999 (30.6%) in the proportions of cases reported to the study who died - probably reflecting a change in the way in which priority codes were allocated to calls in that service.

Fig 6.2. Proportion of patients dying before discharge by year and service



This change affected several groups of patients especially those with chest pain who were not reported as unconscious or not breathing. In service 1 in 1997 227 patients were coded like this and reported to us but only 59 in 2001. Since the despatch codes assigned to calls are 'labels', which to some extent can be changed by policy and practice, rather than fixed characteristics (such as age, sex, or clinical condition), the changing pattern of despatch codes may reflect either a different casemix or the same casemix with different labels. If the changing pattern of codes reflects a changing casemix with the codes being assigned consistently over time then we can use despatch code to adjust for case-mix in the analysis. If, however, the changing patterns merely reflect a different priority labelling of the same case-mix then using despatch code may cause bias in the analysis. We have therefore not used despatch code to adjust for casemix in all of the main analyses comparing outcomes over time., and we have tried either adjusting for the fixed characteristics, or omitting service 1. However, we have also used the despatch code in some analyses on the assumption that the change in the numbers of patients with different despatch codes reflects a real change in the numbers of such patients identified as A- .

6.5 Intended service analysis

Across all four services together the unadjusted odds of dying before discharge changed by an average of +3% per year from 1997 – 2001 (Table 6.3). Adjusting for the fixed characteristics – clinical code, age, time of day and service – the odds of dying across all four services together changed by +1% per year. However, there were significant differences between the services ($X^2 = 11.1$, $df = 3$, $p = 0.02$) with a substantial increase in service 1 (+16% per year) , negligible reductions in services 2 and 3, and a reduction in service 4 (-10%

pa). Further adjusting these estimates for despatch code made little difference, although a more consistent reduction of -1% to -5% was found in services 2 to 4.

Table 6.3 **Estimated change in odds of dying per year**

Service	Crude estimate	Estimates adjusted for characteristics ¹ and despatch code	Adjusted for characteristics ¹ only	
			Estimates	(95% CI)
1	1.22	1.13	1.16	(1.04, 1.29)
2	0.90	0.97	0.99	(0.90, 1.09)
3	1.06	0.99	1.0	(0.91, 1.10)
4	0.95	0.95	0.90	0.81, 1.01)
All	1.03	1.02	1.01	(0.96, 1.06)
Services 2, 3, 4	0.96	0.97	0.96	(0.91, 1.02)

1. Clinical code, age, and time of day.

Adjusting for the fixed characteristics, SMRs showing the ratio of the observed numbers of deaths to the numbers predicted by the casemix adjustment model by year for all services together are shown in Fig. 6.3, SMRs and response times in Fig 6.4, and SMRs and by service in Fig. 6.5. There is clearly no evidence of improving response times and declining SMRs.

As shown in Fig. 6.2 the results for service 1 probably reflect a change in prioritisation policy between 1997 and 1999 and we have therefore re-examined these analyses. Excluding service 1 it is estimated that there was a reduction in the odds of dying of -4% (95%CI -9%, +2%) per year. However, there was little change in reported response times in services 2, 3 and 4 either (see Fig 6.6).

We have also examined the year-on-year change in the odds of pre-hospital death (ie. before admission). In these analyses patients who died after being admitted to hospital are classified as survivors. For pre-hospital death the crude odds changed by an average of +4.5% per year, and the adjusted odds by +4.9%. Excluding service 1 the crude odds fell by -0.9% per year, but the adjusted odds increased by +3.0%.

Thus, there is no evidence in the data that outcomes improved over the five study years.

Fig 6.3 SMR (and 95% confidence interval) by year for all services

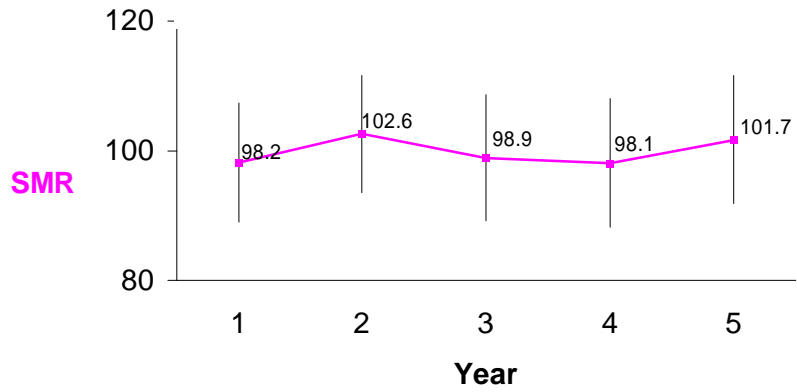


Fig 6.4 SMR and response performance by year

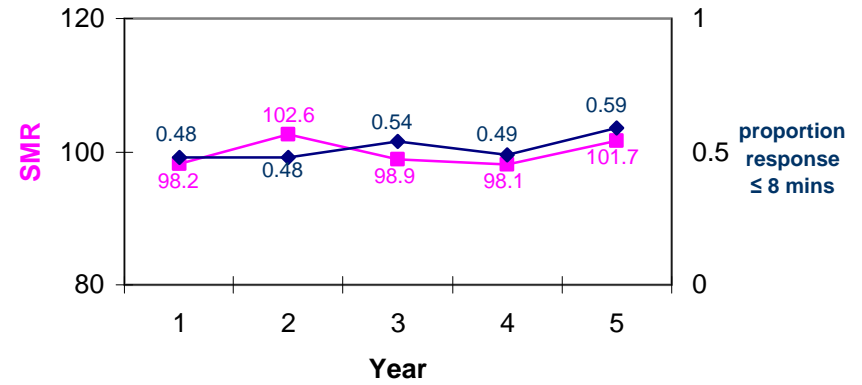


Fig 6.5 SMRs by service and year

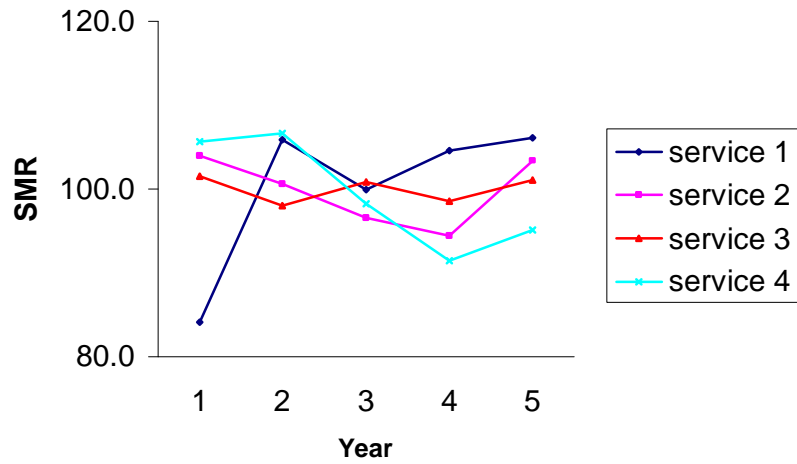
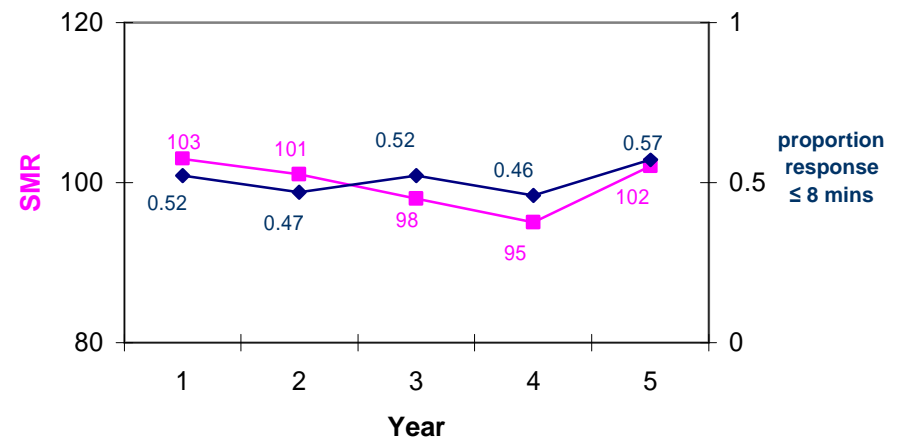


Fig 6.6 SMR and response time performance in services 2, 3, and 4 by year



6.6 Service received analysis

Number of cases

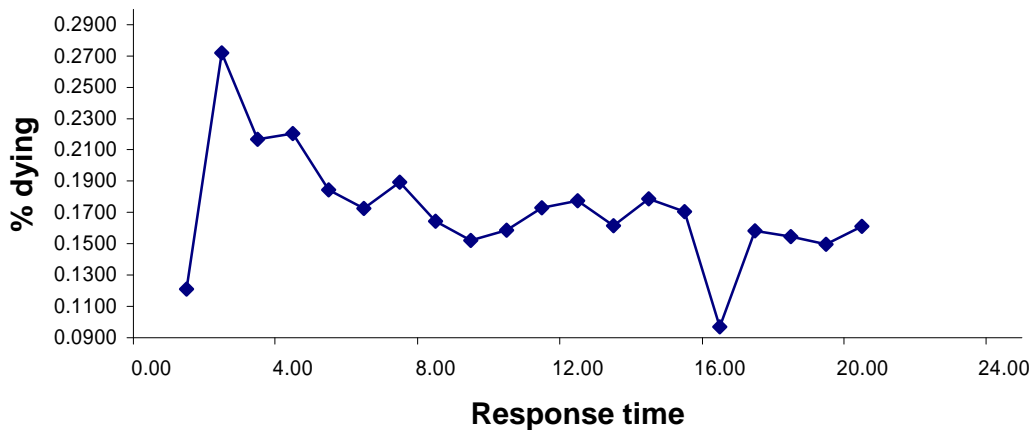
The effect of the actual response time has been estimated by examining the probability of dying in relation to the response time achieved, adjusting for the same casemix factors used above. Other differences in casemix between services and over time have also been accounted for in the model by fitting a term for each service by year. In effect the model examines the relationship between response time and the risk of dying within each service and year cohort. Thus the data omitted from service 1 because of a possible change in prioritisation procedures and hence casemix can be included in this analysis.

However, there are also n=202 cases with missing response times that have to be excluded, leaving n=12319 cases for analysis.

Mortality

Death before discharge is plotted against response time in Fig 6.7. Mortality appears to fall for response times between 1 and 8 minutes and thereafter appears steady at about 16%. Overall, there is an estimated 1.5% decline in crude mortality per minute increase in response time. However, adjusting for casemix this effect is reversed, and there is a non-significant increase of +0.4% (95% CI -1.1%, +2.0%) in mortality for each minute increase in response time.

