Evaluation of outreach services in critical care

Project SDO/74/2004

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1. Executive summary

Introduction

In May 2000, with the publication of Comprehensive Critical Care, critical care outreach services (CCOS) were formally promoted as Department of Health policy as an important component of their "vision for future critical care services". This policy was promoted despite lack of evidence for benefit and without any ongoing evaluation. Three essential objectives for CCOS were identified: to avert admissions (either preventing admission or ensuring timely admission); to enable discharges (that is, to support continuing recovery after critical care); and to share critical care skills with non-critical care staff. No explicit model for CCOS was promoted; Critical Care Networks and NHS Trust-wide Critical Care Delivery Groups were encouraged to develop their own locally customised service.

In the 1990s, it became apparent that many patients sustaining significant organ failure warranting critical care often exhibited abnormal physiological observations, sometimes for hours, before their final "collapse". Physiological track and trigger warning systems (TTs) were developed for use outside critical care areas with the objective of ensuring timely recognition of all patients with potential or established critical illness and timely attendance from appropriately skilled staff. TTs use periodic observation of selected basic vital signs (the "tracking") with pre-determined criteria (the "trigger") for requesting the attendance of more experienced staff, since 2000, usually in the form of the CCOS. A wide variety of TTs exist to detect patients whose condition is deteriorating but there is no clear evidence to indicate either which are valid and reliable or which is best.

In April 2003, the NHS Research and Development, Service Delivery and Organisation Programme called for an evaluation of CCOS. This study adopted a multi-disciplinary, multi-methods approach to evaluation and comprised linked sub-studies under two general themes: TTs and CCOS.

Methods

The evaluation of TTs comprised five sub-studies: a systematic review of studies covering the range of TTs, to explore the extent of their development and testing relative to methodological quality standards; a descriptive national survey, covering the introduction and use of TTs across acute NHS Trusts in England; an analysis of available TT data of suitable quality from NHS hospitals in England, to review all aspects of their validity and utility; a single-centre inter- and intra-rater reliability study of the more common TTs; and a qualitative evaluation to elicit a wide range of stakeholders' views on TTs.

The evaluation of CCOS comprised five sub-studies: a systematic review of evaluative studies, to explore the evidence for their impact; a descriptive national survey covering the introduction, implementation and current models across acute NHS hospitals in England; an interrupted time series at the critical care unit level, to explore their impact; a matched cohort analysis at the critical care patient level to evaluate their impact; and a qualitative evaluation to characterise

the impact of the introduction, development and current models of CCOS within acute NHS Trusts in England.

Results

TTs

There was little rigorous evidence for the validity, reliability and utility of TTs. The reported proportion of hospitals using some form of TT was almost 100%. The majority of hospitals reported using the Early Warning Score or some modification of it. Most hospitals reported that more than one member of staff was notified in the response algorithm, presumably graded by risk. Response within thirty minutes was reported as the agreed response time; a balance between the ideal (immediate) and the pragmatic (achievable).

Using a composite outcome measure for established critical illness, the sensitivities and positive predictive values were low and the specificities were generally acceptable. Low sensitivities may have been due, in part, either to rapidly deteriorating patients or to patients where no physiological warning of impending catastrophe, by virtue of the disease process, was likely or due to infrequent and non-standardised measurement of the physiological parameters. Low positive predictive values may have been due to legitimate triggering for potential rather than established critical illness. The summary ROC curve indicated that differences between TTs may have largely reflected differing trigger thresholds; evidence suggested that trigger thresholds were placed artificially high to manage workload. In terms of reproducibility, there was only fair to moderate agreement for measurement of the physiological parameters used to generate scores and for the scores; there was better agreement on the trigger. Reproducibility was partially a function of simplicity; intra-rater reliability was better than inter-rater reliability.

Many interviewees suggested that TTs were helping inexperienced staff identify sick and deteriorating patients, giving them “objective evidence”. TTs were seen to increase staff knowledge and understanding but this had to be finely balanced against over-reliance. Local issues were identified that might affect the accuracy of TTs. These ranged from lack of, or poor, use in some hospital areas, variation in use among staff and issues of completion and interpretation. Training, particularly informal training, was seen to be extremely important. Local issues were raised about response algorithms for TTs, predominantly around communication, delay, resistance, authority and documentation.

CCOS

There was insufficient robust, rigorous research on the impact of CCOS on patient or service outcomes. CCOS have evolved quickly and the overwhelming picture was one of diversity of service provision.

Presence of a formal CCOS was associated with a significant decrease in: CPR rates during the 24 hours prior to admission; out-of-hours admissions to the critical care unit; and acute severity of illness of admissions; for admissions from the ward. No sustained effect was seen on mortality or readmission rates for patients discharged alive from the critical care unit.

Patients with CCOS visit(s) pre-critical care unit admission, when matched by individual patient characteristics or by propensity score, were most associated with decreased CPR rates during the 24 hours prior to admission and increased critical care unit length of stay.

Patients with CCOS visit(s) post-discharge from the critical care unit, when matched by patient characteristics or propensity score, were most associated with decreased hospital mortality and decreased post-critical care unit, hospital length of stay.

The difference in mean total cost per patient between patients receiving CCOS visit(s)) post-discharge and matched controls ranged from -£289 to -£34. Though not statistically significant, the differences indicated a high probability that CCOS visits following discharge from critical care were cost effective, regardless of willingness to pay.

CCOS studied had different methods of operation and priorities. It was difficult to identify common themes except for an education role. The reassurance given to ward staff was the most important, quoted impact. This was linked to a feeling of empowerment arising out of educational activity. The development of CCOS appears to have contributed to a rapprochement between wards and critical care units. This has worked in both directions - from the perspective of the wards, the critical care unit is no longer a mysterious black box, whereas from the perspective of the critical care unit, there is enhanced understanding of the pressures on ward staff. The original meaning of “critical care without walls” was related to clinical objectives which have been only partially achieved. Yet, the aspiration of “critical care without walls” also has a valid organisational and social meaning about which there is considerable evidence of achievement.

Conclusions

The low sensitivity of existing TTs means that a high number of patients with established critical illness requiring intervention were likely to be missed if ward staff relied solely on these for identifying deteriorating patients. It may be possible to increase the sensitivity, at the cost of increased workload, by reducing trigger thresholds. TTs will never provide 100% identification of critically ill patients (nor potentially critically ill patients) and should therefore always be used as an adjunct to clinical judgment and experience. Our results suggested that accurate use of a TT and response algorithm may improve the pathway of care for the recognition and management of the acutely ill patient on the ward, both prior to and post-admission to a critical care unit.

CCOS form a spectrum of different service models across the NHS and are, therefore, complex interventions making evaluation difficult. CCOS appear to fill gaps according to local need and “one size may not fit all”. Perhaps pragmatically, “best fit” for local needs has predominated.

Despite precise service models varying, the underlying principles are the same. The objectives of CCOS are to improve the quality of acute patient care and

experience. Despite the introduction of CCOS into the NHS without any provision for a concurrent evaluation (and thereby preventing robust evaluation within an RCT), our more limited, yet rigorous, non-randomised evaluation suggested, both quantitatively and qualitatively, some positive effects. However, no clear characteristics of what should form the optimal CCOS could be identified.

Though not an original aim for CCOS, they facilitate connectivity, reduce communication difficulties and enhance the delivery of care across organisational, professional and speciality boundaries and may, in this way, create an important culture change leading to improved quality of care, that is, improved recognition of acute deterioration, initial management and escalation of treatment. CCOS also appear to have made a siginificant impact on morale, career development, ward staff clinical skills, confidence levels, education and training. However, ultimate management of the critically ill should be the responsibility of those who have the appropriate knowledge and experience.

Recommendations for further research:

CCOS activities and workload depend on the CCOS being alerted at the right time to the right patient. Therefore, research on CCOS should focus, first, on improved TTs.

2. Introduction

The increasing complexity of medical and surgical treatments, combined with an ageing, in-patient population and a trend towards shorter lengths of hospital stay, have all contributed to increased acuity of hospital in-patients. This has resulted in patients outside designated critical care areas being either critically ill or at risk of developing critical illness.

Physiological track and trigger warning systems (TTs)
Physiological observations (vital signs) have been used to help assess the well-being of patients for centuries with the tacit expectation that the observers will appreciate the significance of deviations from normal and respond accordingly.

In the 1990s, it became apparent that, for a variety of reasons, healthcare workers completing routine observations on hospital wards, and charged with responding accordingly, were failing both to routinely record observations and to appreciate the significance of abnormal observations, thus failing to respond in a timely fashion by providing, or calling relevant experienced staff to provide, appropriate therapeutic intervention.

It also became apparent that many patients sustaining significant organ failure warranting critical care often exhibited abnormal physiological observations, sometimes for hours, before their final "collapse". This suggested that patients were being referred very late (possibly too late) for critical care relative to the course of their acute illness. This ran counter to the established and growing body of evidence suggesting the common sense perception that intervention as early as possible in the course of critical illness optimises the chances for successful outcome.

TTs were developed for use outside critical care areas with the objective of ensuring timely recognition of all patients with potential or established critical illness, timely attendance from appropriately skilled staff and timely determination of an appropriate management plan, tailored to the patient's needs[1].

TTs use periodic observation of selected basic vital signs (the 'tracking') with predetermined criteria (the 'trigger') for requesting the attendance of more experienced staff. Once triggered, TTs rely upon a non-negotiable obligation from experienced staff to attend the patient's bedside, as a priority.

In most cases TTs are drawn from routine observations of vital signs carried out by ward staff, allowing a large number of patients to be monitored without incurring major additional workload. TTs can be classified as:

- single parameter systems – periodic observation of selected vital signs which are compared to a simple set of criteria with predefined thresholds, with a response algorithm being activated when any criterion is met;
- multiple parameter systems – where the response algorithm involves more than one criterion being met or differs according to the number of criteria met;

- aggregate weighted scoring systems – where weighted scores are assigned to physiological values and compared to predefined trigger thresholds; or
- combination systems – involving single or multiple parameter systems in combination with aggregate weighted scoring systems.

A wide variety of TTs exist to detect patients whose condition is deteriorating but there is no clear evidence to indicate which is best. Furthermore, the extent to which existing systems are valid and reliable measurement tools for detecting patients with potential or established critical illness is not known.

Single parameter systems have been used extensively by Medical Emergency Teams (MET) in Australia[2]. Multiple parameter, aggregate weighted scoring and combination systems are mainly in use in UK hospital settings. A survey of acute hospitals in England in 2002 indicated that most hospitals were using aggregate weighted scoring systems[1]. But the concept is rapidly gaining momentum worldwide, in the US, Rapid Response Teams are a key component of the Institute for Healthcare Improvement 100 000 Lives Campaign[3], and the International Partnership for Acute Care Safety (IPACS) initiative, endorsed by the World Health Organisation, is shortly to commence a global study to investigate antecedents to cardiac arrest, death and emergency intensive care admission.

Critical care outreach services (CCOS)
In 1999, the Department of Health reviewed adult critical care services in the National Health Service (NHS) and recommended the development of CCOS as a pragmatic approach to supporting the management of these patients. In May 2000, with the publication of *Comprehensive Critical Care* (Department of Health, 2000), CCOS were formally promoted in the NHS in England as an important component of their "vision for future critical care services". Such promotion of CCOS occurred despite evidence for their benefit and without any proposed ongoing evaluation.

Three essential objectives for CCOS were identified: to avert admissions (either preventing admission or ensuring timely admission); to enable discharges (that is, to support continuing recovery); and to share critical care skills with staff on general hospital wards and in the community.

Neither *Comprehensive Critical Care* nor any subsequent documentation (e.g. Intensive Care Society, 2002) was explicit in terms of what model of CCOS should be developed locally. Critical Care Networks and NHS Trust Critical Care Delivery Groups were encouraged to develop their own locally customised service.

An audit conducted by the NHS Modernisation Agency in 2002 indicated that, in the intervening years, a wide range of services falling under the umbrella of outreach services has been developed, introduced, incrementally implemented and improved over time. Thus, outreach services do not follow one model and survey data (Department of Health and Modernisation Agency

2003; Audit Commission 1999) suggested that these services vary by (at least): objectives; function; coverage; staffing; equipment and activities

CCOS activities included:

- critical care education and training for general ward staff;
- physiological track and trigger warning systems in general wards;
- telephone 'hotline' advice for ward staff ;
- post critical-care discharge follow-up;
- direct bedside clinical support on general wards; and
- audit and evaluation of critical care outreach activity.

In the UK, the development of CCOS is an illustration of a service development where the momentum for change appears to have overtaken the search for evidence. Recent reports have called for all hospitals to establish CCOS providing cover 24 hours a day, 7 days per week, however, no comprehensive evaluation of CCOS has been performed in the UK.

Report

In April 2003, the NHS Research & Development, Service Delivery and Organisation (SDO) Programme called for the evaluation of CCOS. The variety of CCOS in existence indicated that the evaluation would need to adopt a multi-disciplinary, multi-methods approach.

At the beginning of 2004, funding (SDO/74/2004) was awarded to researchers based at the Intensive Care National Audit & Research Centre (ICNARC) and the University of Sheffield. The proposed evaluation comprised seven linked sub-studies under two themes: TTs and CCOS.

A systematic review and an evaluation of TTs were undertaken. A systematic review, descriptive survey and both a quantitative and qualitative evaluation of CCOS were undertaken. This work brought together key stakeholders in the field of CCOS and they were involved in this research at every stage – design, conduct, management, participation, analysis and interpretation of results including policy implications. Each sub-study was overseen by a small sub-group of applicants, including at least one stakeholder. This work was supported by the Intensive Care Society and by the National Outreach Forum (NOrF).

This report presents and summarises our findings.