Fig 6.7 Death before discharge by response time

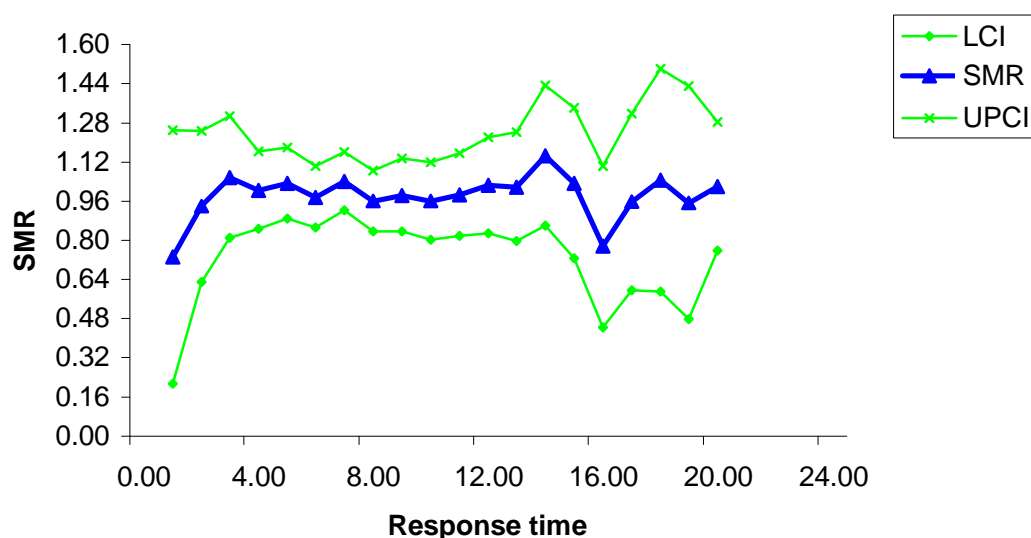


The SMR adjusted for the characteristics clinical condition, age, time of day, year and service is plotted against response time in Fig 6.8, which also shows the lower 95% confidence limit (LCI) and the upper limit (UPCI).

The adjusted odds of dying when the response time was greater than 8 minutes were +1.4% higher (-13%, + 18%) than when it was less than or equal to 8 minutes. Using the cut-off

recommended by Pons^(ref) the adjusted odds of dying when the response time was greater than 4 minutes compared to ≤ 4 minutes were +4.1% (-22%, +39%).

Figure 6.8 SMR adjusted for characteristics by response time



Repeating these analyses for deaths before admission to hospital, there was a similar 1.5% decline in crude mortality per minute increase in response time. Adjusting for case-mix, however, there was weak evidence of a +2.3% (95% CI: 0.0%, +4.7%) increase in death before admission for each extra minute it took to respond.

The adjusted odds of death before admission when the response time was > 8 minutes compared to when it was ≤ 8 minutes were +9.7% (-13.2%, +37.1%), and when the response time was > 4 minutes the odds were +49.8% (+0.5%, +223%) higher than when the response time was ≤ 4 minutes.

Despatch groups

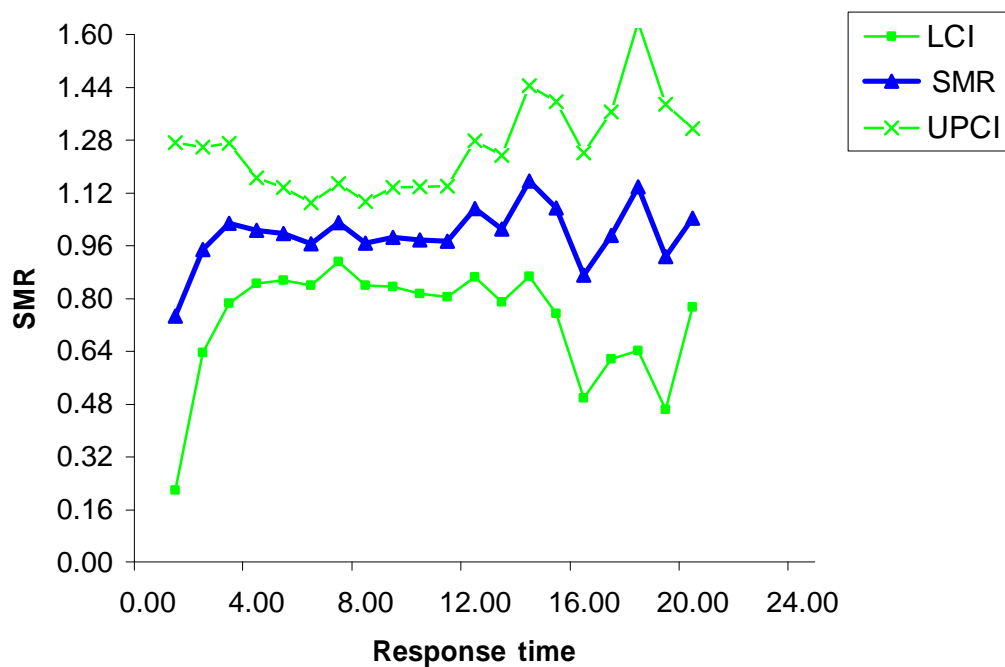
One explanation for why there is no discernible relationship between response time and survival is that the benefit of rapid response occurs only for a very small number of patients, and any effect is being balanced by despatchers and crews occasionally being able to respond faster to those most at risk. We know that this reverse causality might be happening to some extent because there is a very small but significant amount of heterogeneity between clinical groups in their mean response times ($F_{17, 12301} = 6.3, p < 0.001$) with low response times in cardiac arrest and asphyxia for example, and higher times in patients with non-specific signs and symptoms. Furthermore, there are significantly shorter response times for patients unconscious, not breathing, and/or with no pulse at the time of the crew arriving on scene compared to patients whose vital signs weren't compromised. Of course reverse causality of

decreasing response times being associated with an increasing risk of death merely serves to show how well despatchers and crews identify those most at risk even within clinical groups.

One possible way to take this into account is to examine the actual despatch codes issued by despatchers at the time of the call. These codes are not the same for all cases in each clinical group, indicating that a different response may be being made to different cases within each group.

Given the clinical group, age, sex, time of day and year and service, the despatch code is a very significant additional predictor of survival to discharge ($\chi^2 = 598$, $df = 25$, $p < 0.001$), and adjusting the regression of survival on response time for the despatch code as well as the other characteristics there is some weak evidence for an increase of +1.4% (95%CI: -0.3%, +3.1%) in the odds of dying for each minute increase in response time. The estimated increase in the odds of dying for response times over 8 minutes compared to response times less than 8 minutes is now +7.5% (-8.7%, +26.5%). The SMR adjusted for despatch code as well as the fixed characteristics is plotted against response time in Fig 6.9.

Fig 6.9 SMR adjusted for despatch code as well as other characteristics by response time



7. RESULTS - CLINICAL GROUPS AND OTHER OUTCOMES

7.1 Introduction

Overall there is little evidence in the data that faster response times have led to better outcomes. This is probably due to several factors. For example,

- 1) Reported response times only improved slightly over the five year period and real response time improvements may have been even smaller. Substantial improvements were only reported in Service 1, and this service also had substantial increases in crude mortality during the early years of the study.
- 2) Response times can show 'reverse causality' in which faster responses are delivered to those most at risk, even with A- calls.
- 3) The number of patients who can benefit from fast response is actually very small and the benefit in this small group is being 'lost' in the large group who do not need (ie. have no capacity to benefit from) fast response.

The latter point suggests that it might be helpful to examine response time benefits in particular groups of patients in whom there may be capacity to benefit and this is done below.

7.2 All clinical groups

Overall, there was only very weak evidence of improving outcomes with faster response times. Adjusting the raw data for clinical group, despatch code, age, time of day, service and year using a logistic regression model with death at any time as the outcome, the estimated change in the odds of dying per minute faster response time was -1.4% (95% CI +0.3%, -3.1%). The estimated improvement in the odds of dying with responses ≤ 8 minutes versus responses over 8 minutes was -7.5% (+8.7%, -26.5%).

The estimated odds of dying with response times over 8 minutes compared to ≤ 8 minutes are shown in Table 7.1 estimated for each clinical category separately. There was no reliable evidence of an improvement in outcome with short response times in any of these groups. Indeed for asphyxiation there was some evidence of an inverse relationship. In the crude data there were 2/14 (14.3%) deaths due to asphyxiation at response times >8 mins and 15/36 (41.7%) at response times ≤ 8 mins. There was a large estimated benefit in out of hospital cardiac arrest (OHCA) with no other diagnosis with the odds of surviving doubling for response time ≤ 8 mins, but because there were few survivors there was no robust evidence of benefit. In fact, there were many other patients who suffered an OHCA, but who had other cardiac diagnoses such as MI recorded. We have therefore examined the effect of changing response times separately in all OHCA's below.

Other groups in whom there is capacity to benefit include trauma and severe haemorrhage (which includes ruptured aortic aneurysms for example). In neither case was there evidence

of benefit, although both groups had an estimated 25% increased chance of dying with longer response times. These groups are also examined in more detail below.

Table 7.1 Effect of slow response on survival by clinical group

	Clinical Group	Estimated odds of dying with response >8 minutes	(95% CI)
1.	Cardiac arrest (no other diagnosis found)	2.2	(0.60, 8.0)
2.	Confirmed MI	1.0	(0.65, 1.54)
3.	Other cardiac disease	0.72	(0.48, 1.06)
4.	Chest pain ? cause	1.05	(0.36, 3.02)
5.	Respiratory disease	0.75	(0.44, 1.28)
6.	Respiratory symptoms ¹	-	-
7.	Asphyxia	0.16	(0.03, 0.90)
8.	Injury/Trauma	1.27	(0.57, 2.83)
9.	Poisoning	1.01	(0.22, 4.74)
10.	Serious haemorrhage	1.28	(0.44, 3.72)
11.	Stroke	1.21	(0.83, 1.78)
12.	Collapse unresponsive	1.63	(0.88, 3.02)
13.	Fits/Convulsions	1.37	(0.08, 32.8)
14.	Diabetes related	0.43	(0.04, 5.2)
15.	Psychiatric ¹	-	-
16.	Other diagnosis	1.62	(0.94, 2.78)
17.	Other signs/symptoms	0.69	(0.22, 2.13)
18.	Missing/Not known	1.45	(0.92, 2.28)

1. There were too few deaths in these groups to estimate the OR.

7.3 Out-of-hospital cardiac arrest

A total of 1258 patients in whom there was attempted resuscitation were classified by the attending paramedics as having an out-of-hospital cardiac arrest. For most of these patients no (other) clinical diagnosis was found in A and E or hospital notes, usually because the patient died before admission into hospital. However, 80 patients had a non-cardiac diagnosis recorded and these patients were excluded from the analysis (see Table 7.2). No outcome was found for a further 17 cases, leaving 1161 patients in the main analysis.

Epidemiology

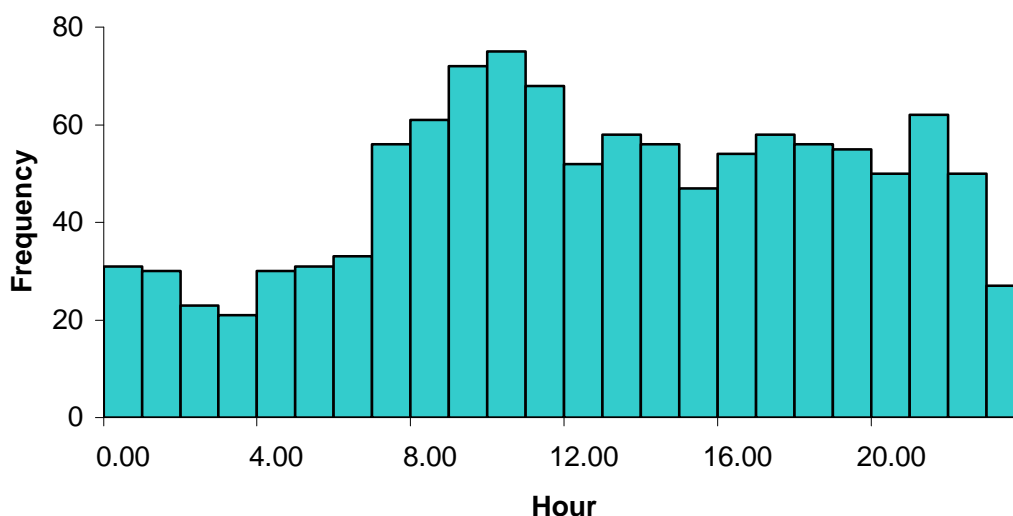
The median age of the patients was 71 (IQR 60 to 79); just over two-thirds were male (787/1148, 13NK). 999 calls for arrests which resulted in attempted resuscitation were about twice as common during the day as during the night and they happened fairly evenly throughout the day, though the busiest period was in the morning from 0900 – 1159 (see Fig. 7.1).

Table 7.2 Clinical diagnosis of out-of-hospital cardiac arrests

	<u>N</u>	<u>%</u>
<u>Cardiac disease</u>		
Confirmed MI	46	3.7
Other cardiac disease	28	2.2
<u>Non Cardiac disease</u>		
Injury	7	0.5
Asphyxia	10	0.8
CVA	9	0.7
Other haemorrhage	54	4.3
<u>No clinical diagnosis</u>	1104 ¹	87.8
All	1258	100.0

1. Of these, 17 had a missing outcome.

Fig 7.1 Time of day of call for cardiac arrests



Survival

Overall 30 (2.6%) of the 1161 cardiac arrest patients survived to hospital discharge, which is typical of that reported in the UK though much less than has been reported elsewhere, most notably in Seattle, USA.

Crew witnessed arrests

Not all of the 1161 patients had an ambulance called because they had arrested. In 58 cases the arrest occurred after the crew arrived at the patient. Eight of these 58 patients survived (13.8%) compared to just 19 of the 1054 patients (1.8%) whose arrest was not witnessed by crews (Table 7.3). We don't know the time of arrest for these patients and hence cannot

determine whether the response time was a factor in their arrest being witnessed, and hence in the survival of these 8 patients.

Rhythms

An initial rhythm was recorded for 1010 of the 1161 patients of whom 25 survived (2.5%), 20 of these were in VF (Table 7.4). Twelve patients were initially recorded in sinus rhythm and 11/12 of these cases the patient was given CPR and was recorded as being in sinus rhythm afterwards. It is unclear whether the AS crews have contributed to resuscitation in these cases. For example, one patient was a baby attended by a midwife who appears to have resuscitated the baby prior to the arrival of the crew on scene. The baby survived and although the crew may have contributed to this outcome it is unclear whether rapid response and resuscitation by the ambulance crew played any part.

Table 7.3 Survival by whether the arrest was witnessed by the crew

	Survival to discharge		Total
	n	%	N
Crew witnessed	8	13.8	58
Not crew witnessed	19	1.8	1054
Not recorded	3	6.1	49
Total	30	2.6	1161

Table 7.4 Survival by presenting rhythm

Rhythm	Crew witnessed			Not crew witnessed			All ¹		
	N	n	%	N	n	%	N	n	%
Sinus rhythms	6	2	33.3	6	2	33.3	12	4	33.3
VF	20	5	25.0	395	15	3.8	415	20	
Asystole	3	0	0.0	414	1	0.2	417	1	
Other	18	0	0.0	140	0	0.0	158	0	
NK	11	1	9.9	99	1	1.0	110	2	
Total	58	8	13.8	1054	19	1.8	1112	27	2.4

1. There are a further 49 patients for whom there was no information about whether the arrest was witnessed.

Bystander intervention

Of the 1054 patients whose arrests were not witnessed by crews, nearly half (437) were witnessed by bystanders. In these patients 2.8% survived compared to only 0.9% of those not witnessed. This is partly due to the fact that the time from collapse to contact will be shorter when the collapse is witnessed, but is also due to bystanders intervening to provide resuscitative assistance, typically some form of CPR. Overall 3.3% of patients survived

whose collapse was witnessed and who were given bystander CPR compared to 2.1% who weren't given CPR (Table 7.5).

Table 7.5 Bystander CPR

Bystander witnessed	Bystander CPR	Survived		Total
		n	%	
Yes	Yes	8	3.3	240
	No	4	2.1	190
No	Yes	2	1.1	188
	No	3	0.8	366
Not known	Yes	1	8.3	12
	No	0	0.0	32

Of course the benefits of bystander CPR are even more evident for patients who were found in VF at the time of contact, in whom 5.4% survived (Table 7.6).

Table 7.6 Bystander CPR in patients found in VF

Bystander witnessed	Bystander CPR	Survived		Total in VF
		n	%	
Yes	Yes	7	5.4	129
	No	3	3.3	90
No	Yes	2	3.2	62
	No	2	2.4	83
Not known	Yes	1	16.7	6
	No	0	0.0	13

Response times

In the 1054 patients whose arrests were not witnessed by crews after they had arrived on scene, 19 patients (1.8%) survived. The survival rates by response time are shown in Fig 7.2. Survival shows the expected pattern with survival worsening with lengthening response time. However, there were 4 survivors at response times between 8 and 12 minutes. Examining the effect of response time in patients found in VF (Fig 7.3) shows that all the survivors at longer response times were in VF. It also shows that short response times under 6 minutes can lead to a survival chance over 5%. In fact 9/62 (14.5%) of patients in VF attended within 6 minutes who had bystander CPR survived (Fig 7.4), illustrating the possibilities for an effective emergency care system to make a difference in these patients.

Fig 7.2 Survival in OHCA, by response time

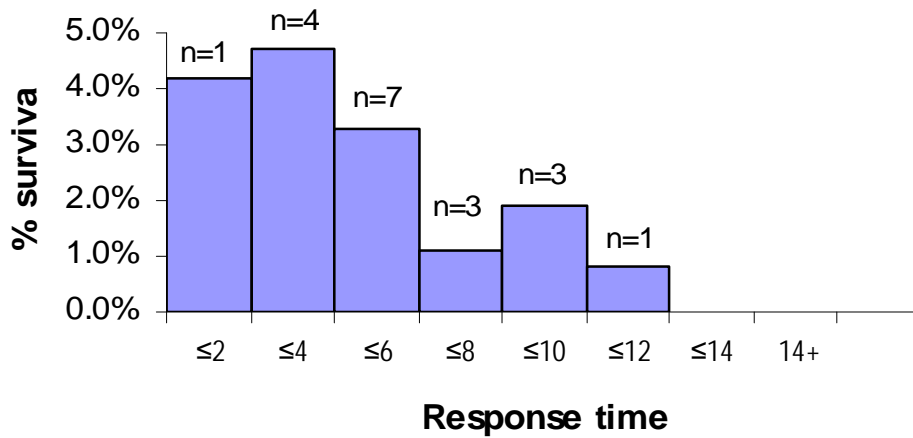


Fig 7.3 Survival in OHCA of patients in VF, by response time

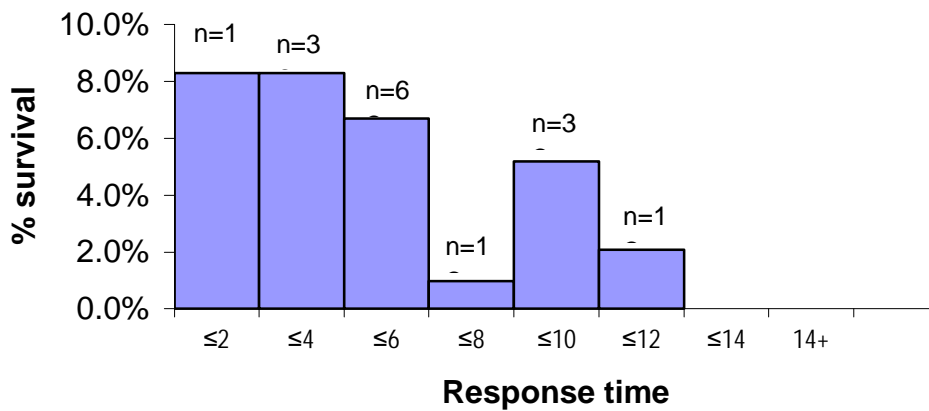
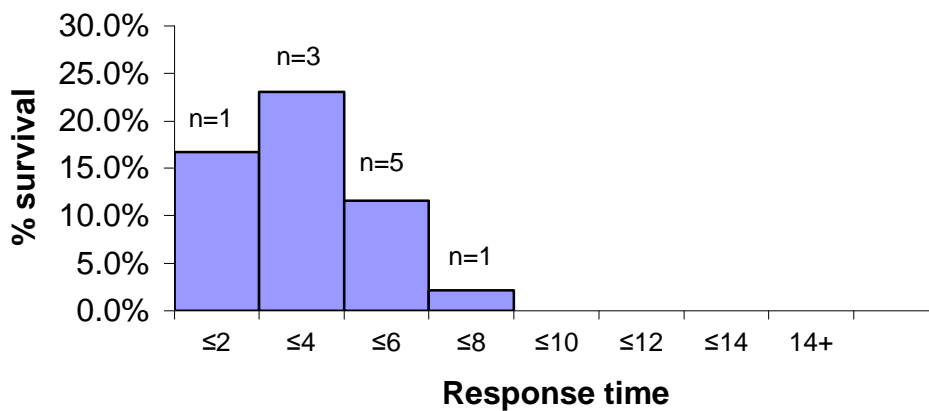


Fig 7.4 Survival of OHCA patients found in VF who had bystander CPR, by response time



Factors associated with survival in not crew witnessed OOH cardiac arrest

Including all the factors in a multiple logistic regression model the most important predictive factors for survival were response time, whether in VF or not, and whether the arrest was witnessed (Table 7.7). The estimated effect of a one minute reduction in response time was to improve the odds of survival by 19% (95% C: +3%, +33%).

Table 7.7 Odds of survival in OHCA

Factor		Odds ratio for survival	95% CI
Rhythm -	In VF vs not	6.73	1.46, 31.0
Response time -	Per minute shorter	1.19	1.03, 1.49
Witnessed arrest -	Witnessed vs not	3.09	0.84, 11.4

7.4 Ruptured aortic aneurysms and other serious haemorrhage

A recent UK study has found no relationship between the estimated time from the patient's home to the nearest hospital and survival from ruptured abdominal aortic aneurysms (RAAA)¹⁵. However, other studies have found such a relationship and patients in whom there is severe bleeding plainly have the capacity to benefit from rapid response and transfer to definitive care and we have therefore also considered this group.

There were 125 cases of serious haemorrhage in the 12521 patients in the response and outcomes dataset (ie. who were taken to hospital and in whom there was attempted resuscitation). 100 (80%) of these patients died.

No clear evidence of a relationship between straight-line distance from scene to hospital was found (odds of dying at 20kms+ compared to <10kms = 1.32 (0.42, 33.3). The crude estimate of the relationship between the odds of dying and response time was a 24% fall in the odds for responses over 8 minutes compared to responses \leq 8 minutes. However, adjusted for age, time of day, service and year using the earlier model, the estimated effect was for a 28% (95% CI: -56%, +272%) increase in the odds of dying for longer responses, indicating the potential for benefit in this group.