3. Evaluation of TTs

Publications:

Gao H, McDonnell A, Harrison DA, Moore T, Adam S, Daly K, Esmonde L, Goldhill DR, Parry GJ, Rashidian A, Subbe CP, Harvey S. Systematic review and evaluation of physiological track and trigger warning systems for identifying at risk patients on the ward. Intensive Care Medicine 2007;33(4):667-79.

McDonnell A, Esmonde L, Morgan R, Brown R, Bray K, Parry G, Adam S, Sinclair R, Harvey S, Mays N, Rowan K. The provision of critical care outreach services in England: findings from a national survey. Journal of Critical Care 2007;22(3):212-8.

Subbe CP, Gao H, Harrison DA. Reproducibility of physiological track-and-trigger warning systems for identifying at-risk patients on the ward. Intensive Care Medicine 2007;33(4):619-24

3.1 Systematic review of TTs

Abstract

Objective

TTs are used to identify patients outside critical care areas at risk of deterioration and to alert a senior clinician, CCOS or equivalent. The aims of this work were to identify and describe the range of published TTs, as used by a CCOS or equivalent, and to explore the extent to which each system has been developed according to established procedures.

Design

Systematic review of studies identified from electronic-, citation- and hand-searching, and expert informants.

Measurements and results

Thirty-six papers were identified describing 25 distinct systems. Thirty-one papers described the use of a system, and five were studies examining the development or testing of systems. None of the studies met all methodological quality standards.

Conclusion

A wide variety of systems were in use with little evidence of validity, reliability and utility.

3.2 Descriptive national survey of TTs

Brief introduction

The aim of the descriptive survey was to describe the development, introduction, implementation and current models for CCOS within acute NHS hospitals in England. This aim was achieved by a national, postal survey of NHS acute hospitals in England which routinely provide care for Level 1 patients (n = 239). As part of the survey, respondents were asked about activity relating to the introduction and use of TTs in 2004 including any changes since 1996.

Methods

The methods for and results of the descriptive, national survey of CCOS are described in detail in Appendix 1. Briefly, in February 2005, one copy of the questionnaire was sent to each hospital, enclosing a stamped addressed envelope for replies. Completed questionnaires were received from 191 (79.9%) hospitals.

Results

TTs

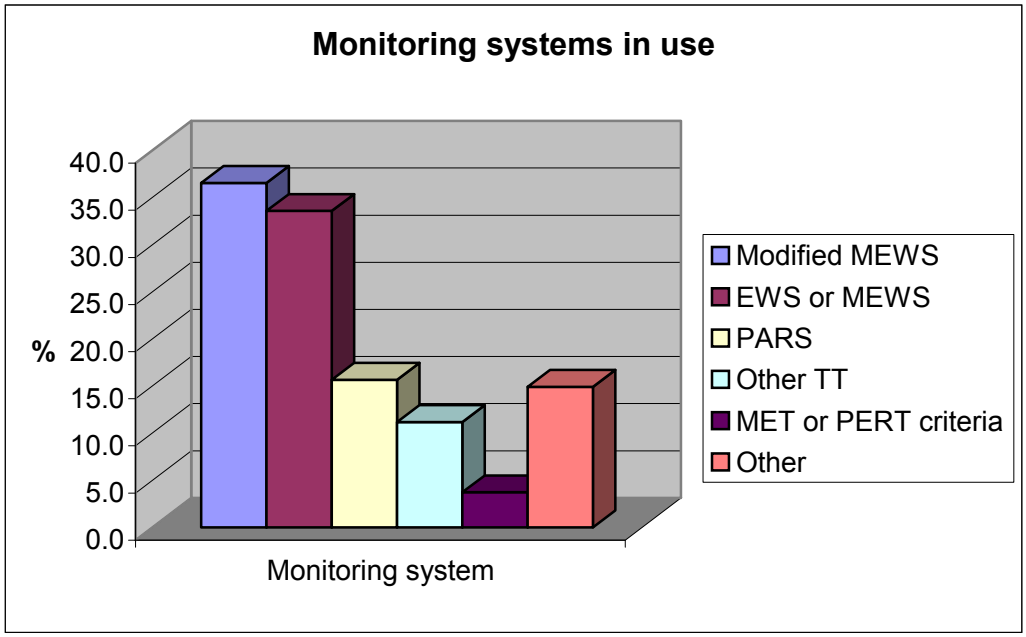
Of the 191 hospitals responding, 139 (72.8%) had a formal CCOS. Almost all hospitals with a CCOS (96.4%, n = 134) used a TT to monitor and identify patients on adult wards. The equivalent figure for 2002 (most recent, previous survey data available for comparison) was 81.5% (n = 97). Figure 3.2.1

illustrates the variety of TTs in use. Over 70% of hospitals were currently using the Early Warning Score (EWS) or a modification based on EWS.

Although most hospitals only used one TT (85.8%, n=115), some hospitals had more than one in use (2 TTs 12.7%, n=17; 3 TTs 1.5%, n=2). Figure 3.2.2 presents the parameters included in the TTs in use. Respiratory rate, heart rate, blood pressure and conscious level were most likely to be included. Other parameters, not in Figure 3.2.2, included level of oxygen therapy, cause for concern, level of pain, blood sugar, non-invasive ventilation or continuous positive airway pressure, arterial blood gases, presence of a tracheostomy and grading of encephalopathy. Almost all the TTs included more than four elements; the majority including six (Figure 3.2.3).

In 69.6% (n = 94) of hospitals, a TT was in use on all adult wards. In the wards where the TT was in use, most hospitals (72.7%, n = 96) used the system for all patients. The equivalent figure for 2002 was 46% (n = 49). Over half the hospitals completed the TT with routine observations (Figure 3.2.4), but for the remainder of hospitals a variety of systems were in use, namely: according to concerns of staff (n=14); according to score/trigger (n=12); according to need (n=9); ad hoc (n=6); according to standards/protocols (n=3); and at request of, or on referral to, CCOS (n=2).

Figure 3.2.1: TTs in use



MEWS Modified Early Warning Score, EWS Early Warning Score, PARS Patient At Risk Score, MET Medical emergency team, PERT Patient emergency response team

Figure 3.2.2: Physiological parameters incorporated in the TTs in use

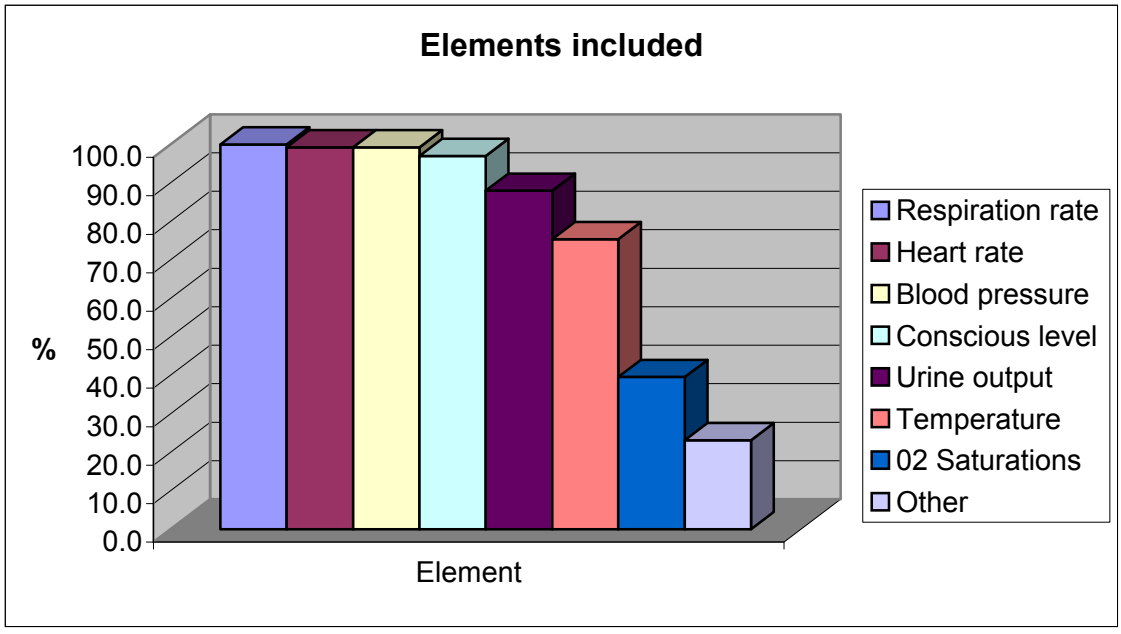


Figure 3.2.3: Total number of physiological parameters included in TTs in use

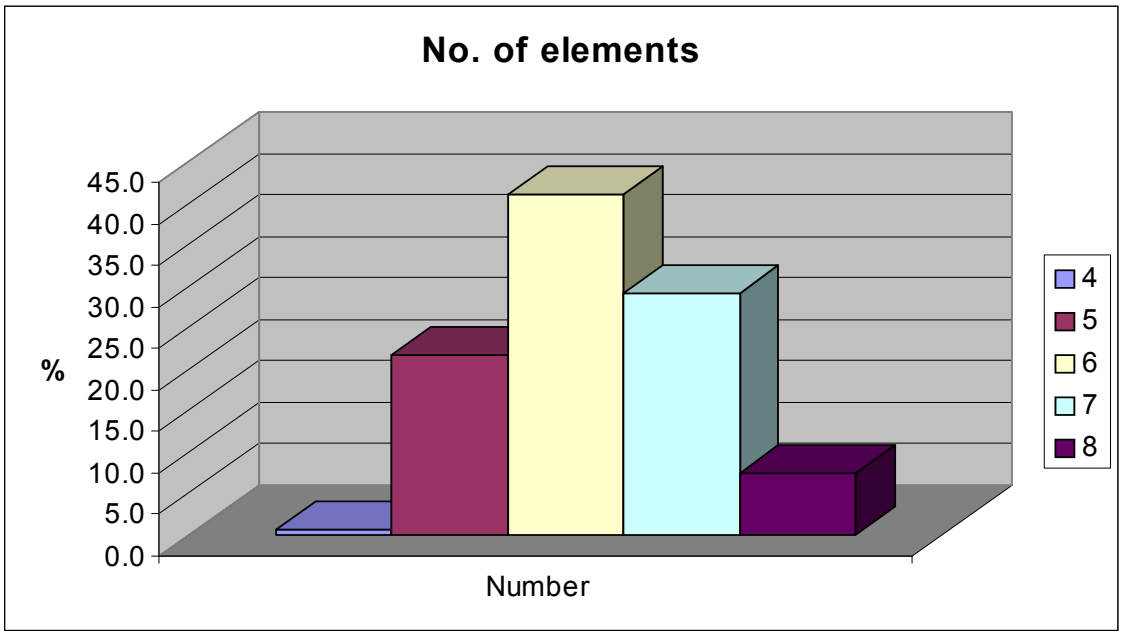
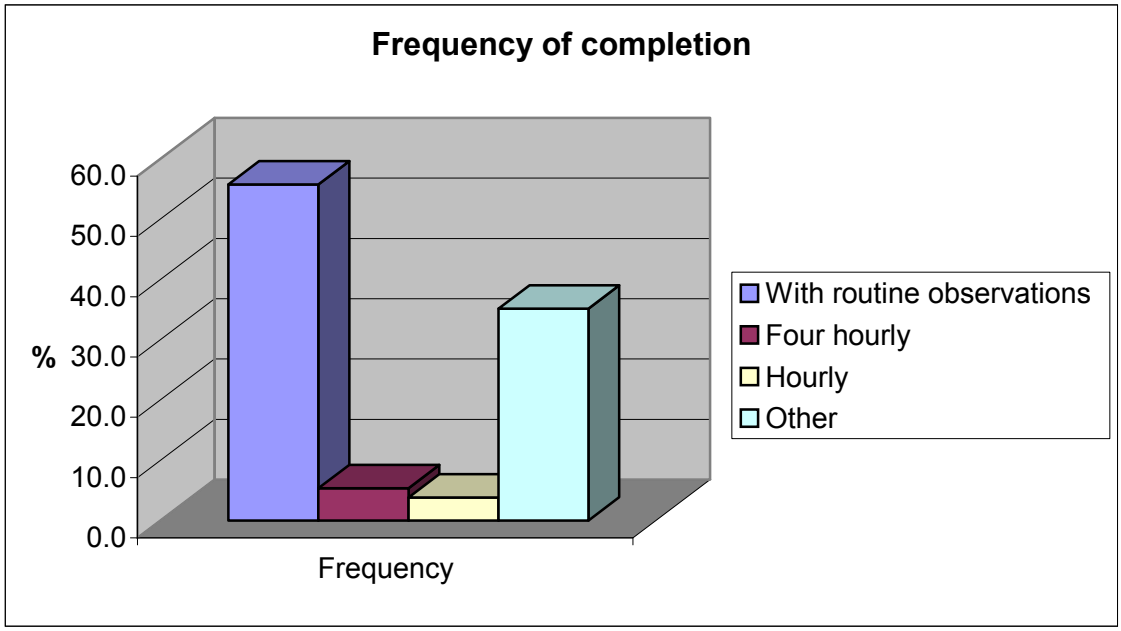
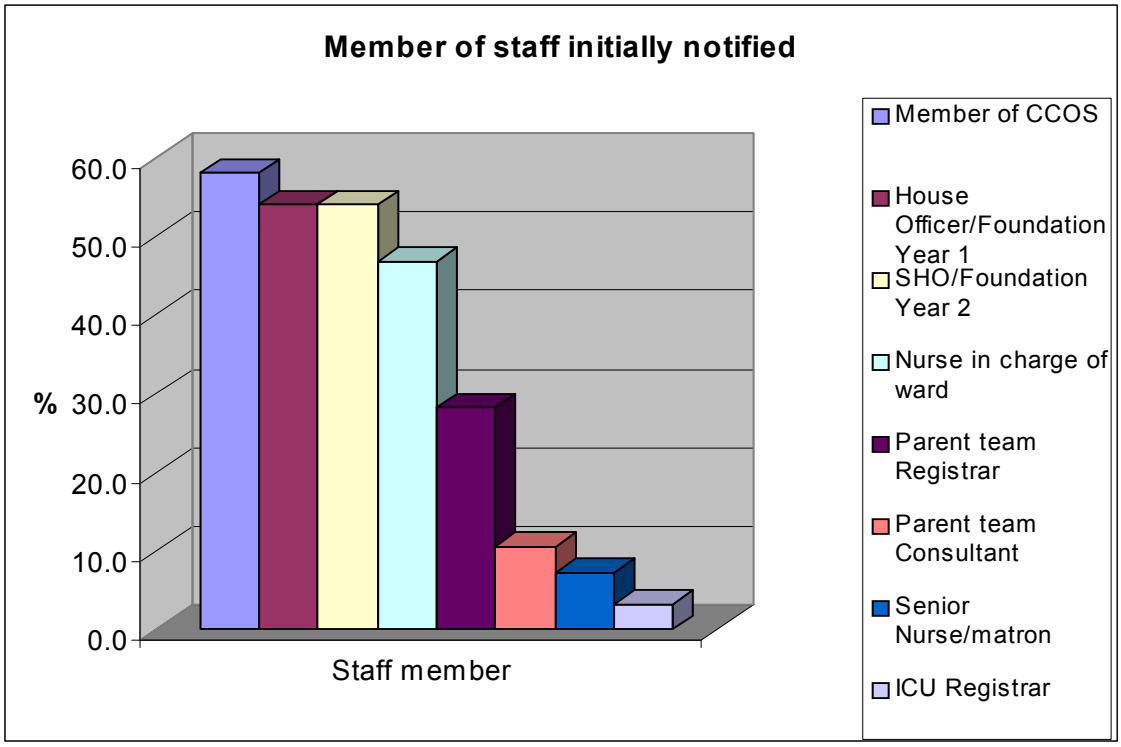


Figure 3.2.4: Frequency of completion of TTs in use



Response algorithms/protocols
The majority of hospitals (88.4%, n = 122) with a CCOS had a specified initial response algorithm for patients identified as being "at risk" on the basis of the TT in use. The equivalent figure for 2002 was 74%. For most hospitals (76.4%, n = 90), the response algorithm identified more than one member of staff who should be notified, presumably graded and depending on the level of risk. As was the case in 2002, it is noticeable that many primary respondents to a trigger are junior medical staff from the parent ward team or ward nursing staff (Figure 3.2.5).

Figure 3.2.5: Primary respondent(s) in response algorithm on trigger



Some respondents (n = 61) provided figures for the number of patients on adult wards who were identified as "at risk" each month on the basis of the TTs used. The median (IQR) number of patients was 50 (25 – 84.5). Of these patients, the median (IQR) number seen by the CCOS was 45 (19 – 82). The median (IQR) difference between the number of patients identified "at risk" and the number seen by CCOS was 0 (0 – 0), indicating that, in most of the hospitals who were able to provide this information, the outreach service saw all patients identified as "at risk" on the basis of the TT used.

Most hospitals (67.2%, n = 86) had an agreed target response time for "at risk" patients. The mean (SD) time was 28.8 (13.1) minutes. This reflects the picture in 2002, when the majority of respondents had an agreed target response time of 30 minutes.

3.3 Quantitative evaluation of TTs

3.3.1 Study 1 - evaluation of TTs

Brief introduction

An analysis of available datasets from UK hospitals to identify and describe the range of TTs in use, by CCOS or equivalent was undertaken with the primary objective to review all aspects of the validity, reliability and utility of existing systems e.g. sensitivity, specificity and predictive validity. A secondary objective of the evaluation was to identify, if possible, the best (most valid, reliable, useful) TT for ensuring timely recognition of all patients with established critical illness.

Methods

Data sources and quality assessment

Primary collection of TT data did not fall within the resources available for this sub-study from those provided for the overall evaluation of CCOS.

Advantage was taken of datasets available to us from existing sources. To this end, all acute National Health Service (NHS) hospitals in England with critical care facilities were contacted by post or email for relevant TT datasets. Respondents were asked 'Do you collect data for a TT?' and 'Are you able to send a copy of your dataset to ICNARC to be included in the analysis?'. One follow-up letter was sent to non-responders. Relevant TT datasets were also sought through study Steering Group members, their contacts and authors of relevant published studies.

Criteria for assessing the coverage and accuracy of the TT datasets were developed based on those used by the Directory of Clinical Databases (DoCDat) (http://www.docdat.org)[4] and the QUADAS tool for evaluation of studies of diagnostic accuracy[5] (Table 3.3.1.1). All TT datasets received were assessed according to the criteria.

Inclusion criteria

TT datasets were excluded from the analysis if: there was no clear definition of the criteria used for inclusion and exclusion; the TT dataset did not include the minimum outcome measures of admission to critical care or death; or data for fewer than half of variables were less than 95% complete.

Data were excluded from the analyses based on the following criteria: patients aged less than 12 years; anonymous unique patient identifier and date of admission to hospital both missing; composite outcome measure could not be identified.

Logic, range and consistency checks were applied to data for each variable used in the analysis. Illogical values, values outside the maximum possible range and inconsistent data were removed. Patients with missing summary scores were treated as not triggered if there were no raw physiological data for TT variables or summary TT variables/scores recorded in the TT dataset.

Table 3.3.1.1: Modified DoCDat criteria for assessing the coverage (A–D) and accuracy (E–F) of TT datasets

	Level 1	Level 2	Level 3	Level 4
A) Was the spectrum of patients representative of the patients who will be monitored with the TT in practice?	No evidence or unlikely to be representative (e.g. only patients referred to CCOS)	Some evidence that eligible population is representative (e.g. all patients seen by CCOS for CC follow-up identifiable)	Good evidence that eligible population is representative (e.g. all patients on selected wards)	Total population in your current setting (e.g. all patients on all wards that could be attended by CCOS)
B) Were selection criteria clearly defined?	No			Yes
C) Completeness of TT variables	Only summary TT variables or scores	Summary TT variables or scores; at least admission to CC and death recorded as minimum outcomes	Raw physiological data for TT variables; at least admission to CC and death recorded as minimum outcomes	Raw physiological data for TT variables; all outcomes; all important confounders
D) Completeness of data (% variables at least 95% complete)	Few (<50%)	Some (50-79%)	Most (80-97%)	All or almost all (>97%)
E) Use of explicit definitions and rules for variables	None	Some (<50%)	Most (50 -97%)	All or almost all (>97%)
F) Extent to which data are validated	No validation	Range or consistency checks	Range and consistency checks	Range and consistency checks plus external validation using alternative source

TT physiological track and trigger warning systems, CCOS critical care outreach service(s), CC critical care

Methodology

The main outcome measure for this study was the presence of established critical illness. Accurate outcome measures to evaluate the TTs for the presence of potential critical illness (TTs were developed for use outside critical care areas with the objective of ensuring timely recognition of all patients with potential or established critical illness) were not available.

Established critical illness was defined as the composite of death, admission to critical care, 'do not attempt resuscitation' (DNAR) placed or cardiopulmonary resuscitation (CPR). For patients with multiple outcomes, the first outcome to occur was used, if the date could be identified, otherwise outcomes were considered to have occurred in the order of CPR, DNAR placed, admission to critical care and death. For TTs with graded responses, a trigger event was defined as any response involving informing a more experienced member of staff. Responses resulting in, for example, increasing the frequency of observations were not included as trigger events.

For TT datasets solely containing data for patients seen by CCOS, two groups of patients were analysed separately (if they could be identified from among all patients seen by the CCOS) – (i) referrals from the ward (any patients causing concern or who triggered) and (ii) critical care follow-up patients. Only positive predictive values could be calculated for referrals from the ward whereas sensitivities, specificities and negative predictive values could also be calculated for critical care follow-up patients. If patients had more than one CCOS episode during their hospital stay, only data (TT and outcomes) from the first episode were analysed.

Statistical analysis

For each TT dataset, the primary assessment was by sensitivity (proportion of patients with established critical illness who triggered) and positive predictive value (proportion of triggered patients with established critical illness). The secondary assessment was by specificity (proportion of patients without established critical illness who did not trigger) and negative predictive value (proportion of not triggered patients without established critical illness). Where possible, receiver operating characteristic (ROC) curves were plotted.

Important confounding variables were taken into account by repeating the analyses in subgroups defined by age (12-17, 18-49, 50-69, 70-79, 80+ years), ward (surgical and medical) and specialty (trauma and orthopaedics, vascular surgery, general surgery, medicine, obstetrics and gynaecology, and neurosurgery).

Heterogeneity among the TT datasets was evaluated with the Q-statistic for the log diagnostic odds ratio[6] and quantified with the H-statistic[7]. A random-effects meta-regression was used to explore the degree to which the heterogeneity could be explained by the physiological variables included in each TT, the outcome measures recorded in each TT dataset, and the inclusion of critical care follow-up versus all ward or Medical Admissions Unit (MAU) patients.

The TT datasets were randomly assigned letters of the alphabet (Hospital A, Hospital B, etc) for anonymous presentation of the results. Statistical analyses were performed using Stata 8.2 (StataCorp LP, College Station, TX).

Results

Of the 221 hospitals approached, 139 (62.9%) responded. Of these, 47 (33.8%) indicated that they did not collect data for a TT. Twenty-seven TT

datasets were received, representing 30 hospitals in England and one in Wales (Figure 3.3.1.1). Of these, 12 did not meet the quality criteria and were excluded from the study and 15 did meet the quality criteria and were included (Table 3.3.1.2). Among the 12 excluded datasets, one dataset contained only 30 cases and was considered too small to be included, one dataset did not record TT variables or aggregate scores, one dataset was evaluated at Level 1 in Section D of the Modified DoCDat Criteria (the percentage of variables at least 95% complete is less than 50%) and 9 datasets were evaluated at Level 1 in Section C of the Modified DoCDat criteria (did not record the minimum required outcomes of admission to critical care and death). The questionnaire used to elicit information about each TT dataset and the users' guide for assessing the TT datasets according to the modified DoCDat criteria are described in Appendix 3.

Figure 3.3.1.1: Flow chart for TT datasets

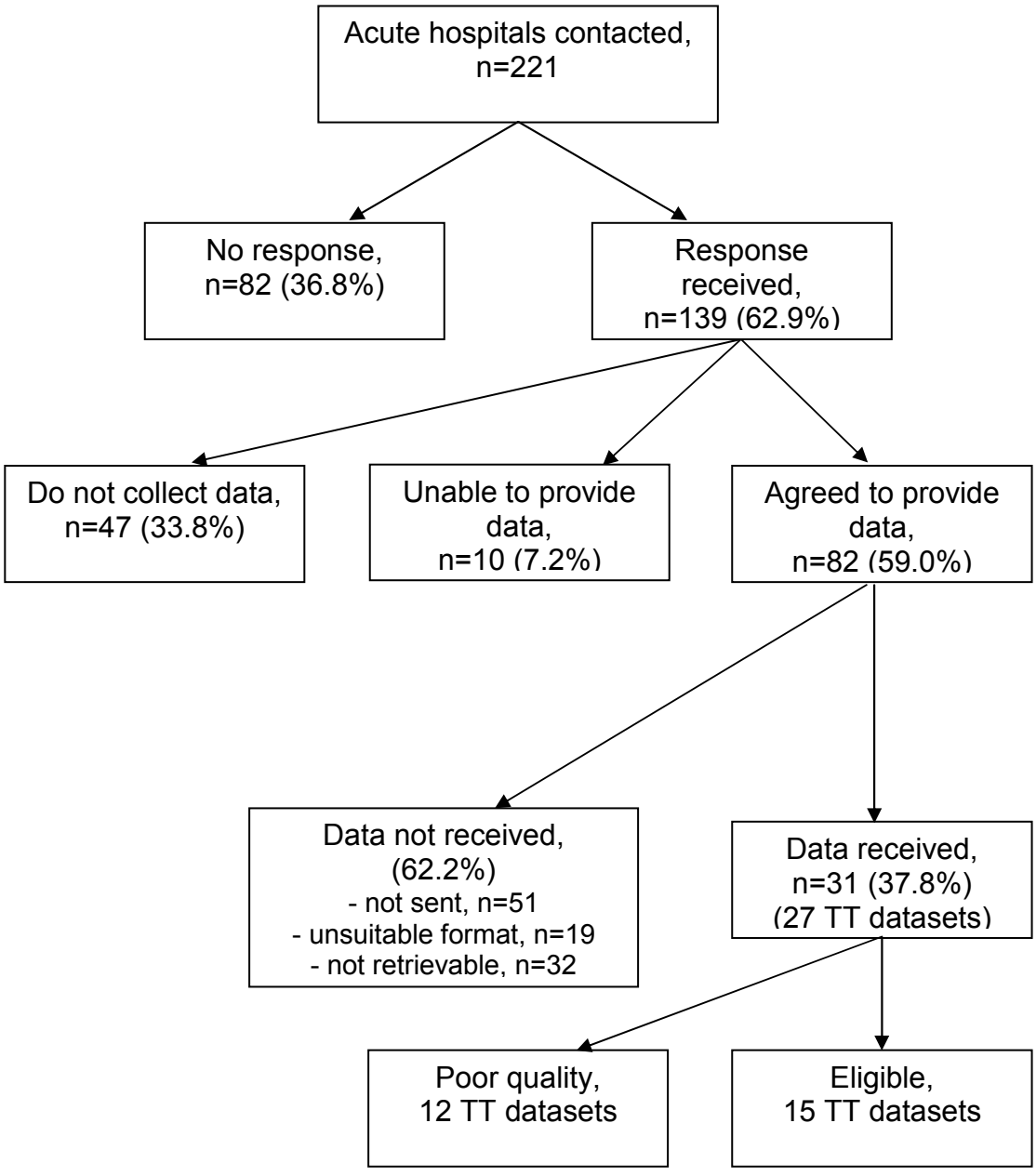


Table 3.3.1.2: Performance levels of included fifteen TT datasets against Modified DoCDat criteria