7.5 Trauma

There is a more substantial literature on the relationship between response times and survival in trauma. However, little evidence has been found either that short response times or short total pre-hospital times lead to better outcomes¹⁶⁻¹⁹. In the 12521 patients in the response and outcome dataset, there were 795 injured patients of whom only 30 (3.8%) died.

The crude estimate was for a 6% lower odds of dying with response times over 8 minutes. Adjusted for age, time of day, service and year the estimated odds of dying before discharge were 27% higher for longer response times. This estimate was adjusted further for injury severity using the ISS score, and the estimated odds of dying with response times over 8 minutes compared to under 8 minutes were -1.5% lower (-59.3%, +138%).

7.6 Summary

We have considered four clinical groups in which we expected that there might be some discernible benefit from faster response – asphyxia, cardiac arrest, serious haemorrhage, and trauma. There was no evidence of any significant effect in trauma, serious haemorrhage, or asphyxia although there was an indication that there may be a potential benefit for patients with serious haemorrhage. However, for out-of-hospital cardiac arrest we found that with other factors taken into account a one minute reduction in response time was estimated to increase the odds of survival to discharge by 19%.

We have also found that the arrival of a crew prior to arrest may be one of the most beneficial interventions an ambulance service can make. In patients who have already arrested and whose collapse is witnessed by bystanders even rapid response within a few minutes only results in about 5 – 10% of patients being resuscitated and surviving to discharge. If the patient is in VF and bystanders provide CPR, results may be better than this. Nevertheless, quick response to patients in severe acute crushing chest pain may enable rapid reperfusion preventing arrest in some patients and in those that do arrest in the presence of the crew 14% may still be resuscitated to survive to discharge.

8. ECONOMIC EVALUATION

The economic evaluation of the response time policy aimed to estimate the costs of improving response times and match these with improvements in mortality to produce an incremental cost per life-year saved. The estimation of costs was to be split into two separate components; pre-hospital care, and hospital care. The costs of pre-hospital care were estimated using the four study ambulance services as case studies, with data collected via interviews with Trust staff. This was supplemented by an analysis of national ambulance service data collected through annual surveys. The costs of hospital care were to be estimated by patient-level costing of the study data collected for the main part of the study. Together, these data would give an estimate of the costs associated with the changes seen over the study period. Further analysis was also planned to examine the costs of improving response times further, by extrapolating the study findings.

8.1 Case studies

This work aimed to directly identify and analyse changes in ambulance service provision specifically undertaken to reduce response times. The case studies were undertaken in West Midlands, Berkshire, Essex and Derbyshire (now part of East Midlands Ambulance Service). These four areas were chosen because they were about to implement priority dispatch systems: that is, the prioritisation of all 999 calls into categories based on their level of medical urgency.

Methods

Interviews with relevant ambulance service personnel were conducted in the four ambulance Trusts in order to gather more detailed data on some aspects of changes in service. In particular, the interviews attempted to: identify all planned service changes; identify the reasons for the changes; identify all possible resource consequences of these changes; and gather qualitative data on the effects of changes in service provision e.g., on-the-job training which reduces time off the road for ambulance crews.

Service changes and reasons for the changes were documented to ensure transparency. This was to reduce subjectivity in assessing the impact of the changes on improved response times. For example, extra crews may primarily be aimed at reducing response times but might also be required to meet increased demand.

Interviews were first conducted in the summer of 1998 and they focused on changes in service provision during the financial year April 1997 to March 1998. A second round of interviews was held in early 2001 asking about changes in service provision between April 1998 and March 2000.

Results – Service 1

Between April 1997 and March 1998 the largest item of resource use in Service 1 was the investment in information technology which was introduced in order to assist with demand management (Table 8.1). Other service developments were aimed at maximising the number of crews and vehicles on the road e.g. changes to vehicle servicing and staff rotas, and these required few resources.

In the second period, April 1998 to March 2000 stand-by locations were introduced (Table 8.2). This development was facilitated by use of system status management technology as well as local knowledge. Planning and organising the stand-by locations was done in house.

Results – Service 2

In the first study period, only small investments were made with respect to improving response times, with the only large initiative being funded through winter pressure monies (Table 8.3). The other changes were funded within budget, and as such represent improvements in efficiency.

Between April 1998 and March 2000, an investment of £2.2 million was made to recruit staff and purchase vehicles. This was funded by local purchases and savings identified within the service (Table 8.4). Other initiatives also continued.

Results – Service 3

From the start of the study period April 1997, Service 3 invested in increasing capacity with the purchase of motorbikes, implementation of voluntary first responder schemes and utilisation of some managers as first responders (Table 8.5). Other work also went into reducing pressure on the A&E vehicles by minimising the impact of Category C and non-urgent workload. Other smaller investments were made to improve call handling and vehicle allocation (e.g. predictive analysis and standby points).

In the second study period, April 1998 to March 2000, capacity was increased substantially following the investment of £1.1 million (Table 8.6). This investment followed research by ORH that identified this sum as the amount required to meet the 75% Category A target. This was spent on crews and vehicles. Other smaller initiatives were also expanded or continued.

Results – Service 4

Table 8.7 below shows that most of the service developments that took place between April 1997 and March 1998 were aimed at improving technical efficiency: that is, improving response times within existing budget. Very few of the changes that were identified involved increased spending and those that did were relatively low cost. During this period, according to Trust personnel, the service development that had the biggest impact on improving response times was the introduction of stand-by locations.

Table 8.8 identifies further changes in the service in the two-year period between April 1998 and March 2000. In this period as well as improving efficiency through such activities as reviewing stand-by locations and using more staff as first responders substantial increases in operational staff and vehicles were directly targeted at reducing response times.

Discussion

All services implemented multiple initiatives to improve response times, and showed great imagination in identifying ways of attempting to achieve this. Many of the changes, particularly in the early years of the study, were financed within budget, and as such improved the efficiency of operation. In only two services were large investments made in operational capacity (Services 2 and 3).

Common across the four services were improvements in call handling and vehicle location. Most services also tried to reduce pressures on the A&E service by handling urgent and Category C calls differently, and increasing capacity by changes to working practices (e.g. through changes in rotas, job training, operationalising supervisors). First responder schemes were also instituted in two of the services, as a way of increasing capacity.

However, several problems were encountered with this approach. Firstly, it was difficult to identify changes that were implemented with the sole intention of improving response times. Within all services, call volume was increasing, and so many changes had the dual role of improving response times and meeting increased call volume. These two aspects of service delivery are inseparable. Consequently, identifying the 'pure' cost of improved response times is not possible using this method.

Secondly, identifying the relevant initiatives was subjective. The interconnectedness of ambulance services meant that initiatives away from Category A calls, were frequently cited as helping Category A response times, e.g. increasing the capacity of PTS.

Thirdly, many of the initiatives were undertaken within budget, by reallocating resources and generating cost savings. This made it difficult to estimate costs, as budgets had not changed, and business plans or contracts had not been drawn-up to justify the service initiative. Only in rare cases was a cost readily identifiable with a service development (e.g. use of winter pressure monies, or large investments in staff/vehicles). All other costs had to be pieced together from various sources, taking up a lot of Trust time.

One consequence of these difficulties is that producing a total cost of changes implemented to improve response times was not sensible. The data collected, however, gives a clear picture of ambulance service ingenuity in implementing diverse changes in service to improve response times within budget. Methodologically, it also highlights the need for an approach that can disentangle changes in response times and changes in workload.

8.2 National survey of costs and response times

Identifying the costs associated with improving response times within the four services is limited by our ability to control for confounding factors, most notably, increases in volume. With a large enough sample, this can be done statistically through regression analysis; an approach known as cost function analysis within the economics literature.

Methods

The key data for the analysis are cost per case and response times. Volume of calls are included as economic theory suggests that this will heavily influence average costs. Response time and call volume were collected from Ambulance Service Statistical Bulletins and cost data from Trust Financial Returns, for the years 1997/8 through to 2003/4. Cost data were adjusted to 2003/4 prices using the Hospital and Community Health Service Pay and Prices Index, where available, and using General Domestic Product deflators elsewhere.

Of note, is that during the period studied, there were several mergers;

- Derbyshire, Nottinghamshire and Leicestershire became East Midlands Ambulance Service (EMAS).
- Cleveland, Humberside and North Yorkshire became Tees, East and North Yorkshire Ambulance Service (TENYAS).
- Durham and Northumbria became North East Ambulance Service (NEAS).
- Shropshire merged into West Midlands Ambulance Service.

The new services, and their pre-existing constituent services, were coded as separate services.

Cross-sectional time-series data (or panel data) can pose some problems with estimation. A simple pooled analysis of the data, for instance, does not take account of differences in the underlying data generating process over time or service specific effects. The model used therefore included effects to describe the variation between services, plus year dummies to allow for changes in the productive process over time.

The analysis specified cost per incident attended as the dependent variable, with response times, call volume, call volume squared and year as the independent variables. An additional set of analyses were undertaken on the subset of services that were not involved in mergers.

Results

The data shows large increases in the percentage of category A calls responded to in less than 8 minutes, although this is not noticeable until 2001/2 (Table 8.9). Also of note is the steady increase in activity over the time period, and the reduction in cost per case. The increase in the number of Ambulance Services contributing data (n) over time reflects the

introduction of priority despatch systems into the different Ambulance Trusts, which are required to categorise calls into A or B.

The full model is based around a specification that reflects the study question (i.e. the impact of response time on costs) and theoretical considerations (e.g. the common existence of economies of scale). This shows a positive, but statistically insignificant relationship between the main response time target – the proportion of category A calls responded to in under 8 minutes (Table 8.10, Model 1). The also appears to be a 'u'-shaped cost curve, with Trusts experiencing increasing, then decreasing returns to scale.

Overall the models do not produce any statistically significant coefficients with respect to the response times, which casts doubt on the existence of clear relationships within the data. This uncertainty is also shown by a change in the sign on 'cata8', when a more parsimonious formulation is used (i.e. Model 2).

The analyses on the subset of services that did not undergo mergers has little effect on the specification of the models other than to produce positive coefficients on the 'cata8' variable for both models.

Discussion

The models show a clear relationship between volume of calls and cost per case, but not response time. This is thought to be a product of a large amount of variability in the data, which in turn reflects large differences that exist between services in terms of costs. Another reason for a clear relationship not appearing is that some improvements in response times were achieved without increases in budgets, but through efficiency gains or shifts within the budget. It was expected that the year dummies would play an important role in describing these changes in the underlying production function that have taken place over the time period, but these were not statistically significant. Alternative specifications have been used to try and take into account these changes, and as a result, clarify the relationship between cost and response time. However, the data required for these analyses (e.g. unit hour utilisation) are poor, and produce only minor changes to the results.

The coefficient on 'cata8' in Model 1 indicates a 27.1 pence rise in cost per call for each percentage point increase in response time; using mean 2003/4 activity, this corresponds to around £37,000 increase in the average Ambulance Trust's annual costs. The twenty percentage point increase in the Category A response times over the period shown in Table 8.1 therefore corresponds to a £750,000 increase per annum. The lack of statistical significance on this coefficient, and its sensitivity to changes in specification, however, mean that we should be extremely cautious about this interpretation. Alternative specifications estimate cost savings from improved response times (Model 2) to £1.7 million per annum (Model 4).

8.3 Patient-level costing of hospital care

This part of the study aimed to estimate a cost associated with each patient included in the main part of the study, by applying costs to the following patient categories; (i) deaths before arrival at hospital, (ii) deaths at hospital before admission, (iii) deaths in hospital, (iv) survivors not taken to hospital, (v) survivors taken to hospital but not admitted, and (vi) survivors admitted.

However, no significant differences were found in the relationship between response times, mortality and hospital admission. Consequently, it was decided not to pursue this part of the analysis as the policy decision would not be affected by it.

8.4 Discussion and conclusion

The economic study collected detailed case study data and analysed national ambulance service data to assess the costs associated with improving response times. The case study data provide vivid picture of services making changes in an attempt to improve response times with limited additional funding (in the early years at least). These change were not restricted to increases in capacity, but included a diverse range of initiatives touching on all aspects of the service. However, costs attributable to improved response times could not be estimated, primarily due to the difficulty in disentangling the impact of increased call volume on service costs.

The analysis of national ambulance service data give a better chance of separating the effects of response times, call volume and efficiency changes. The results showed a clear relationship between average costs and call volume, but a less robust relationship between average costs and response times. The preferred model (Model 1) indicates a £37,000 increase in the average Ambulance Trust's annual costs per percentage point improvement in response times. The lack of statistical significance on this coefficient, and its sensitivity to changes in specification, however, mean that we should be extremely cautious about this interpretation.

The costing of hospital care was abandoned due to the lack of a relationship between response times and patient outcomes. Likewise, the estimation of a cost-effectiveness ratio was not possible due to the lack of a clearly identifiable improvement in outcomes. It is technically possible to undertake the costing of hospital care and merge it with the survey analysis results and mortality results to estimate a cost per life-year saved (and its associated cost-effectiveness acceptability curve). However, the results are unlikely to change the policy implications associated with the null results with respect to mortality.

Table 8.1: Service developments in Service 1 aimed at improving response times in the year April 1997 to March 1998

Service development	Date	Purpose	Resource consequences	Effects of changes
Reduction in number of stations	96-99		Realised £1m in capital and £50k revenue savings	Savings put into patient transport service not emergency service. Unlikely to effect Category A response times.
System status management software developed	97-98	Helps with planning vehicle locations, staff requirements	£25-30k for software + £15k revenue costs + WTE x 1 @ £18k.	More efficient management of resources should improve response times
Vehicles serviced by mileage rather than time	97-98	Vehicles off the road less often	WTE x 1 employed @ £20k (met within budget)	More vehicles on road at anyone time. Should have some effect on response times.
Mobile mechanic	97-98	Vehicle problems sorted on road rather than having to come into workshop	Mechanic supplied from existing workforce	As above.
Staff rota changes: 12 hour shifts vs. 8 hours	97-98	Thought to help reduce sickness absence	Approx £2k per annum	If sickness absence reduced then more vehicles and crews on the road at any on time.
Supervisors (x3) become operational	97-98	Three additional staff to be utilised as crew members	No resource consequences	Increase in operations staff will effect response times.

Table 8.2: Service developments in Service 1 aimed at improving response times in the year April 1998 to March 2000

Service development	Date	Purpose	Resource consequences	Effects of changes
Introduction of stand-by locations	6/98	Allows better targeting of crews to areas where likelihood of incidents is high	More wear and tear on vehicles and additional fuel costs	Vehicles closer to incidents therefore faster response times
First responders based in the community	8/98	RBAS uses volunteer first responders for remote areas	Training costs. Defibrillator x 1 = £3.5. Expansion of this service to cost approximately £20k.	Will greatly improve response times in remote areas.
Monitoring delays in A&E	10/98 and ongoing	Working with emergency planners to reduce delays. Bed management scheme will help.	Minimal resource consequences	By reducing time spent in A&E by crews, vehicles get back on the road sooner, thereby reducing response times
Terrafix software data transmission	10/99	Crew receive text message in vehicle	Uncertain	Text takes up less time than verbal message. Crew can respond faster.

Table 8.3: Service developments in Service 2 aimed at improving response times in the year April 1997 to March 1998

Service development	Date	Purpose	Resource consequences	Effects of changes
Streamlining of stores and ordering	1997	Remove shortages and reduce stocks	Uncertain.	Increase vehicles on the road.
Increased PTS workload	1997	Remove Category C calls from emergency ambulances	£80k funded through winter pressures monies.	Frees up ambulances from Category C calls to focus on Category A and Bs.
Vehicle changes to improve working conditions	1997	Allow crews to be away from stations (e.g. cool boxes) and better staff support programme (e.g. counselling)	Uncertain.	No effect on response times.
Increased use of standby points	1997	More spread-out starting points for vehicles responses	No fees, but possible increase in fuel costs	To reduce response times when vehicles on stand-by.
Emergency medical services restructuring	1998	Free up budgets to allow recruitment of two new paramedics and one emergency controller in the A&E room	Three staff recruited from within budget.	Increase control room and operational capacity.
New emergency control procedures	1998	Tighter rules for deployment, change in software and better training	Training time and software development. Uncertain.	Quicker dispatching.
Operational and management procedures	1998	Greater focus on Cat A calls, managers as first responders, rota changes to be demand sensitive, and regular auditing of response statistics	Uncertain.	Increased capacity and better call handling.

Table 8.4: Service developments in Service 2 aimed at improving response times in the year April 1998 to March 2000

Service development	Date	Purpose	Resource consequences	Effects of changes
Increased staffing and vehicles	2000	Additional staffing	115 WTE staff and 52 vehicles. £2.2m funded from purchasers (1.5m) and savings (0.7m)	Increase capacity
Increased PTS workload	1998 onwards	Remove Category C calls from emergency ambulances	Renegotiated each year. Uncertain.	Frees up ambulances from Category C calls to focus on Category A and Bs.
Standby development	1999 onwards	More spread-out starting points for vehicles responses	No fees, but possible increase in fuel costs	To reduce response times when vehicles on stand-by. To allow change in station profile.
Work based training	1998 onwards	Reduction in time taken off the road for training	Seconded trainers from operations, but increased on-road capacity	Increased capacity.
System status management	2000 onwards	To identify incident hot spots and move vehicles to that they are closer to them	Computer hardware, software, staff training and ongoing database managements.	To improve vehicle positioning and response times.

Table 8.5: Service developments in Service 3 aimed at improving response times in the year April 1997 to March 1998

Service development	Date	Purpose	Resource consequences	Effects of changes
Upgrading the predictive analysis system	4/97	Upgrade system for better prediction of incidents	One-off £4k fee.	Assist with positioning of vehicles to allow faster response times.
Increase in first response vehicles	4/97	Increase number of response vehicles	Four new motorbikes @ £10k plus equipment, insurance and training.	To reduce response times.
Introduction of standby points	1997	More spread-out starting points for vehicles responses	No fees, but possible increase in fuel costs	To reduce response times when vehicles on stand-by.
Support care crew scheme	10/97	PTS crews are trained to enable them to transfer sick patients, thereby taking pressure off the emergency ambulance service	£79k of winter pressure monies. Annual equivalent costs uncertain.	To reduce non-urgent workload of first emergency ambulances.
Improved call handling	1997	Ongoing training to improve standards and speed of call taking	Uncertain.	Reduce call taking to a target of 45 seconds.
Change in manager responsibilities	1997	Some managers have become first responders, and all have performance targets.	Uncertain.	Increase in number of responders and incentives to improved response times.
First responder schemes	1997	To increase the number of first responders	Five voluntary first responder schemes. Training costs plus equipment (e.g. mobile phones, defibrillators and consumables)	To reduce response times.
Research into Category C calls.	1997	To investigate ways for reducing category C calls	£60k	Reductions in Category C calls will improve response times for Category A and B calls.

Table 8.6: Service developments in Service 3 aimed at improving response times in the year April 1998 to March 2000

Service development	Date	Purpose	Resource consequences	Effects of changes
Automatic vehicle location	2000	Better positioning and allocation of vehicles to calls. Requires better screens for vehicles and maps.	Upgraded screens £20k and better maps £80k.	Improve response times by better vehicle allocation.
Predictive analysis	1999	ORH commissioned to identify investment required to meet Category A target	£15 for research. It identified need for £1.1m more funding	Precipitated 48 more staff (see immediately below)
More staff	2000	Increase operational and control centre capacity	44 operational staff and 4 control staff. £1.1m funding as identified by ORH.	Greater capacity to reduce response times. Training not complete until Feb 2001.
Rapid response vehicles	1998-2000	Increase in number of bikes from 4 to 6. Purchased/leased 8 cars	Cost taken from £1.1 identified above.	Greater capacity to reduce response times.
Increase in dynamic standby points	2000	Position vehicles closer to incidents	Increase fuel costs	Quicker response. May necessitate air conditioning in vehicles.
Support care crew scheme	1998-2000	Expansion of original scheme from 2 to 5 vehicles. Now covering 25% of doctor's urgent calls per day.	Uncertain.	Frees up ambulances from Category C calls to focus on Category A and Bs.

Table 8.7: Service developments in Service 4 aimed at improving response times in the year April 1997 to March 1998

Service development	Date	Purpose	Resource consequences	Effects of changes
Introduction of stand-by locations: 23 in Birmingham; 18 in Coventry; and 16 in Black country	7/97 to 11/97	Allows better targeting of crew to areas where likelihood of incidents is high	£10,000 for stand-by points per annum	Vehicles closer to incidents therefore faster response times
Introduction of pre alert system	4/97	Crew alerted to a possible A or B call and set off with minimal info. Rest given on route.	Software developed in-house	Speeds up activation. Can reduce response times by 45 to 60 seconds.
Introduction of caller line identify		Caller's address flashes up on operator's screen	£5,000 per year operating costs £5,000 for cost of developing software	Reduces time taken to process a call but does not affect response time as currently defined.
Trail period of conveying patients to primary care treatment centre (PCTC)	12/97 to 3/98	Ambulance takes some category C callers to PCTC rather than A&E		These calls stay out of the 999 system thereby freeing resources for cat A calls
Criteria based dispatch codes no on computer rather than in code manuals	98	Allows operators to categorise calls faster		Speeds up activation of crews
Shared facility with fire service	98	Allows standby point in rural area of Staffordshire		Faster response times in rural areas
Commissioned external report on most cost effective way of reaching response time targets	98	To help target resources at specific developments aimed at reducing response times		

Note

Several other large investments were made to help improve response times, such as the implementation of a pre-alert system at around £420,000, but these took place before the start date of the evaluation.