Hospital	A) Representative of patients	C) Completeness of TTs	D) Completeness of data	E) Explicit rules and definitions	F) Validation	Number of variables
A	2	4	4	3	3	10
B	2	2	4	1	Not known	8
C	1	2	3	1	Not known	5
D	2	2	4	1	Not known	4
E	2	4	4	1	1	14
F	2	2	4	1	1	6
G	4	4	4	1	Not known	290
H	1	2	4	1	Not known	5
I	1	4	4	3	3	11
J	2	4	2	1	1	12
K	2	2	4	1	Not known	7
L	2	4	2	1	Not known	17
M	4	4	4	1	3	61
N	2	2	4	1	Not known	3
O	2	4	4	1	Not known	12

Notes:
Performance levels were assessed based on the full dataset from each hospital and rated on a scale of 1 to 4, with Level 1 representing the least rigorous items and Level 4 representing the most rigorous items.
All datasets were assessed at Level 4 of Criteria B: selection criteria were clearly defined
The possible variables involved in the study were raw physiological values or scores for TTs, outcomes, and confounding variables: age, wards (surgical/medical) and specialty. Hospital number, date of admission, date and time visit or assessment are used in identifying the initial assessment from the first CCOS episode if patients had more than one CCOS episode.
Number of variables reflects the complexity of the dataset (repeated recording of raw physiology) provided and not the number of parameters in the TT (see: Table 3.3.1.3)

Of the 15 TT datasets that did meet the quality criteria, no further exclusion of admissions (e.g. patients aged less than 12 years; anonymous unique patient identifier and date of admission to hospital both missing) was required in 8 TT datasets, less than 5% of admissions were excluded in a further 5 TT datasets and in 2 (A and B) exclusions accounted for 9.6% and 15.4%, respectively.
All TTs in the 15 TT datasets included in the study were different, having been

modified according to local needs. TTs were classified as: single parameter systems; multiple parameter systems; aggregate weighted scoring systems; or combination systems (Table 3.3.1.3).

Table 3.3.1.3: Summary of available TT datasets and details of TTs

Hospital	Type of TT	Data collection period	Setting	Number of patients	Parameters									
					Number	Heart rate	Respiratory rate	Blood pressure	Temperature	Urine	O_2 saturation	Consciousness	Concern	Other
A	Combination system	2001-2002	CCOS referrals and follow-up	946	7	✓	✓	✓	✓	✓	✓	✓		
B	Aggregate scoring system	Jan-Aug 2004	CCOS referrals and follow-up	471	5	✓	✓	✓		✓		✓		
C	Aggregate scoring system	Apr-Sep 2004	CCOS referrals	405	6	✓	✓	✓			✓	✓	✓	
D	Combination system	2002-2004	CCOS referrals and follow-up	2371	6	✓	✓	✓	✓	✓		✓		
E	Aggregate scoring system	2003-2004	CCOS referrals and follow-up	3266	6	✓	✓	✓	✓	✓		✓		
F	Aggregate scoring system	Jan-Nov 2004	CCOS referrals and follow-up	330	6	✓	✓	✓	✓	✓		✓		
G	Aggregate scoring system	Aug-Oct 2003	MAU patients	750	5	✓	✓	✓	✓			✓		
H	Aggregate scoring system	2002-2003	All CCOS	1051	8	✓	✓	✓		✓	✓	✓	✓	Respiratory support
I	Aggregate scoring system	2001-2004	Referral*	2463	8	✓	✓	✓	✓	✓	✓	✓		Level of oxygen
J	Combination system	2003-2004	CCOS referrals and follow-up	1964	6	✓	✓	✓	✓			✓	✓	
K	Aggregate scoring system	Jan-Nov 2004	CCOS referrals and follow-up	380	7	✓	✓	✓		✓	✓	✓		Respiratory support
L	Aggregate scoring system	2002-2004	CCOS referrals and follow-up	339	6	✓	✓	✓	✓	✓		✓		
M	Aggregate scoring system	Mar 2000, Feb-Mar 2001	MAU patients	2321	5	✓	✓	✓	✓			✓		
N	Combination system	2001-2004	CCOS referrals and follow-up	2548	6	✓	✓	✓	✓	✓		✓	✓	
O	Single parameter system	2002-2004	CCOS referrals and follow-up	592	8	✓	✓	✓		✓	✓	✓	✓	Bicarbonate; Level of oxygen; PaO2; pH

TT physiological track and trigger warning systems, CCOS critical care outreach service(s), MAU medical admissions unit, *Includes 1167 (47.4%) critical care admissions not seen by the CCOS

The TTs were broadly similar to those identified in studies from UK centres in the systematic review, but only one was incorporated into a study identified in the systematic review. There were ten aggregate scoring systems, one single parameter system and four combination systems. The TT datasets varied in

period of data collection (from 2001 to 2004), setting, sample size (n=330 to 3266) and physiological variables recorded. All TTs included heart rate, respiratory rate, systolic blood pressure and level of consciousness, but they varied in terms of the choice of other physiological variables, assignment of scores to physiological values, and trigger thresholds. The details of each TT are described in Appendix 3.

Response algorithms also varied considerably. Many of the systems used a graded response incorporating different responses at different thresholds, typically increasing the frequency of observations at a relatively low threshold, informing the nurse in charge or junior doctor at an intermediate threshold, and informing the CCOS or senior doctor at a higher threshold. Only five of the response algorithms, as reported, explicitly stated that further help should be sought for any patient causing concern. The referral algorithms for each TT dataset are described in Appendix 3.

Variations also existed in the physiological values and outcome events (Table 3.3.1.4). As would be expected, the datasets including all patients on a MAU (Hospitals G and M) exhibited less extreme physiology and considerably lower levels of outcome events than those consisting of patients attended by a CCOS. Summary of all physiological parameters both on initial assessment and when trigger happened are presented in Appendix 3.

The diagnostic accuracy of the TTs varied widely (Table 3.3.1.5). For the composite outcome (presence of established critical illness defined as the composite of death, admission to critical care, DNAR placed or CPR), sensitivities (proportion of patients with established critical illness who triggered) and positive predictive values (proportion of triggered patients with established critical illness) were low with median (quartiles) values of 43.3 (25.4–69.2) and 36.7 (29.3–43.8), respectively.

Although considered to be of secondary importance, specificities (proportion of patients without established critical illness who did not trigger) and negative predictive values (proportion of not triggered patients without established critical illness) were generally acceptable. The median (quartiles) values were 89.5 (64.2–95.7) and 94.3 (89.5–97.0), respectively. Results across different age groups, wards and specialties and sensitivity analyses including multiple visits from the CCOS as part of the composite outcome are presented in Appendix 3.

Areas under the receiver operator characteristic (ROC) curves for critical care follow-up patients varied from 0.61 to 0.84 across the TT datasets (Figure 3.3.1.2). Within hospitals, there were some differences in the discrimination of TTs in different age groups, wards and specialties, but these were not consistent across hospitals.

Table 3.3.1.4: Summary of core physiological variables on initial assessment and outcome completeness and events in each TT dataset

Hospital	Physiological measurements, mean (SD)				Outcome complete, n (%)	Outcome measures, n (%)				
	Heart rate	Resp. rate	Systolic BP	Temp.		CPR	DNAR	Critical care	Death	Composite
A	90.1 (20.0)	21.9 (7.4)	130.8 (24.4)	36.9 (0.8)	946 (100)			118 (12.5)	61 (6.5)*	179 (18.9)
B					471 (100)		45 (9.6)	45 (9.6)	14 (3.0)	104 (22.1)
C					405 (100)	48 (11.9)	23 (5.7)	36 (8.9)		107 (26.4)
D					2371 (100)	187 (7.9)		218 (9.2)	73 (3.1)	478 (20.2)
E	88.2 (19.4)	20.7 (6.5)	129.0 (25.2)	36.7 (0.8)	3000 (91.9)		229 (7.6)	235 (7.8)	52 (1.7)	516 (17.2)
F					328 (94.0)		17 (5.2)	55 (16.8)	9 (2.7)	81 (24.7)
G	85.2 (19.5)	19.3 (4.9)	141.4 (32.2)	36.7 (0.8)	750 (100)	4 (0.5)		4 (0.5)	35 (4.7)	43 (5.7)
H					960 (95.0)		72 (7.5)	230 (24.0)	50 (5.2)	352 (36.7)
I	99.7 (25.9)	26.2 (8.4)	119.9 (31.0)	37.0 (1.0)	2460 (99.9)	145 (5.9)	57 (2.3)	1385 (56.57)	1 (0.04)	1592 (64.7)
J	89.5 (19.8)	19.5 (8.0)	121.4 (39.6)	36.8 (0.8)	1929 (98.2)	26 (1.4)	128 (6.6)	147 (7.6)	47 (2.4)	348 (18.0)
K					377 (99.2)		10 (2.7)	29 (7.7)	10 (2.7)	49 (13.0)
L	104.5 (21.9)	24.7 (7.3)	116.4 (29.9)	36.8 (0.9)	333 (98.2)		44 (13.2)	106 (31.8)	8 (2.4)	158 (47.5)
M	86.1 (20.5)	20.1 (5.5)	139.1 (27.0)	36.6 (0.8)	2321 (100)	42 (1.8)	37 (1.6)	87 (3.8)	120 (5.2)	286 (12.3)
N					2515 (98.8)		472 (18.8)	241 (9.6)	47 (1.9)	761 (30.2)
O	103.3 (25.3)	25.1 (7.9)	115.7 (31.7)	36.9 (1.1)	582 (98.3)		108 (18.6)	189 (32.5)	9 (1.6)	306 (52.6)

SD standard deviation, Resp. respiratory, Temp. temperature, BP blood pressure, CPR cardiopulmonary resuscitation, DNAR do not attempt resuscitation, *Treatment limit including decision that critical care not appropriate and death while under review by CCOS

Table 3.3.1.5: Sensitivity and specificity of TTs by hospital for critical care unit follow-up and referrals from ward

Hospital	Subgroup	Patients n (%)	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	Prevalence (95% CI)
A	Follow-up	701 (74.1)	32.8 (21.3, 46.0)	85.5 (82.5, 88.1)	17.7 (11.2, 26.0)	93.0 (90.7, 95.0)	8.7 (6.7, 11.0)
	Referral	245 (25.9)			48.2 (41.8, 54.6)		
B	Follow-up	209 (44.4)	42.9 (17.7, 71.1)	95.4 (91.2, 98.0)	42.9 (17.7, 71.1)	95.4 (91.2, 98.0)	7.4 (4.1, 12.1)
	Referral	262 (55.6)			31.8 (26.4, 37.6)		
C	Referral	405 (100)			26.4 (22.2, 31.0)		
D	Follow-up	1098 (46.3)	3.2 (0.1, 16.7)	99.2 (98.4, 99.6)	10.0 (0.3, 44.5)	97.2 (96.1, 98.1)	2.8 (1.9, 4.0)
	Referral	1273 (54.7)			35.1 (32.5, 37.8)		
E	Follow-up	1119 (34.3)	43.3 (32.9, 54.2)	90.4 (89.0, 91.7)	17.4 (12.7, 23.0)	97.2 (96.3, 97.9)	4.5 (3.6, 5.4)
	Referral	2149 (65.7)			43.2 (40.0, 46.3)		
F	Follow-up	289 (87.6)	60.9 (48.4, 72.4)	64.2 (57.5, 70.6)	35 (26.5, 44.2)	83.8 (77.4, 89.1)	24 (19.2, 29.4)
	Referral	41 (12.4)			29.3 (16.1, 45.5)		
G	MAU patients	750 (100)	65.1 (49.1, 79.0)	65.8 (62.1, 69.3)	10.4 (7.0, 4.6)	96.9 (94.9, 98.2)	5.7 (4.2, 7.6)
H	All CCOS	1051 (100)			36.7 (33.6, 39.8)		
I	Referral*	2463 (100)			64.7 (62.8, 66.6)		
J	Follow-up	1512 (78.4)	15.8 (9.8, 23.6)	99.1 (98.5, 99.6)	61.3 (42.2, 78.2)	93.2 (91.8, 94.4)	7.9 (6.6, 9.4)
	Referral	417 (21.6)			54.7 (49.8, 59.5)		
K	Follow-up	323 (85.0)	69.2 (48.2, 85.7)	89.5 (85.4, 92.7)	36.7 (23.4, 51.7)	97.0 (94.3, 98.7)	8.1 (5.4, 11.7)
	Referral	57 (15.0)			40.4 (27.6, 54.2)		
L	Follow-up	240 (70.8)	100 (89.7, 100)	14.3 (6.7, 25.4)	38.6 (28.4, 49.6)	100 (66.4, 100)	35.1 (25.6, 45.4)
	Referral	99 (29.2)			52.5 (46.0, 59.1)		
M	MAU patients (no CCOS)	1672 (72.0)	25.4 (15.8, 37.1)	92.9 (90.5, 94.9)	30.5 (19.2, 43.9)	91.0 (88.4, 93.2)	10.9 (8.6, 13.6)
	MAU patients (with CCOS)	649 (28.0)	19.1 (14.0, 25.0)	95.4 (94.2, 96.4)	38.0 (28.8, 47.8)	88.9 (87.2, 90.4)	12.9 (11.3, 14.6)
N	Follow-up	520 (20.4)	84.3 (71.4, 93.0)	47.3 (42.7, 52.0)	14.9 (11.0, 19.5)	96.5 (93.2, 98.5)	9.8 (7.4, 12.7)