Table 8.8: Service developments in Service 4 aimed at improving response times in the year April 1998 to March 2000

Service development	Date	Purpose	Resource consequences	Effects of changes
Review of stand-by locations based on appropriateness using predictive analysis	98	Better use of stand-by points to improve responsiveness	Done in-house	Reduced number of stand-by locations but remainder better placed
Introduction of Aqua evaluation system	98	Audits sample of 999 calls for standard of processing and ability to identify cat A calls	£8k software + £3.5 + hardware costs + one WTE operator @ £16k	By more easily identifying life threatening calls response times are improved
Locating crews at fire stations	98-00	Partnership with fire service ensures better location of crews	£5,000 (10 stns x £500)	Has improved response times within the areas affected
More use of operators and support managers for first responder work	98-00	Additional support for existing first responder network	Difficult to quantify	Provide additional reserves throughout peak periods
Recruitment of operational and control staff	98-00 + ongoing	Additional staff (+ vehicles see below) aimed at improving response times	£320k (£16k x 20 operational staff) + £16k x 1 control staff + training costs	Direct attempt to improve response times via additional staff and vehicles
Vehicle replacement plan in place	98-00 + ongoing	Plan to increase emergency vehicle was but more likely to focus on FRVS	Difficult to quantify marginal effect	Direct attempt to improve response times via additional staff and vehicles

Table 8.9: Response time, cost and activity trends over time

Year	n	% Category A calls within 8 mins	% Category A calls within 14/19 mins	% Category B calls within 8 mins	% Category B calls within 14/19 mins	Activity '000s) ⁺	Cost per case ⁺⁺ (£2004)
Mean							
1997/8	8	53.88	95.38	49.10	93.48	85.42	202.99
1998/9	16	59.01	95.04	53.49	93.86	89.22	195.66
1999/0	20	57.23	95.61	52.62	94.29	107.15	193.43
2000/1	31	60.93	94.42	53.35	93.37	111.20	192.20
2001/2	32	73.00	95.82	58.21	93.50	119.37	191.02
2002/3	32	74.97	95.66	57.80	92.68	126.86	190.82
2003/4	31	74.97	94.92	55.92	90.54	137.66	188.82

⁺ Defined as the number of emergency calls resulting in a responder on scene.

⁺⁺ Defined as the cost of emergency patient transport services divided by activity.

Table 8.10: Models of cost per case

	Full sample		Services not involved in mergers	
	Model 1	Model 2	Model 4	Model 5
N_obs	168	168	137	137
N_groups	36	36	27	27
cata8	+0.271	-0.042	+0.600	+0.106
cata1419	-0.870	-	-0.572	
catb8	-0.447	-	-0.814	
catb1419	+0.812	-	+0.721	
emcallsc	-0.628**	-0.619**	-0.510	-0.442
emcallsq	+0.001**	+0.001**	+0.001*	+0.001*

* = p<0.05, ** = p<0.01

Variable descriptions

cata8	Percentage of category a calls responded to in under 8 minutes	emcallsc	Number of emergency calls resulting in a responder on scene
cata1419	Percentage of category a calls responded to in under 14 minutes (urban) or 19 minutes (rural)	emcallsq	Number of emergency calls resulting in a responder on scene squared
catb8	Percentage of category b calls responded to in under 8 minutes	Year2-7	Year dummies for 1999/2000 onwards
catb1419	Percentage of category b calls responded to in under 14 minutes (urban) or 19 minutes (rural)		

9. DISCUSSION AND CONCLUSIONS

Response times

We have examined response times and outcomes for calls identified as life threatening in 4 Ambulance Services across 5 years. Nearly 18,000 responses to patients were examined from the time of introduction of the new response time standard (1996/7) up to the time that the target of 75% of category A life-threatening calls responded to in 8 minutes was expected to be achieved (2000/1).

During these five years, the four study services made many changes to their operations to improve response times including, for example, better communications, and introducing fast response vehicles and elements of system status management such as dynamic deployment and predictive analysis.

Nevertheless, response times only improved from 47% in 8 minutes to 60% in 8 minutes, with mean times reducing from 9:21 (mins:secs) to 8:18. There were similar small improvements in the proportion of short response times in 5 minutes which increased from 17% to 24%. However, overall these improvements were disappointing and, although greater gains have been achieved in recent years, they point to the difficulties of improving response times for selected life-threatening cases at a time when the total number of all categories of call was increasing rapidly. Interestingly, despite these rises in call volume, the number of Category A* calls appears to have remained relatively stable over the 5 years, suggesting that increases are the result of more calls for less serious conditions.

There were other changes to the services, such as the merger of service 2 with neighbouring services, and the change of EMD system midway through the study in Service 4, which may have confused the response times picture. Furthermore, in Service 1 there were clearly major changes in how calls were prioritised as the crude mortality rate of life-threatening A-calls reported to the study doubled from 15% to 30% between 1997 and 1999. Since there were also substantial improvements in the response times in Service 1 over this period it is likely that the service was focusing resources more closely on a smaller number of more serious calls.

Targeting

The evaluation has focused on 999 calls for potentially life-threatening conditions when a faster response may have some impact on patient outcome. To provide consistency in the reporting of category A response time performance once call prioritisation was introduced, the Department of Health produced a list of both AMPDS and CBD codes which were considered to correspond to the seven condition types identified as category A calls. We have included a sub-sample of all category A calls in which the patient was also reported as unconscious OR not breathing OR with acute chest pain. We have termed these A* calls and it is these calls that make up the cases included in our study in order that the study would be focused on

those patients most likely to benefit from rapid response. However, even for these patients 11.5% (1729/14993) did not need to be transported to hospital and a further 31.9% (4978/14992) were discharged from A and E the same day. The difficulty of identifying the true needs of patients on the basis of 999 caller information has been highlighted several times before and this leads to two related problems.

- 1) ambulance resources, in this case rapid response, are inappropriately targeted and in order therefore to avoid 'false positives' – that is patients who could benefit being wrongly prioritised – it becomes necessary to overtriage.
- 2) In turn, overtriage means that the cost-effectiveness of rapid response strategies to improve patient outcomes is compromised since for every patient who is attended rapidly who could benefit there are many patients who couldn't.

Outcomes

Given the (relatively) small improvement in response times we couldn't find a discernible year on year improvement in survival to discharge. Adjusting for case-mix, the estimated change in the odds of survival to discharge per year was +1% (-4%, +6%). Excluding Service 1, where there may have been changes in prioritisation which may not be taken into account using case-mix adjustment, the estimated year-on-year change was -4% (-9%, +2%). We did not find any improvement in survival to hospital admission over this five year period either, 88.8% survived to hospital in 1997 and 88.0% in 2001. The casemix adjusted estimate of year-on-year change in the odds of surviving was +4.9%.

The main reason why we have not found any year on year improvement in survival is because recorded response times only improved slightly during the five years, despite the organisational resources focused on this issue. A second reason why no benefit could be discerned could be that any improvements in response that were achieved may have been for patients who could not benefit from rapid response due to the difficulties in targeting rapid response discussed above. A third possibility is that improvements occurred in the wrong part of the response time distribution, at times which could have little benefit.

Given that there were no discernible year on year benefits, we have instead examined the relationship between response time and outcome on an individual patient basis in order to estimate the potential benefits of performance improvements. Again, however, we found little evidence of discernible benefits. Overall we estimated that the odds of survival to discharge increased by +0.4% (-1.1%, +2.0%) for each minute reduction in response time. Comparing response times within 8 minutes to response times over 8 minutes the estimated benefit to the odds of survival to discharge was +1.4% (-13%, +18%).

We also examined the effect of rapid response on survival to hospital admission. In this case we did find some weak evidence that the odds of survival to admission improved by +2.3% for

each minute faster response time, and the odds of surviving to admission were doubled for response times within four minutes compared to response over four minutes.

It is less clear why the benefits of rapid response could not be detected for individual patients. However, this has been noted elsewhere in a study using similar methods²² and we hypothesise that it is because

- 1) response times can show 'reverse causality' in which faster responses are achieved for those most at risk, even within a group of calls identified as A- . There was some evidence for this and this is a potential benefit of EMD systems which enable dispatchers to relay further information to crews as the response is happening. Unfortunately an observational study of achieved response times and outcomes cannot examine this benefit. However, when we tried allowing for the despatch code in the analysis, the estimated benefits did increase and we estimated that the odds of surviving to discharge increased by +1.4% (-0.3%, +3.1%) for each minute faster response.
- 2) However, the main reason why we could not discern the benefits of faster response was probably due to the fact that the number of patients who can benefit is actually very small, and the benefit in this small group is being lost in the large numbers of patients who cannot benefit. We therefore also examined the benefits in specific groups.

Clinical groups

In line with previous studies in the UK^{7,20} we did find reliable evidence that faster response led to improved survival in cardiac arrests which occurred prior to crews arriving on scene. Allowing for all other factors including the initial rhythm, whether the arrest was witnessed, the use of bystander CPR, as well as characteristics of the patient and service, we estimated that the effect of a one minute reduction in response time was to improve the odds of survival by 19% (+3%, +33%).

We also found that in our whole sample of n=14993 A- patients with known outcomes there were 58 patients who had a cardiac arrest after the crew arrived on scene. Eight (14%) of these patients survived. We have not been able to determine whether any of these survivors resulted from rapid response.

Several previous studies have looked directly or indirectly at the relationship between response times and outcome in other clinical groups such as trauma and ruptured aortic aneurysms. In line with the findings from such studies we could not find any benefits in other clinical groups such as trauma, asphyxiation, and serious haemorrhage.

Estimating the benefit of improved response

In the light of our findings of no overall benefits of faster response, both at a service level over time and in individuals with different response times, except in patients with OHCA, can we estimate what the effect of improving response times further would be?

We assume that only patients in OHCA can benefit. Excluding patients known to be in sinus rhythm when the crew arrived, there were only 17 OHCA patients not witnessed by crews who survived. Given that a one minute reduction in response time improves the odds of survival by 19% we can thus estimate that a reduction in response times of one minute across the board would have resulted in an extra 4 – 5 not crew witnessed OHCA survivors. We do not know what the effect of response time on survival in the crew witnessed arrests was. However, we optimistically assume that 1/8 of the survivors would not have survived if response was one minute slower. Thus in total we estimate 5-6 extra survivors per minute faster response. These 5 – 6 extra survivors would occur out of 14,993 A- calls which is approximately 0.04%. A typical ambulance service receives 100,000 calls per annum resulting in patients being attended at the scene. Of these about 10% might be classified as A- calls, and thus improving response times by one minutes across the board might save an additional 4 lives per annum in a typical ambulance service.

We can make this calculation in a different way. We have sampled approximately 105 AS weeks, or 2 AS years, which identified 17,950 A- patients. Again this results in an estimate of about 4 extra survivors per AS per annum for a one minute reduction in response times across the board.

We have to make this calculation assuming a reduction across the board, ie. for all A- calls, because as discussed above the priority despatch systems are not sensitive and specific enough to focus AS resources on faster response only for OHCA patients.

Other benefits

One of the main limitations of our study is that we have only considered benefits in terms of survival. Although there is no evidence that we know about which has identified other health benefits in terms of reduced disability or other morbidity, there are plainly other types of benefit for patients, carers, callers, and bystanders. In a 999 emergency in which a patient is unconscious, not breathing, or suffering acute chest pain even a small reduction in actual response time may give large benefits in perceived time. There may also be an associated reduction in anxiety, distress, pain and discomfort and further research to measure if these potential benefits are real and valuable to patients would be worthwhile.

There are other possible benefits and disbenefits. For example, if the odds of survival to hospital (rather than to discharge) can indeed be doubled with response times \leq 4 minutes compared to over 4 minutes, so that more people are admitted alive even if they subsequently

die, then families may have the chance to see their relatives before death. However, patients may not value short extensions like this or even consider them a disbenefit.

Economic evaluation

The economic evaluation we have undertaken aimed to assess the benefits on survival to discharge and costs at a service level in order to examine the cost-effectiveness of improving response times. Because there is no evidence of any such benefits we have not been able to undertake any such evaluation. However, we have estimated that it costs an AS £37,000 for each percentage point improvement towards the 8 minute target for response times in category A calls. We could try to combine this estimate with the estimate of improved survival in OHCA to produce a cost per QALY. However, because neither the cost estimate nor the benefit estimate is robust, and because the costs incurred to achieve an improvement in response are certain to increase with the baseline performance, the answer would be unhelpful given current levels of performance. We also think that such an evaluation should value all the other types of benefit described above, and currently we have no means for doing this.

Nevertheless, for interest we show the shape of such a calculation. Figure 4.3 shows that a one minute reduction in response times across the board would result in approximately 10% more responses within 8 minutes. Our estimate suggests that this would cost £370,000 in an average ambulance service. Such a reduction would lead to an estimated 4 lives being saved (all from OHCA). The median age of these patients is 71. We do not know the average length of survival of an OHCA patient who survives to discharge, nor their quality of life. However, there would have to be approximately 5 QALYs gained per survivor for the cost per QALY to meet a target threshold of £20,000 per QALY.

Limitations

There are three important limitations to this study.

1. Firstly, the study was designed to look at costs and benefits at a service level on the assumption that the services would be substantially improving response times during the five year period from the introduction of priority-based targets and the expected date of achievement. During this period, however, improvements were small, and the service level analysis could not, nor be expected to, find any effects.
2. Given this, we have had to examine the relationship between response times and outcomes at an individual level. However, because of what we have termed 'reverse causality' (which is sometimes called indication bias) it is possible that the magnitude of the response time has been determined in part and in a few cases by the expected outcome. Although we expect that the chance of this is small in A- calls, there is some evidence that it did happen. For example, we found shorter response times in

patients with no or few vital signs at arrival on scene compared to other patients. Indication bias is very difficult to overcome even with case-mix adjustment.

3. The only benefits we have examined are in terms of survival. We have no doubt that there were other substantial and important benefits from fast response in apparently life-threatening incidents. For example, in terms of a reduction in anxiety, distress, and pain.

Recommendations for further research

The findings of the study have highlighted factors that pose particular difficulties in using differential response time standards as performance measures.

Firstly, we have demonstrated that only a small proportion of calls prioritised as category A have a truly life-threatening, time dependant condition. As a consequence there is significant over-triage in the categorisation process at the call handling stage and the current methods of prioritisation are not sufficiently sensitive to identify the small number of critical cases that require the fastest response. As the most recent DH report on NHS Ambulance Services²⁰ has clearly recognised there is an urgent need for “better ways of identifying the 10% who really need an emergency response”. There are similar concerns about the ability of priority dispatch systems to identify suitable low urgency (category C) calls that may benefit from responses other than a lights and sirens ambulance. This issue has become more pressing with the change in policy regarding the management and reporting of category C calls. The priority dispatch systems currently in use were designed to categorise calls on the basis of a simple two level assessment of need; level of care (ALS or BLS) and speed of response (lights and sirens or not) and they fulfil this function well. However, they have been used within the UK to try and prioritise calls into specific time based categories. In addition the range of response options available to ambulance service dispatchers is now much greater. Priority dispatch systems are increasingly being used to try and match patients’ clinical needs to the most appropriate response although this is not the systems intended purpose. It is becoming increasingly clear that a more sophisticated approach is needed to the assessment of patients needs at the time of the emergency call and the subsequent care delivery response.

Secondly, response time performance and the achievement, of response time standards has been the single measure against which the quality of ambulance services has been judged. The results of this study show that, with the exception of a very small number of individuals, response time itself is not a factor that affects patient outcome. Response time alone is not therefore a very useful indicator of quality, in terms of patient outcome, for the vast majority of callers to the ambulance service. Neither is it a useful benchmark for comparing services as it only reflects the transport element of the service and not the care provided. Use of response time performance also forces ambulance services to organise and manage their service around the needs of a few which can then result in an inappropriate service (for

example transport to hospital for conditions that, with the correct response, could be managed at home) for many others.

The econometric analysis produced uncertain findings. This is probably due to several reasons, although it is thought that the main reason is the lack of clear relationship and large variations between services. At the individual service level, the cost of improving response times is more apparent. Such analyses are better handled using simulation models, and several of the ambulance trusts utilised external consultancies to model the resource requirements for their services. Anecdotal evidence points to these models producing realistic predictions, and future work looking at changes in the operational characteristics of ambulance services, should consider simulation modelling for this.

Many of these issues are already being addressed as current policy priorities require further research to provide a sound evidence base to inform future developments. The research priorities now are to:

- Conduct a further rigorous and detailed investigation of the relationship between emergency call assessment, actual clinical need, appropriate response and patient outcome across all categories of calls
- Use this information to inform the further development of priority dispatch systems that can more accurately determine patient need.
- Develop a system that integrates call assessment to an appropriate response. This could entail enhancement of current systems or the development of a new system
- Identify factors in the clinical care of patients that have a true impact on patient outcome
- Further investigate users' views on their expectations of and what they consider to be the important factors in providing a good quality ambulance service
- Use these to develop performance indicators for ambulance services that more accurately reflect the contribution made to the health care process.

Policy implications

The key finding in this study mirrors that in contemporary studies in the US^{22,23}. Rapid response to achieve most responses within 8 minutes delivered across the board makes no discernible difference to survival to discharge. There are, however, some details which need to be considered before the broad policy implications can be drawn out.

Firstly, Pons²² and Blackwell²³ found that there was improved survival to discharge for very short response times ≤ 4 minutes or ≤ 5 minutes respectively. However, we have not found any such effect. Instead we found that very short response times ≤ 4 minutes doubled the odds of

surviving to hospital, but not to discharge. Nevertheless, the general point is that it may only be some parts of the response time distribution that are critical, not the whole distribution.

Equally, we have found that although there is no discernible benefit for all A+ calls together, there is benefit in out of hospital cardiac arrest.

The implication of these three findings (no overall benefit, possible benefit with very short responses, benefit in OHCA) suggests that any strategy around response time targets should be re-focussed on achieving very short responses to OHCA. This might mean concentrating resources in high risk areas such as urban business districts, or using fire and police responders, for example.

Unfortunately the current targeting systems are too imprecise for such a strategy to work for OHCA alone, and consequently given the necessary level of overtriage very short response times may not be achievable at current resource levels for the number of calls that would be identified.

Instead, we believe that the finding of no overall benefit from faster response points to the conclusion that, other things being equal, attention should be re-focussed on the clinical care provided by crews when they get to the scene rather than how fast they get there.

We know that the right care can make a difference, for example, avoiding IV fluids in bleeding abdominal trauma, giving early thrombolysis for patients having a myocardial infarction, and defibrillating patients in VF arrests. The results presented here show that the care provided by crews to patients who arrest after they have arrived on scene can be effective.

Of course, there are short term and occasionally long term benefits from fast response, and for a given level of resources response times clearly need to be minimised. However, given that AS are now responding to 75% of A calls within 8 minutes, our results point to the conclusion that further developments should be focused on better targeting and clinical care rather than further response time improvements.

REFERENCES

1. Cummins R, Ornato J, Thies W, Pepe P. Improving survival from sudden cardiac arrest: The "Chain of Survival" Concept. A statement for health professionals from the advanced life support committee and the emergency cardiac care committee, American Heart Association. *Circulation* 1991; 83: 1832-47.
2. Becker L, Pepe P, Ensuring the effectiveness of community wide emergency cardiac care. *Annals of Emergency Medicine* 1993; 22(2): 354-365.
3. Eisenberg M, Horwood B, Cummins R, Reynolds-Haertle R, Hearne T. Cardiac arrest and resuscitation: A tale of 29 cities. *Annals of Emergency Medicine* 1990; 19: 179-186.
4. Waalewijn R, de Vos R, Koster R. Out of hospital cardiac arrests in Amsterdam and its surrounding areas: results from the Amsterdam resuscitation study (ARREST) in Utstein style. *Resuscitation* 1998; 38(3): 157-167.
5. Kette F, Sbrojavacca R, Rellini G, Capasso M, Aricidiacono D, Bernadi G, Frittitta P. Epidemiology and survival rate of out of hospital cardiac arrest in North East Italy: The F.A.C.S. study. Friuli Venezia Giulia Cardiac Arrest Co-operative Study. *Resuscitation* 1998; 36(3): 153-159..
6. Pell J, Sirel J, Marsden A, Ford I, Cobbe S. Effect of reducing ambulance service response times on deaths from out of hospital cardiac arrest: a cohort study. *BMJ* 2001; 322: 1385-1388.
7. Brison R, Davidson J, Dreyer J, Jones G, Maloney J, Munkley D, O'Connor H, Rowe B. *CMAJ* 1992; 147(10): 1427-1428.
8. Wright D, Bannister J, Ryder M, Mackintosh A. Comparison of two methods of transporting paramedics to cardiac arrests outside hospital. *Resuscitation* 1992; 23: 193-197.
9. Herlitz J, Engdahl J, Svensson L, Angquist K, Young M, Holmberg S. Factors associated with an increased chance of survival among patients suffering out of hospital cardiac arrest in a national perspective in Sweden. *Am Heart J* 2005; 149(1): 61-66.
10. Finn J, Jacobs I, Holman C, Oxe H. Outcome of out of hospital cardiac arrest patients in Perth, Western Australia, 1996-1999. *Resuscitation* 2001; 51(3): 247-255.
11. De Maio V, Stiell I, Wells G, Spaite D. Optimal defibrillation response intervals for maximum out of hospital cardiac arrest survival rates. *Annals of Emergency Medicine* 2003; 42(2): 242-450.
12. Chapman R. Review of ambulance performance standards, Final report of steering group. NHS Executive 1996.
13. Nicholl J, Gilhooley K, Parry G, Turner J, Dixon S. The safety and reliability of priority dispatch systems. Medical Care Research Unit 1996; University of Sheffield.
14. Nicholl J, Turner J, Cleary K. The costs and effects of the implementation of the new ambulance service response time standards. Interim report to the Department of Health. Medical Care Research Unit 1999; University of Sheffield.
15. deSouza VC, Strachan DP. Relationship between travel time to the nearest hospital and survival from ruptured abdominal aortic aneurysms: record linkage study. *J. Public Health*, 2005; 27(2): 165-170.
16. Pons PT, Markovchick VJ. Eight minutes or less: does the ambulance response time guideline impact trauma patients outcome? *J. Emerg. Med.*, 2002; 23: 43-48.
17. Fiedler MD, Jones LM, Miller SF, Finley RK. A correlation of response time and results of abdominal gunshot wounds. *Arch. Surg.*, 1986; 121: 902-904.