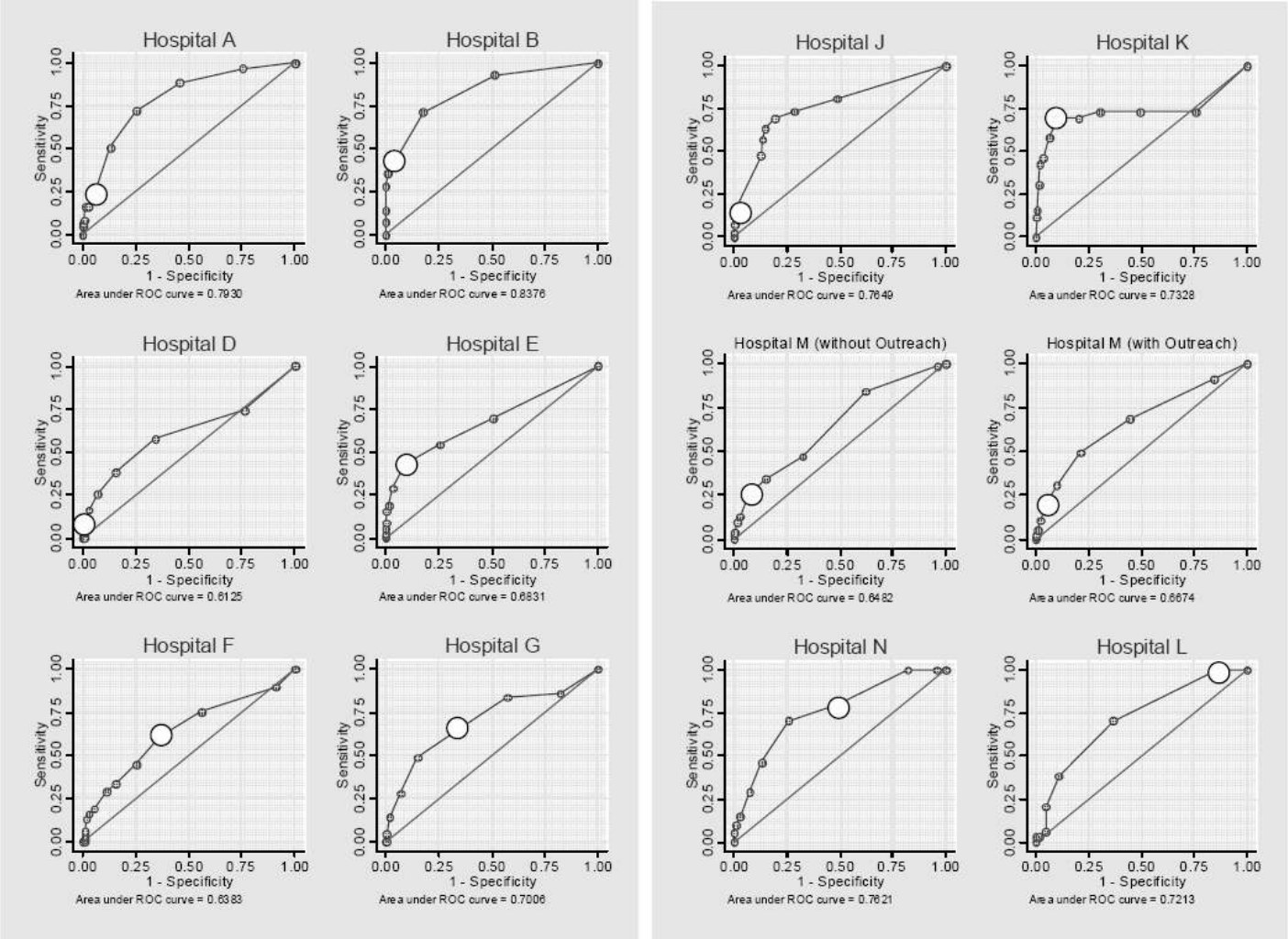
Hospital	Subgroup	Patients n (%)	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	Prevalence (95% CI)
	Referral	2028 (79.6)			35.5 (33.4, 37.6)		
O	Follow-up	412 (69.6)	78.0 (65.3, 87.7)	50.4 (41.1, 59.7)	43.8 (34.1, 53.8)	82.2 (71.5, 90.2)	33.1 (26.3, 40.6)
	Referral	180 (30.4)			61.1 (56.2, 65.9)		

CI confidence interval, PPV positive predictive value, NPV negative predictive value, *Includes 1167 (47.4%) critical care admissions not seen by the CCOS, MAU medical admissions unit, CCOS critical care outreach service(s)

Twelve datasets including critical care follow-up or all ward/Medical Admissions Unit patients were identified, of which 11 datasets were included in the meta-regression; one dataset was dropped since all patients experiencing the composite outcome measure triggered. There was strong evidence of heterogeneity across datasets in the diagnostic accuracy (Q=38.3 on 10 degrees of freedom, P<0.001; H=2.0, 95% confidence interval 1.5 to 2.6) (Figure 3.3.1.3). Differences in diagnostic accuracy among the datasets were not explained by the physiological variables included in the TT, the outcome measures available within the TT dataset, or the inclusion of critical care follow-up versus all ward/Medical Admissions Unit patients (Table 3.3.1.6).

Figure 3.3.1.4 shows the summary ROC curve. Each circle represents one TT dataset; the area of each circle is inversely proportional to the variance of the log diagnostic odds ratio. The fitted line shows the summary ROC curve. The area under the summary ROC curve = 0.73, representing acceptable discrimination. However, most datasets are towards the low end of the curve indicating low sensitivity for the composite outcome measure (presence of established critical illness defined as the composite of death, admission to critical care, DNAR placed or CPR) and suggesting trigger thresholds are too high.

Figure 3.3.1.2: ROC curves for composite outcome measure in critical care follow-up patients



○ Trigger in use in the hospital

Figure 3.3.1.3: Forest plot of log diagnostic odds ratio (lnDOR)

The size of each square is inversely proportional to the variance of lnDOR. The horizontal lines are 95% confidence intervals for lnDOR.

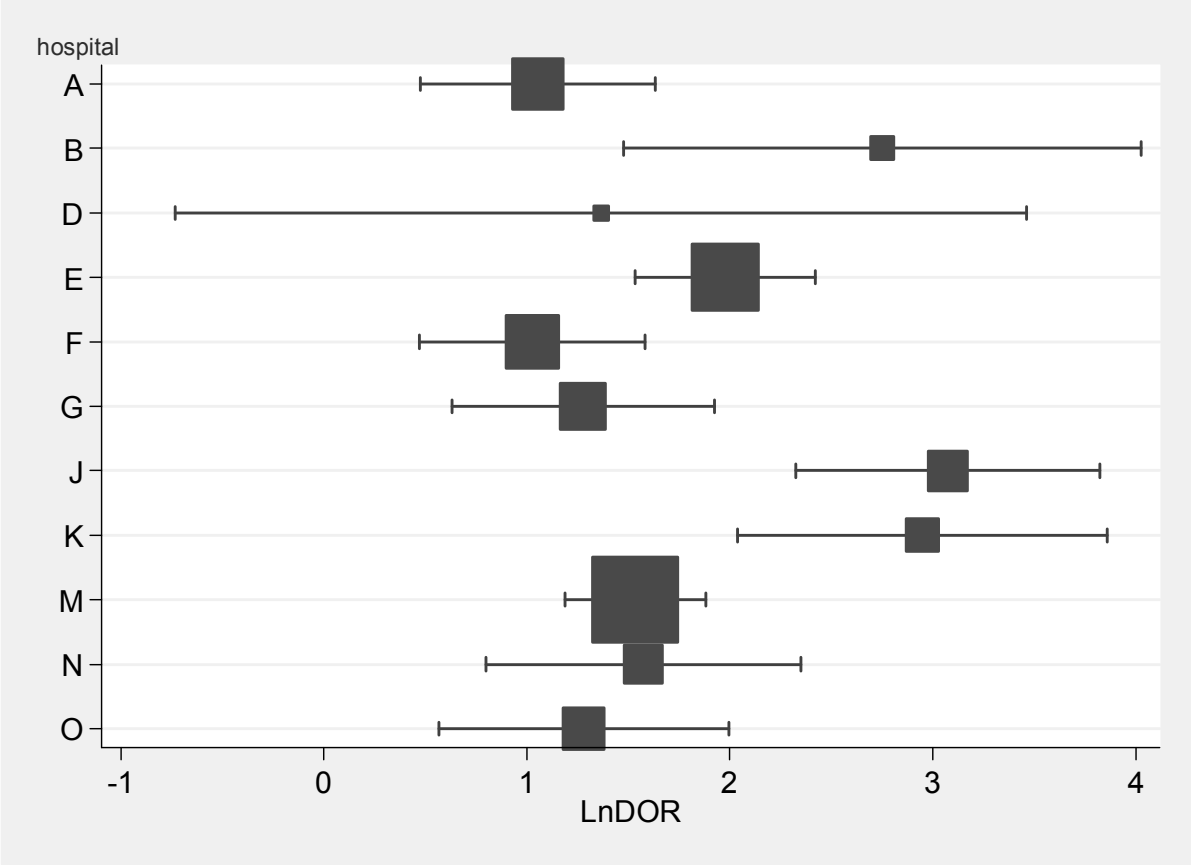
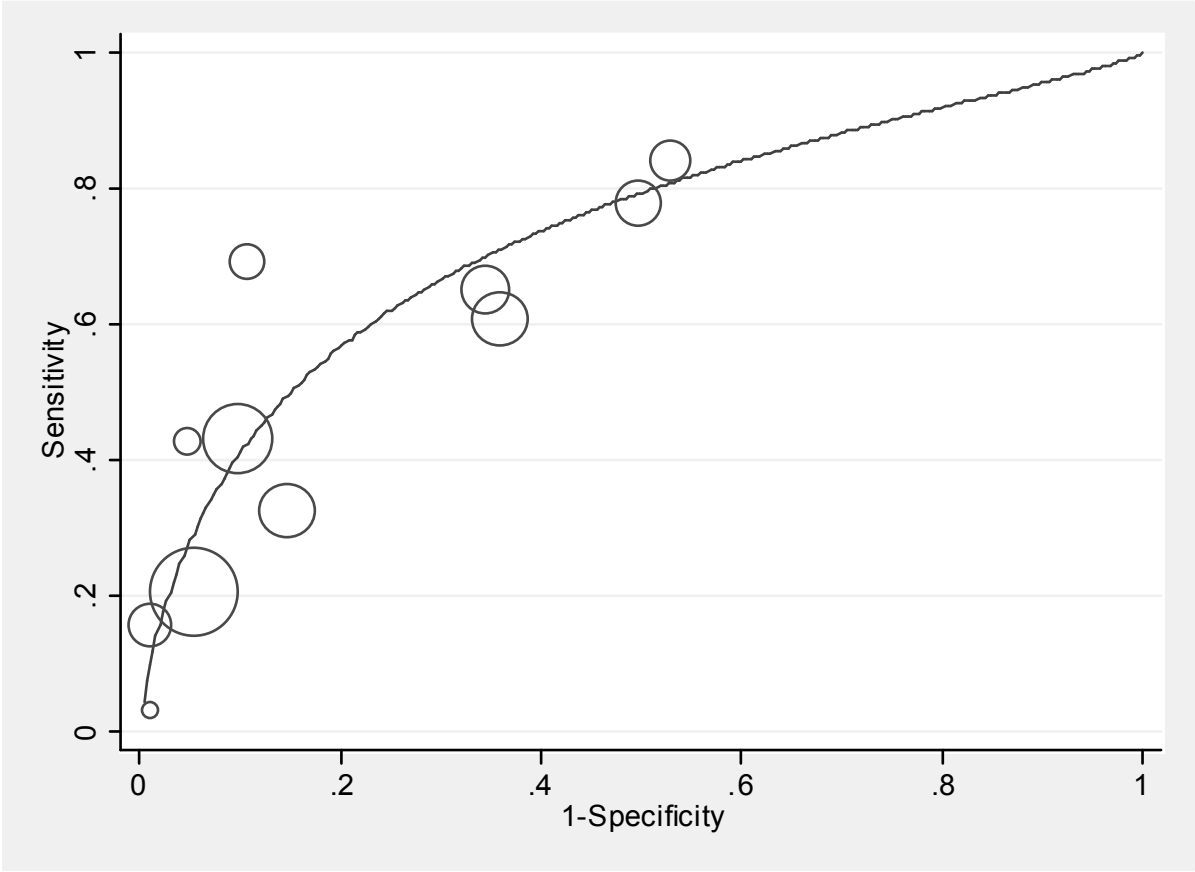


Table 3.3.1.6: Results of meta-regression on log diagnostic odds ratio (lnDOR)

Physiological variables*	Coefficient	95% confidence interval
Temperature	−1.2	(−4.4, 1.9)
Urine output	−0.1	(−1.9, 1.8)
Oxygen saturation	0.2	(−1.7, 2.1)
Outcome measures†	Coefficient	95% confidence interval
Cardiopulmonary resuscitation	1.2	(−1.4, 3.9)
Do not attempt resuscitation	0.7	(−1.9, 3.4)
Patient group	Coefficient	95% confidence interval
Critical care follow-up patients‡	1.0	(−1.6, 3.7)

*the following physiological variables were included in all TTs: heart rate, blood pressure, respiratory rate, conscious level; the following physiological variables were included in a single TT only: respiratory support, acid base disturbance; † the following outcome measures were included in all TT datasets: admission to critical care, death; ‡ comparison group: all Medical Admissions Unit patients

Figure 3.3.1.4: Summary Receiver Operating Characteristic (ROC) curve for composite outcome measure in critical care follow-up and Medical Admissions Unit patients



3.3.2 Study 2 - reproducibility of TTs

Brief introduction

In this study, inter-rater and intra-rater reliability of the physiological measurements, aggregate scores and triggering events of three systems were examined: a single parameter system, the call-out criteria for MET[2], and two aggregate scoring systems, the Modified Early Warning Score (MEWS)[8] and the Assessment Score for Sick patient Identification and Step-up in Treatment (ASSIST)[9].

Methods

Design and data collection

A prospective observational study was conducted at a District General Hospital in North Wales. The study was approved by the Local Research Ethics Committee. Participants were adult patients from general medical and surgical wards. A number of wards were selected to satisfy the sample size calculation (below) and all patients on these wards able to give informed consent were invited to participate. Patients were informed about the purpose of the study and received an information leaflet. Verbal consent was obtained.

Based on assumptions for inter-rater reliability (kappa=0.8, proportion of positive results=0.07) with four raters, a sample of 93 patients was required to estimate kappa with a standard error of 0.1. For the intra-rater reliability, with an assumed value of kappa=0.9, the required sample size was 44 patients. Sample size calculations were performed using a custom-designed module[10].

Data were collected by four members of hospital staff on three days. All four raters were familiar with the scoring methods in their clinical practice and received an induction prior to the study. A copy of the consent form and the data collection sheet are presented in Appendix 3.

For inter-rater reliability, data were collected on two acute medical and two acute surgical wards. A senior doctor (Certificate of Completion of Specialist Training equivalent to Intensive Care Medicine), junior doctor (Senior House Officer level), registered nurse (E-grade; five years' experience) and student nurse (nursing auxiliary who had previously worked as a health care assistant) collected the data. The order of the raters taking the measurements was randomized for each ward from a set of possible permutations. Raters were blinded to the results of their colleagues.

For intra-rater reliability, data were collected on one acute medical and one acute surgical ward. The same raters collected the data. Each rater examined the same patient four times, in 15-minute intervals, while blinded to their previous scores. There were no interventions between the four sets of measurements.

Age and normal blood pressure, the latter derived from an average of the charted values in the previous 48 hours, were collected first. Raters then

measured the remaining parameters – systolic blood pressure, temperature, respiratory rate, pulse rate, urine output and level of consciousness.

Blood pressure was measured electronically (DINAMAP™, Critikon Inc, Tampa) and checked manually, where appropriate. Blood pressure was measured by all four raters for the first 18 patients. For subsequent patients (as the repeated measurements were found to be unacceptable to patients), blood pressure was measured only once by the first rater, noted on the patient's bedside sheet, and copied by subsequent raters. Temperature was taken orally (Temp-PlusII®, IVAC-Corporation, San Diego), measured only once by the first rater, noted, and copied by subsequent raters. All other parameters were measured by each rater in turn. Respiratory rate was counted over thirty seconds and pulse rate was counted over fifteen seconds in regular heart rhythm and one minute in irregular heart rhythm. Raters calculated urine output per kilogram per hour from urine output charted over the last four hours.

Raters scored the observations according to the three systems. MET call-out criteria scored one if any criterion was fulfilled, otherwise zero was scored. MEWS and ASSIST were scored according to the scoring charts. Blood pressure scoring in MEWS differed from the published version by using the deviation from the patient's normal blood pressure (Stenhouse C, personal communication) (Table 3.3.2.1).

Data were entered into a spreadsheet by a data entry clerk not involved in data collection. Logic, range and consistency checks were applied to all variables. Outliers and missing data were checked against original data collection sheets.

Statistical analysis

Statistical analysis was performed using intraclass correlation coefficients for continuous variables (systolic blood pressure, temperature, respiratory rate, pulse rate and aggregate scores), and kappa statistics for categorical variables (level of consciousness, aggregate scores and trigger levels). Two-way and one-way analysis of variance was used in calculating the intraclass correlation coefficient for inter-rater and intra-rater studies, respectively[11]. Bootstrap methods were used to provide bias-corrected confidence intervals. For the inter-rater study, kappa and phi statistics were also calculated[12] for each of the six possible pairings among the raters. All analyses were performed in Stata 8.2 (StataCorp LP, College Station, TX).

As disagreements in total scores and trigger events could be a result of disagreements either in the physiological measurements or incorrect calculation, to examine the relative impact of these, the three systems were recalculated from the original physiological measurements and agreement was assessed both on the scores as recorded by the raters and on the corrected scores.

To interpret the strength of agreement, we adopted the following guidelines[13]: <0.20 poor; 0.21–0.40 fair; 0.41–0.60 moderate; 0.61–0.80 good; 0.81–1.00 very good.

Table 3.3.2.1: TTs used in the study

Medical Emergency Team (MET) call-out criteria

Criterion	Assessment
Airway	Threatened
Breathing	All respiratory arrests Respiratory rate <5 per minute Respiratory rate >36 per minute
Circulation	All cardiac arrests Pulse rate <40 per minute Pulse rate >140 per minute
Neurology	Sudden fall in level of consciousness (Fall in Glasgow Coma Score of >2 points) Repeated or prolonged seizures
Other	Any patient who does not fit the criteria above but whom you are seriously worried about

Trigger threshold: One or more of the above criterion met

Modified Early Warning Score (MEWS)

	3	2	1	0	1	2	3
Heart rate (min^{-1})		<40	40-50	51-100	101-110	111-129	≥130
Systolic blood pressure (mmHg)	By scoring chart below						
Respiratory rate (min^{-1})		<9		9-14	15-20	21-29	≥30
Temperature (°C)		<35		35-38.4		≥38.5	
AVPU score				Alert	Reacting to voice	Reacting to pain	Unresponsive
Urine ($ml\ kg^{-1}\ h^{-1}$)	Nil	<0.5	<1	1-1.5	>1.5		

Trigger threshold: Total score ≥3 (possible range 0–20)

PATIENTS NORMAL BLOOD PRESSURE

Measured Blood Pressure	200	190	180	170	160	150	140	130	120	110	100	90	80
200	0	0	0	1	1	2	2	2	3	3	4	5	5
190	0	0	0	0	1	1	1	2	2	3	3	4	5
180	0	0	0	0	0	0	1	1	2	2	3	3	4
170	1	0	0	0	0	0	1	1	2	2	3	3	4
160	1	1	1	0	0	0	0	0	1	1	2	2	3
150	1	1	1	1	0	0	0	0	0	1	1	2	2
140	2	2	1	1	1	0	0	0	0	0	1	1	2
130	2	2	2	1	1	0	0	0	0	0	0	1	1
120	2	2	2	2	1	1	0	0	0	0	0	0	1
110	3	3	2	2	2	1	1	0	0	0	0	0	0
100	3	3	3	3	2	2	2	1	1	0	0	0	0
90	4	4	3	3	3	2	2	2	1	0	0	0	0
80	4	4	4	4	3	3	3	2	2	1	1	0	0
70	4	4	4	4	4	3	3	3	2	2	2	1	0
60	4	4	4	4	4	4	4	4	3	3	3	2	1
50	5	5	5	5	5	5	5	5	4	4	4	3	2
40	6	6	6	6	6	6	6	6	5	5	5	4	3

NB If Scoring 4 on BP, re-check the blood pressure and call for experienced help

Assessment Score for Sick patient Identification and Step-up in Treatment (ASSIST)

	4	2	1	0	1	2	4
Systolic blood pressure (mmHg)	<85	85-90	91-99	100-220			>220
Heart rate (min^{-1})	<50		50-60	61-100	101-120	121-140	>140
Respiratory rate (min^{-1})	<10			10-25	26-30	31-35	>35
Neurological score				Alert and orientated	Confused[1] or agitated	Drowsy but easily rousable	Not rousable or only by nail pressure
Age				<70	≥70		

[1]Confusion should not be charted in patients with previously documented dementia.

Trigger threshold: Total score ≥4 (possible range 0–17)

Results

Inter-rater reliability

In the inter-rater study, 114 patients were examined. The four raters were not able to perform four sets of measurements on all 114 patients, as some patients were called for clinical investigation or were otherwise unavailable. In total, 433 sets of measurements, of a total possible 456, were obtained. A further nine sets of observations from three patients were excluded as their

normal blood pressures were missing, leaving 424 sets of observations included in the study.

In total, 109, 102, 107 and 106 patients were examined by the senior doctor, junior doctor, registered nurse and student nurse, respectively. Of the 424 sets of observations, 412 (97.1%) were missing urine output; urine output was therefore excluded from the analysis. All other measurements were 100% complete.

By allowing raters to abstract, rather than measure directly, the temperature and blood pressure (apart from for the first 18 patients), there is the potential to have introduced errors in copying figures. Such copying errors for temperature and blood pressure were identified in 1.4% and 0.6% of observations, respectively.

Agreement for respiratory rate, heart rate and systolic blood pressure was similar (for first 18 patients when blood pressure measured directly by each rater) with intraclass correlation coefficients (95% confidence interval) of 0.57 (0.45–0.70), 0.63 (0.52–0.73) and 0.65 (0.40–0.85), respectively. Copying error had almost no effect on the agreement on systolic blood pressure (for 96 patients where blood pressure measured directly by first rater and copied by subsequent raters), intraclass correlation coefficient 0.99 (0.97–1.00) and only a small effect on temperature, intraclass correlation coefficient 0.74 (0.51–0.91).

There were no significant differences in the mean physiological measurements among the raters for respiratory rate (P=0.44), systolic blood pressure (P=0.34 – measured directly by each rater and P=0.09 – measured by first rater) and heart rate (P=0.23). The small number of copying errors in temperature, predominantly by one rater, where agreement was otherwise perfect, led to a small but significant difference in mean temperature (P=0.03). Kappa agreement was moderate (0.53, 95% confidence interval 0.31–0.78) on levels of consciousness in MEWS and fair (0.35, 0.22–0.48) on levels of consciousness in ASSIST.

The percentage of correctly calculated scores was lower for MEWS and ASSIST than for MET (Table 3.3.2.2). Overall, 27 (6.4%) patients were scored higher and 49 (11.5%) lower for MEWS, and 12 (2.8%) patients were scored higher and 67 (15.8%) lower for ASSIST. There were statistically significant differences in the percentage of correctly calculated scores among raters for MET and MEWS.

The agreement indices among the four raters (Table 3.3.2.3) suggest the raters had higher level of agreement on aggregate score for ASSIST than MEWS. There were no significant differences among raters in mean scores for the two systems (P=0.40 and 0.13 for MEWS and ASSIST calculated by raters, 0.41 and 0.14 when corrected). Agreement on triggers was similar in MEWS and ASSIST, and was improved by using corrected scores. Percentage agreement on triggers was higher than scores. In MET, any patient who did not trigger the first three criteria but caused serious worry was

scored as one. In the 424 sets of observations, five patients were triggered via this criterion, all by one rater.

Table 3.3.2.2: Number of correctly calculated scores for inter-rater study

	Student Nurse	Registered Nurse	Junior Doctor	Senior Doctor	Total	P-value
Observations, n	106	107	102	109	424	
MET, n (%)	98 (92.5)	106 (99.1)	101 (99.0)	109 (100)	414 (97.6)	0.001
MEWS, n (%)	81 (76.4)	81 (75.7)	92 (90.2)	94 (86.2)	348 (82.1)	0.01
ASSIST, n (%)	78 (73.6)	90 (84.1)	86 (84.3)	90 (82.6)	344 (81.1)	0.15

P-value indicates statistically significant difference in proportion of correctly calculated scores, MET medical emergency team call-out criteria, MEWS modified early warning score, ASSIST assessment score for sick patient identification and step-up in treatment

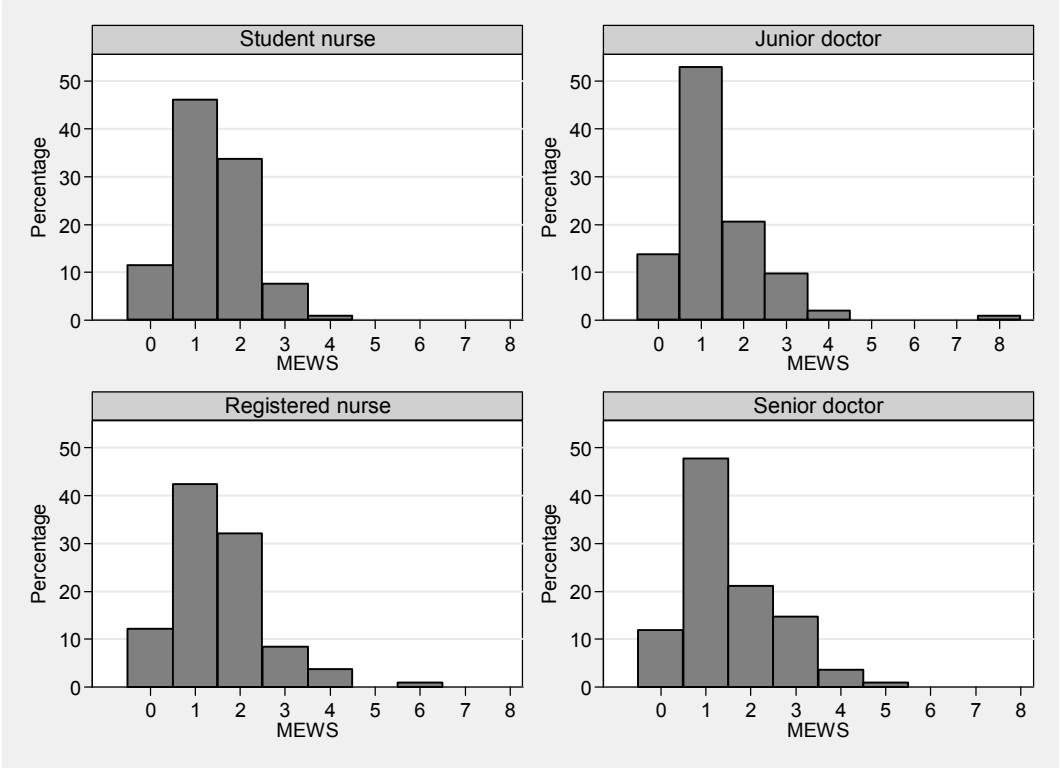
Table 3.3.2.3: Level of agreement of aggregate scores and triggers among the four raters for inter-rater study