18. Pepe PE, Wyatt CH, Bickell W, Bailey ML, Mattox KL. The relationship between total prehospital time and outcome in hypotensive victims of penetrating injuries. *Ann. Emerg. Med.*, 1987; 16: 293-297.
19. Lerner EB, Billittier AJ, Dorn JM, Wu YW. Is total out-of-hours hospital time a significant predictor of trauma patients mortality? *Acad. Emerg. Med.*, 2003; 10: 949-954.
20. Lyon RM, Cobbe SM, Bradley JM, Grubb NR. Surviving out of hospital cardiac arrest at home: a postcode lottery? *Emerg. Med. J.*, 2004; 21: 619-624.
21. Department of Health. Taking health care to the patients: transforming NHS Amulance Services. Department of Health. June 2005.
22. Pons PT, Hankoo S, Bludworth W, et al. Paramedic response time: does it affect patient survival? *Academic Emerg. Med.*, 2005; 12(7): 594-600.
23. Blackwell TH, Kaufman JS. Response time effectiveness: comparison of response time and survival in an urban emergency medical services system. *Acad. Emerg. Med.*, 2002; 9: 288-295.

The Acceptability of Emergency Medical Dispatch (EMD) systems to 999 callers
Analysis of the type and nature of non-serious (category C) calls

The Acceptability of Emergency Medical Dispatch (EMD) systems to 999 callers

Introduction

The introduction of EMD systems to ambulance service control rooms means that there are changes to the way requests for an emergency ambulance are handled. The caller is asked some additional questions which allow the call taker to identify the chief complaint and assign a level of response. In addition the call taker can give pre-arrival instructions and, where necessary, first aid advice including basic instructions for cardiopulmonary resuscitation. The aim of this part of the evaluation was to assess the acceptability of these changes to members of the public who call 999 and request an ambulance.

Methods

In order to assess any changes resulting from the introduction of EMD systems the acceptability of call taking needs to be assessed before and after the introduction of a system. As all four study areas had already implemented priority dispatch systems prior to introduction of prioritisation we recruited a fifth ambulance service – Greater Manchester Ambulance Service (GMAS) – to conduct this part of the study. GMAS introduced AMPDS to their control room during the spring of 1998. This enabled us to conduct a before and after study to elicit the views of callers to the ambulance service.

A random sample of 500 callers to GMAS control centre during one week in January 1998 prior to the introduction of emergency medical dispatch were sent a postal questionnaire which asked questions about the management of their actual call, any advice they were given by the call taker including first aid advice, and their satisfaction with both the service delivered by the control room and the ambulance crew.

The second survey of a further random sample of 500 callers was due to take place during the corresponding week in January 1999 but winter pressures and a flu epidemic meant that the call volume at this time was double the normal rate. This survey was instead carried out during the first week of February.

Summary of results

The response rate was 72% (355/493) before, and 63% (297/466) after the introduction of EMD. There was a reduction, from 81% (284/349) to 70% (200/286), in the proportion of callers who found all the questions asked by the call-taker relevant, although this did not adversely affect the proportion of callers who were very satisfied with the 999 call, which increased from 78% (268/345) to 86% (247/287). The proportion of callers who reported receiving first aid advice increased from 7% (23/323) to 43% (117/272) and general information from 13% (41/315) to 58% (157/269). Satisfaction levels with the amount of advice given increased, while satisfaction with response times remained stable at 76% (254/320) very satisfied before and 78% (217/279) after EMD. The proportion of respondents very satisfied with the service in general increased from 71% (238/336) to 79% (220/277).

There was evidence in respondents' written comments of two potential problems with EMD from the caller's viewpoint. First, some callers were advised to take actions which were subsequently not needed; second, a small number of callers felt that the ambulance crew did not treat the situation as seriously as they would have liked.

Conclusions

Introducing EMD increases the amount of first aid and general advice given to callers, and satisfaction with these aspects of the service, while maintaining satisfaction with response times. Overall satisfaction with the service increased and there were a large number of comments made by respondents on the ability of Emergency Medical Dispatchers to provide a calming influence on what is perceived to be a very stressful incident. However, some changes may be needed to prevent a small amount of dissatisfaction directly associated with EMD, specifically the relevance of some of the questioning and general advice given.

A fuller description is given in the earlier interim report and the two peer reviewed papers that have been published from this study:

O'Cathain A, Turner J, Withers A, Nicholl JP. Views of people who call 999 to request an ambulance. *Pre-hospital Immediate Care*, 1999; 3: 131-135.

O'Cathain A, Turner J, Nicholl JP. The acceptability of an Emergency Medical Dispatch system to people who call 999 to request and ambulance. *Emergency Medical Journal* 2002;**19**:160-163

Analysis of the type and nature of non –serious (category C) calls

Aims

The potential for alternative management strategies for low priority (category C) calls is a critical issue for ambulance services. The aims of this study were to describe the nature and current management of C calls and to assess alternative methods of management other than deploying an emergency ambulance. This is an area of current policy interest as these calls are now excluded from response time standard performance targets and management of these calls including the use of alternative methods of response is decided by individual services.

Methods

A random sample of 50 low priority calls (CBD 'C', AMPDS Alpha) from each of the four study ambulance services was selected from all such calls during the three month period of January to March 1998. Patients were identified from the date and time of call, vehicle call sign and incident number, and their notes accessed at the relevant A and E department.

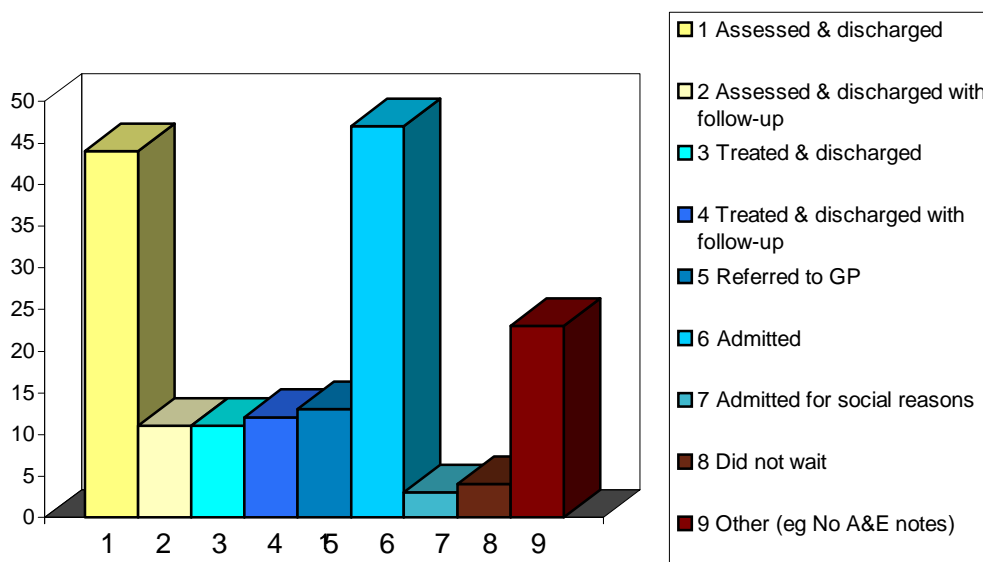
For each call followed up details were abstracted about the incident and A&E events including investigations, treatment, diagnosis and outcome. Alternative management was assessed using the Sheffield algorithm for identifying unnecessary attenders at A and E departments.

In addition an historical sample of 120 C calls were presented to each of three NHS Direct centres used to assess management by NHS Direct.

Results

Of the sample of 200 prospective calls, the number of A and E records which could be traced and reviewed totalled 168. Patients were predominantly adult (90.2%) and female (60.7%) and 96% were registered with a general practitioner. The most common primary complaint was a fall (58.9%) followed by minor medical conditions (20.8%). A third (30.3%) of patients required admission to hospital and a further third required A&E treatment. Thus using the categorisation developed in a previous MCRU study of unnecessary attendance at A and E, it was found that although the majority of patients did need transfer to A and E, approximately one third (54/168 = 32%) would have been judged 'unnecessary attenders'. Of patients with minor injury it was judged that >50% could have been managed at a minor injuries unit. Outcomes are illustrated in figure 1.

Figure 1 – Outcome of attendance at A and E



Of the 120 calls presented at 3 NHS Direct call centres between half and three-quarters would have been directed to A&E for care. However 25-50% were judged not to require A&E attendance and would have been directed to a General Practitioner or self care. There was considerable variation between nurses in the outcome resulting from case assessment. The overall level of agreement between the nurses using the 4 systems was fair ($\kappa=0.375$). Between 21% and 31% of these low priority calls were triaged back to the ambulance service.

Discussion

This study has shown that category C calls represent a heterogeneous group of patients. A third of 999 calls assigned to the lowest priority categories are admitted to hospital and a further third need treatment in A & E.

Altogether 80%-90% would have been directed to seek professional care by NHS Direct with a substantial proportion requiring A&E care. Thus the proportion could potentially be managed by alternative services is small. A major issue confronting services in this area is likely to be around the development of priority dispatch systems capable of reliably identifying calls about patients who could be handled in alternative ways. Only then will investigating alternative management strategies become feasible.

A fuller description is given in the earlier interim report and a peer reviewed paper has been published from this study:

O’Cathain A, Webber E, Nichol J, Munro J, Knowles E. NHS Direct: consistency of triage outcomes. *Emerg Med J* 2003; **20**: 289-292.

AMPDS and CBD codes used for case identification

CBD codes used for case identification

Code	Condition description
01A1	Abdominal/back pain – unconscious or not breathing
02A1	Allergic reaction - unconscious or not breathing
03A1	Animal bites - unconscious or not breathing
04A1	Bleeding - unconscious or not breathing
05A1	Breathing difficulty - unconscious or not breathing
06A1	Cardiac arrest - unconscious or not breathing
06A2	Cardiac arrest – suspected sudden death
06A3	Cardiac arrest – sudden infant death syndrome
07A1	Chest pain - unconscious or not breathing
07A2	Chest pain, short of breath/cannot talk
07A4	Chest pain, severe chest pain with sweating
08A1	Choking - unconscious or not breathing
09A1	Diabetic - unconscious or not breathing
10A1	Environmental emergency - unconscious or not breathing
11A1	Fits/convulsions - unconscious or not breathing
12A1	Gynae/miscarriage - unconscious or not breathing
13A1	Headache - unconscious or not breathing
14A1	Mental/emotional - unconscious or not breathing
15A1	Overdose/poisoning - unconscious or not breathing
16A1	Pregnancy/childbirth - unconscious or not breathing
17A1	Sick/unknown problem - unconscious or not breathing
18A1	Stroke/CVA - unconscious or not breathing
19A1	Unconscious - unconscious or not breathing
19A3	Unconscious – confirmed at time of call
21A1	Assault/trauma - unconscious or not breathing
22A1	Burns - unconscious or not breathing
23A1	Drowning - unconscious or not breathing
24A1	Falls/accident - unconscious or not breathing
25A1	Neurological/head injury
26A1	Road Traffic Accident - unconscious or not breathing
27A1	Child under 2 years – cardiac arrest
27A2	Child under 2 years - unconscious or not breathing

AMPDS codes used for case identification

Code	Condition description
09D01	Suspected cardiac arrest
09D02	Suspected respiratory arrest
10D01	Chest pain – severe respiratory distress
10D03	Chest pain – sweating/changing colour
11D01	Choking
12D03	Fits/convulsions – not breathing
13D01	Diabetic – unconscious
14D01	Drowning – unconscious
14D02	Drowning – not breathing/under water
15D01	Electrocution – unconscious
22D03	Industrial/machinery accident – life status questionable
23D01	Overdose/poisoning – unconscious
25D01	Psychiatric/suicide – hanging/strangulation
31D01	Unconscious at end of interrogation
32D01	Unknown problem – life status questionable