	Trigger: n (%) Score: median (IQR) [range]	Kappa statistic (95% CI)	All four agreed, n (%)	Three agreed, n (%)	ICC (95% CI)
Calculated by raters					
MET trigger	11 (2.6)	−0.03 (−0.05, 0.00)	86 (77.5)	106 (95.5)	-
MEWS score	1 (1-2) [0-8]	0.20 (0.13, 0.27)	17 (15.3)	53 (47.8)	0.45 (0.34, 0.55)
MEWS trigger	60 (14.2)	0.18 (0.09, 0.27)	62 (55.9)	94 (84.7)	-
ASSIST score	1 (0-1) [0-8]	0.46 (0.38, 0.55)	41 (36.9)	80 (72.1)	0.49 (0.40, 0.57)
ASSIST trigger	19 (4.5)	0.20 (0.04, 0.38)	84 (75.7)	104 (93.7)	-
Corrected calculations					
MET trigger	7 (1.7)	−0.02 (−0.04, 0.05)	90 (81.1)	106 (95.5)	-
MEWS score	1 (1-2) [0-8]	0.22 (0.15, 0.30)	18 (16.2)	55 (49.6)	0.50 (0.42, 0.59)
MEWS trigger	69 (16.3)	0.37 (0.25, 0.51)	64 (57.7)	101(91.0)	-
ASSIST score	1 (0-2) [0-8]	0.50 (0.42, 0.58)	43 (38.7)	83 (74.8)	0.66 (0.55, 0.76)

IQR interquartile range, CI confidence interval, ICC intraclass correlation coefficient, MET medical emergency team call-out criteria, MEWS modified early warning score, ASSIST assessment score for sick patient identification and step-up in treatment

The distributions of MEWS and ASSIST scores for the four raters are shown in Figure 3.3.2.1. Pairwise agreements were similar to overall agreement, and agreement using phi appeared better than kappa (Table 3.3.2.4).

Figure 3.3.2.1: Distribution of Modified Early Warning Score (MEWS) and Assessment Score for Sick patient Identification and Step-up in Treatment (ASSIST) for the four raters in the inter-rater study



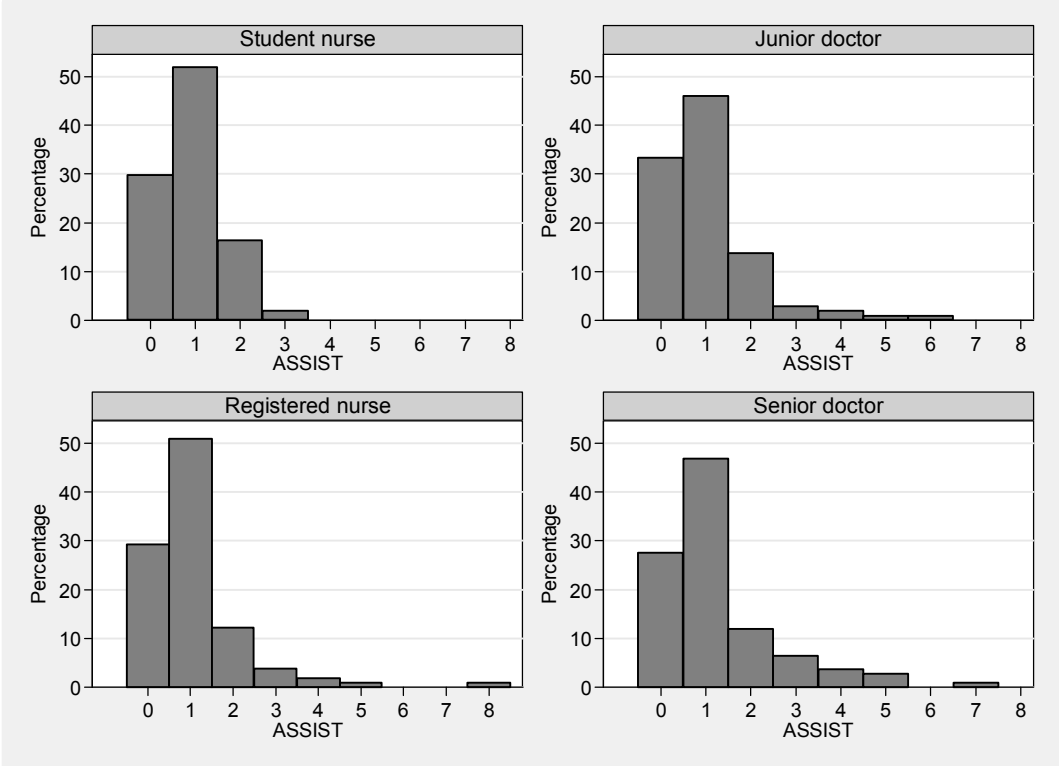


Table 3.3.2.4: Pairwise agreement between raters for inter-rater study

	SN v RN	SN v JD	SN v SD	RN v JD	RN v SD	JD v SD
MET trigger, kappa (95% CI)	−0.1 (−0.1, 0.3)	0.0 (0.0, 0.5)	---	0.0 (0.0, 0.5)	---	---
MET trigger, phi (95% CI)	−1	−1	---	−1	---	---
MEWS score, kappa (95% CI)	0.1 (0.0, 0.3)	0.3 (0.1, 0.4)	0.3 (0.1, 0.4)	0.1 (0.0, 0.2)	0.2 (0.1, 0.3)	0.3 (0.2, 0.4)
MEWS trigger, kappa (95% CI)	0.0 (−0.1, 0.3)	0.2 (0.0, 0.4)	0.3 (0.1, 0.5)	0.3 (0.1, 0.5)	0.3 (0.1, 0.5)	0.3 (0.1, 0.5)
MEWS trigger, phi (95% CI)	0.1 (−0.3, 0.4)	0.3 (0.0, 0.6)	0.4 (0.1, 0.6)	0.3 (0.0, 0.6)	0.4 (0.1, 0.6)	0.4 (0.1, 0.6)
ASSIST score, kappa (95% CI)	0.4 (0.3, 0.6)	0.5 (0.4, 0.6)	0.3 (0.2, 0.5)	0.5 (0.4, 0.7)	0.5 (0.4, 0.6)	0.5 (0.4, 0.6)
ASSIST trigger, kappa (95% CI)	0.3 (0.1, 0.6)	0.1 (−0.1, 0.3)	0.3 (0.1, 0.6)	0.3 (0.1, 0.6)	0.5 (0.3, 0.8)	0.4 (0.1, 0.6)
ASSIST trigger, phi (95% CI)	0.5 (0.1, 0.8)	0.2 (−0.4, 0.6)	0.5 (0.1, 0.8)	0.5 (0.1, 0.7)	0.7 (0.4, 0.9)	0.5 (0.2, 0.7)

SN student nurse, RN registered nurse, JD junior doctor, SD senior doctor, MET medical emergency team call-out criteria, CI confidence interval, --- cannot be calculated since no patient rated by SD triggered, phi = $[(OR)^{1/2} - 1]/[(OR)^{1/2} + 1]$ where OR is the odds ratio on the agreement between two raters, MEWS modified early warning score, ASSIST assessment score for sick patient identification and step-up in treatment

Intra-rater reliability

There were 180 sets of observations from 45 patients in the intra-rater study. All observations were used in the analyses. In total, 170 (94.4%) were missing urine output, which was excluded. All other parameters were 100% complete. There were copying errors for temperature in 0.6% and for blood pressure in 1.1% of observations.

There was 100% agreement on conscious level, with all patients scored as "Alert". Intra-rater agreements on respiratory rate, heart rate and systolic blood pressure were similar to the inter-rater study. Agreement on temperature, intraclass correlation coefficient 0.98 (0.94–1.00), was better in the intra-rater study than the inter-rater study.

The proportions of scores calculated correctly were similar to those from the inter-rater study (Table 3.3.2.5). In MET, patients were 100% correctly scored by all raters. In MEWS, 17 (9.4%) patients were scored higher and 14 (7.8%) lower and in ASSIST 11 (6.1%) patients were scored higher and 22 (12.2%) lower.

The agreement indices (Table 3.3.2.6) suggest intra-rater agreement on score was similar for MEWS and ASSIST. There was good agreement on triggers for MEWS and ASSIST, although the confidence intervals for ASSIST were

very wide due to the low number of events. Only one patient triggered the MET calling criteria on a single observation.

Table 3.3.2.5: Number of correctly calculated scores for intra-rater study, n (%)

	Student Nurse	Registered Nurse	Junior Doctor	Senior Doctor	Total	P-value
Observations, n	48	24	84	24	180	
MET, n (%)	48 (100)	24 (100)	84 (100)	24 (100)	180 (100)	1
MEWS, n (%)	40 (83.3)	24 (100)	66 (78.6)	19 (79.2)	149 (82.8)	0.05
ASSIST, n (%)	33 (68.8)	24 (100)	72 (85.7)	18 (75.0)	147 (81.7)	0.003

P-value indicates statistically significant difference in correctly calculated scores, MET medical emergency team call-out criteria, MEWS modified early warning score, ASSIST assessment score for sick patient identification and step-up in treatment

Table 3.3.2.6: Level of agreement of total scores and triggers among the four raters for intra-rater study

	Trigger: n (%) Score: median (IQR) [range]	Kappa statistic (95% CI)	All four agreed, n (%)	Three agreed, n (%)	ICC (95% CI)
Calculated by raters					
MET trigger	1 (0.6)	−0.01 (−0.02, −0.01)	44 (97.8)	45 (100)	-
MEWS score	1 (1-2) [0-6]	0.53 (0.39, 0.68)	24 (53.3)	37 (82.2)	0.71 (0.60, 0.76)
MEWS trigger	26 (14.4)	0.64 (0.46, 0.84)	37 (82.2)	45 (100)	-
ASSIST score	1 (1-1) [0-5]	0.59 (0.46, 0.74)	27 (60.0)	40 (88.9)	0.81 (0.58, 0.93)
ASSIST trigger	6 (3.3)	0.66 (−0.02, 1.00)	43 (95.6)	45 (100)	-
Corrected calculations					
MET trigger	1 (0.6)	−0.01 (−0.02, −0.01)	44 (97.8)	45 (100)	-
MEWS score	1 (1-2) [0-5]	0.56 (0.42, 0.68)	23 (51.1)	37 (82.2)	0.68 (0.53, 0.75)
MEWS trigger	23 (12.8)	0.58 (0 .31, 0.81)	37 (82.2)	44 (97.8)	-
ASSIST score	1 (1-1) [0-5]	0.54 (0.42, 0.68)	25 (55.6)	35 (77.8)	0.57 (0.24, 0.83)
ASSIST trigger	8 (4.4)	0.48 (−0.03, 1.00)	41 (91.1)	45 (100)	-

IQR interquartile range, CI confidence interval, ICC intraclass correlation coefficient, MET medical emergency team call-out criteria, MEWS modified early warning score, ASSIST assessment score for sick patient identification and step-up in treatment

3.4 Qualitative evaluation of TTs

Brief introduction

The aim of the qualitative evaluation was to characterise, using qualitative research methods, the impact of the introduction, development, incremental implementation and current models/organisation of CCOS within acute NHS Trusts in England. This aim was achieved by obtaining, describing and analysing the perspectives of a wide range of participants and stakeholders, such as intensive care clinicians (doctors and nurses), ward staff (doctors, nurses and allied health professionals), managers, hospital chaplains, patients and their relatives. As part of the qualitative evaluation, interviewees' perspectives on physiological track and trigger warning systems were examined, especially whether interviewees felt there was a role for them in the hospital and whether they were making a difference.

Methods

The methods for the qualitative evaluation of CCOS are described in detail in Section 5.

Results

115 interviews were conducted with 122 individuals (see Table 5.1 and Figure 5.1). TTs had reportedly coincided with the establishment of the CCOS. In some cases, one of the primary responsibilities of the CCOS had been to implement the scoring system across the wards. The types of TT and response algorithm varied between sites (e.g. Patient at Risk (PAR) score, Early Warning Score (EWS); Modified Early Warning Score (MEWS), locally devised score).

TTs

The majority of interviewees were in favour of the use of TTs, which were held to be useful in several ways, generally related to their "objectivity". The objective information provided by a TT could aid a less experienced or junior member of staff in the identification of sick patients and, crucially, provided them with objective information to pass on to others, thereby giving nurses confidence to contact doctors and the CCOS. The idea that TTs provided the user with objective evidence was mentioned on a number of occasions. Interviewees predominantly felt that TTs were of most use to the junior and inexperienced nurses.

> *It gives them (the nurses) a sort of a quantifiable figure to think, well, that's wrong…*
> [G Grade Nurse, Critical care unit]

The scores were seen as beneficial even for those without basic knowledge:

> *It's quite surprising how many don't know a normal blood pressure or a normal heart rate so I think at least the scoring, if they do it, gives them a trigger if they don't know the normal values of things.*
> [G Grade Nurse, CCOS]

Several interviewees saw the prevention of critical care unit admission as directly linked to the provision of better care on the wards, since TTs would enable ward staff to manage patients better and identify problems sooner.

> *The main role is to prevent admissions to critical care unit by using the trigger scores to identify deteriorating patients. [Nurses] would act sooner because the doctors are always busy, you can go in there and do the things and relieve the symptoms from getting worse and prevent an admission to the critical care unit.*
> [G Grade Nurse, CCOS]

One CCOS even had the goal of eventually not being needed although, as this nurse describes, such an ambition was thwarted by increasingly sick patients:

> *I hoped that one day outreach would be less needed, I figured that we could work our way out by training the ward staff… I thought by [teaching] the medical students and nursing staff… giving them the support they acknowledged they needed, we wouldn't be needed and the early warning score would run itself, we wouldn't actually be needed but it's not working like that because the patients are getting sicker so we are going to be needed and if it's going to continue and change the objectives constantly need changing too.*
> [G Grade Nurse, Outreach]

Balanced against this highly mechanistic view of TTs was the view that they can (or perhaps should) encourage ward nurses in their own understanding:

> *[The EWS is] a scaffolding within which you can move around quite happily but actually, a lot of the time, you will need to step slightly off it…I think that having an early warning score which triggers the thought "I should be referring" should actually start the thinking process in anybody…The default is, I call for help but, if they happen to know that… the trigger score is four, it was five an hour ago, I think we're on the right track… what I will do is I will come back in half an hour and then they do it, that's fine… we don't want to discourage people actually thinking (things) through.*
> [Consultant, Critical care unit and Medicine]

Some interviewees suggested that staff either could, or had, become over reliant on TTs. One CCOS nurse suggested that TTs were simply a tool that should help with identification rather than take over from nurses own clinical judgement, feelings and experience. Similarly, one House Officer reported that it was important for individuals to use "common sense" when deciding whether a patient really needed to be referred on to the doctors. Several interviewees suggested that, although TTs were useful, there might be the danger that they lead the user in to a false sense of security: that is, if the patient is not "triggering" they must be well.

Response algorithms/ protocols
The level of protocolisation varied from hospital to hospital. At sites with protocols related to the TTs, interviewees were usually aware of what procedures to follow if they were concerned about a patient or if their score was outside normal parameters.

One study site followed very clear documented protocols which were very rigidly adhered to. At the site itself, this was not considered to be a bad thing and did not, as is evidenced in the conversation below, detract from the overall response to the service by the nurses on the ward:

> *They're rightly not flexible about the policy (so) they can't say "well it's OK this time" because then it muddies waters and confuses people and the policies should just be applied and that's it…And they've stuck very firmly to that but they're supportive of us and they don't come in with a big stick and say this ward's terrible, you didn't follow the policy.*
> [F Grade Nurse, Ward]

A number of issues, however, were raised concerning implementation of response algorithms/protocols: communication; delay; resistance; authority; documentation; or just issues with protocols per se. These are illustrated below.

Ward nurses often reported being unable to contact doctors if they had a sick patient, or that doctors took several hours to actually arrive once called, or doctors simply refused to involve the CCOS or anyone from ITU. Some senior doctors suggested that it was the job of junior doctors to treat sick patients and not the CCOS, although junior doctors were often very grateful for the help of the CCOS.

Frequently, attention was drawn to areas where the protocols were breaking down; one CCOS nurse felt that this was happening at several levels.

> *I know from a recent audit we've done that the protocols are not being followed…for whatever reason, when patients are triggering either it's not being reported to the medical staff or there's a delay in the medical staff coming out to assess the patients and also on the documentation side, there's very little documentation, so it could be that things are being done but unfortunately not being documented.*
> [H Grade Nurse, CCOS]

CCOS perception was that much training worked, in theory and in practice, but trained staff were hampered by practical, organisational or communication issues. In the lengthy quotation below, for example, are described several issues which can be summed up as poor communication within and between medical teams.

> *I think the system, in terms of using simple physiological parameters to identify patients at risk of being critically ill, that works, definitely. You*

> *can almost consistently look back to somebody who's been admitted to ICU or somebody whose cardiac arrest you've had the misfortune of attending and you can see that they've been triggering an early warning score, you can see that the system works in principle. It's just what's done about it beyond a certain level. I think the person taking the score will usually speak to somebody else to let them know but what happens after that…It goes up through the chain of command, within the medical team that's responsible for patient care, but we find that it gets blocked at a fairly low, junior level and often decisions are delayed because of that… Some junior doctors are afraid to call a consultant, or the consultant's away, and cross cover consultant responsibility falls apart. So, often patients go four or five days without being seen by a consultant and, even if they are becoming obviously very ill, nobody wants to call another consultant to review them. I think there's discontinuity of care amongst consultants…*
> [Consultant, CCOS]

One D grade nurse suggested that patients were not brought to the attention of the CCOS in a timely fashion. An F grade nurse felt that it was necessary for the senior nurses to be vigilant to ensure timely referral, but thought that problems occurred at house officer level, as they lacked experience and confidence about the right time to call for extra help. This was a sentiment repeated by other interviewees.

Even where sick patients are appropriately identified, ensuring they receive timely and appropriate treatment and care could be a problem.

> *Often… a nurse has said to me oh, we've flagged him up ages ago and he's triggering, and I know all you are doing is documenting the decline and you need the medical teams to do something, you need that medical power, I mean ITU medics have been up to see him three times, you know, surgeons have been every day reviewing him and yet, the outcome is he's still ended up in ITU…and you think well why? But you think kind of, the tool did not fail*
> [G Grade Nurse, CCOS]

A consultant added that while the trigger scores were useful it was often inexperienced or junior nurses doing the scoring who didn't have the power or knowledge to do much about it - should the scores be outside normal parameters (specifically the Health Care Assistants).

It is difficult to pin point one single area where protocols fail. One consultant felt the answer for the variability in identification was quite complex being dependent on the availability of staff (especially doctors), the number of patients triggering at any one time and the patient profile. Another consultant acerbically commented,

> *Written protocols are a waste of time unless people read them and understand them and implement them. Just because they're there*

doesn't mean very much.
[Consultant, Critical care unit]

Accuracy of TTs
Overall, reactions were mixed as to whether TTs and protocols/response algorithms were actually working. Interviewees reported that, where scores were completed and interpreted accurately, patients certainly received more timely and superior treatment. There were frequently witnessed examples where ward nurses had completed the TTs appropriately, called the treating team and CCOS and initiated nursing treatment. A large proportion of interviewees reported that the identification of sick patients had significantly improved since the introduction of TTs. Some interviewees suggested that communication of information via documentation had improved in relation to better recording of patient observations. One interviewee felt that there was now an increased awareness of how to interpret the subtle alterations in physiological parameters and the importance of checking respiratory rates.

Despite interviewees feeling that there had been significant improvements since the introduction of TTs and CCOS, the most commonly reported problem was with how well sick patients were identified. Many local issues were identified that might affect the accuracy of TTs. These ranged from: lack of or poor use in some hospital areas; variation in use among staff; and data collection. These are summarised below.

TTs were usually used across all hospital wards; although the degree to which they were implemented and integrated with routine practice varied. Several areas were identified where CCOS appeared to have made no impact where some impact might have been expected; areas identified where they were often not used, for example, ICU/HDU, A&E and other higher dependency areas such as CCU. At several sites, ward and CCOS nurses claimed that patients in A&E were poorly assessed using TTs. Some interviewees also claimed that post-CCU patients missed out on crucial follow-up care.

The vast majority reported that identification was extremely variable from ward to ward and, at times, from nurse to nurse. CCOS members often reported knowing which wards were good at monitoring patients using TTs and calling outreach and which were not so good. One G Grade nurse stated that there were times where she had been called to see a patient, who turned out to be fine but while she was on the ward she came across another patient who was triggering and was obviously very sick. Other CCOS nurses concurred adding that they often worried about how many patients they were missing. A CCOS matron suggested that there were particular areas that were still frequently missed, for example, fluid balance charts and respiration rate.

At times during the observational research, nurses failed to identify sick patients or, in the case of correct identification of sick patients, they would not be referred to the doctors or CCOS in a timely manner. There were frequently witnessed examples of very sick patients on the wards who were not identified as such until a CCOS nurse came onto the ward (perhaps attending a patient already on their books or paying a routine visit to a ward). This may have

been because ward staff were expecting the CCOS to visit, although it did seem to a non-clinical outsider that it would have been appropriate to bleep the CCOS. Some nurses (especially more experienced senior nurses), also admitted that they never completed the trigger scores, arguing that they knew from personal experience how to identify a sick patient and could judge whether a patient needed an escalation in their treatment.

The perception during the observational phase was that TTs were completed on an intermittent basis and there was variation (by ward and by staff member) in how well they were completed. Even though some CCOS nurses or ward nurses reported that scoring was done well, incomplete documentation (where no TTs or observations had been recorded) was observed, even where a patient was very sick. At times, CCOS nurses highlighted scoring sheets which were bereft of the necessary information. One H Grade nurse suggested that TTs were both used inconsistently and inaccurately interpreted.

All interviewees agreed that members of the CCOS should be friendly, open and supportive in order to facilitate good working relationships, but also be able to challenge and change working practices. During the observational research, there were many examples where CCOS nurses seemed to not want to challenge ward staff or make an issue about incomplete observations charts or the completion of trigger scores, perhaps for fear of upsetting them. CCOS nurses muttered about incomplete or inaccurate patient observation charts (or directly explained to the researcher why they felt angry or frustrated); however they were observed challenging the nurses responsible on only a few occasions.

The main areas of concern were that trigger scores were not completed, or were inaccurately scored or interpreted and that staff had become over reliant on the system creating a false sense of security. It was felt that the identification of deteriorating patients, or the response to a correctly identified deteriorating patient, was variable. One consultant stated that despite observable improvements in the identification of sick patients, it is still difficult to know whether patients are being missed.

Education and training

Many interviewees felt that TTs only worked when they were accompanied by adequate training. Many interviewees considered training to be extremely important, in order to ensure all new and junior staff were familiar with their completion and interpretation. Despite this, not all study sites ran regular rolling training sessions on TTs.

Formal and informal training was conducted at the majority of the study sites visited, from very structured classroom based study sessions and courses to ad hoc or impromptu skills transfer on the ward while engaged in patient treatment. Much of the education and training was related to the reinforcement of basic and more specialised nursing skills: the recording of patient observations and fluid charts; the recognition of a deteriorating patient; and the use and interpretation of TTs.

It was noticeable in observation that, CCOS which provided a great deal of formal training tended to engage in less ad hoc training on the wards and were more likely to voice frustrations with ward staff who did not appear to know what they were doing or who were not recording observations for TTs. Their view was that they had provided extensive formal training so they could not understand why staff were not using the knowledge. CCOS with little in the way of formal training appeared to conduct much more ad hoc ward training; working much more closely with ward staff and insisting they be involved in the patient's care.

Few study sites provided training for doctors so consequently they were less likely to have experienced any training by the CCOS. One consultant from a study site that did provide training for doctors suggested that House Officers were the ones who benefited most and, because of the training, they had a much better understanding of TTs. Doctors were also accused of failing to heed what the scores were telling them because they had no idea what the trigger scores were. Informal discussions with doctors confirmed that many were not aware of the trigger scores: many of them voiced reservations about the scores, stating that they were not routinely told what trigger scores were when they were contacted by ward nurses about sick patients.

Another nurse felt that it was important to teach HCAs as well as qualified nurses, since HCAs were those who usually completed the observations charts. Rather than simply recording scores without knowing the meaning, the nurse commented that it was important that they were also able to interpret the scores so as to know when to pass things on to qualified nurses.

One such training session was attended, along with junior nurses and HCAs; it was surprising how difficult many of them found grasping the basic logic of the scoring (especially respiration rate, saturations and urine output). That said, one HCA suggested it was possible for them to learn how to accurately score and interpret the data, and that there were possibly other issues preventing it being done properly:

> *A lot of people still don't do respiration rate which is one of the first signs. If we go round the wards now I can guarantee you that [for most of the observations] the respiration rate is missing…they can't stand there for a minute to count someone's [Respiratory rate]… That's not down to outreach, that's down to the people not doing it properly, because outreach has given them the training, they've told you which are the common signs and they're not doing it…*
> [Health care assistant, Ward]

The majority of ward staff felt that training was extremely beneficial especially in terms of empowering ward nurses and improving basic treatment:

> *[Training] made me look and realise that I could do this and I got all me trigger scores and it taught me how to do fluid balance charts correctly and how to work out a positive and negative balance, which…I didn't*

> *have a clue how to do before I did that. All I knew was how to chart something and anything else I left to the nurses.*
> [Health Care Assistant, Ward]

CCOS staff, however, suggested that training was not always doing what the team had hoped for but were not always sure why. Several interviewees felt apathy or lack of motivation played a part, and there was (anecdotal) criticism of ward nurses. For example, one CCOS nurse described a situation where she had taught a ward nurse how to do the physiological warning scores; when she returned to the ward two days later they had not been done at all. When asked why, the ward nurse stated that she could not find the trigger score, although it was right in the front of the folder

Many interviewees felt the educational role of the CCOS needed expanding. Ward nurses and physiotherapists were keen to receive more training and education to improve their own clinical skills and to learn more about outreach, while CCOS members were concerned that, without regular training, ward staff would become deskilled and over reliant on specialists.

4. Quantitative evaluation of CCOS

Publications:

Esmonde L, McDonnell A, Ball C, Waskett C, Morgan R, Rashidian A, Bray K, Adam S, Harvey S. Investigating the effectiveness of critical care outreach services: a systematic review. Intensive Care Medicine 2006;32:1713-21.

McDonnell A, Esmonde L, Morgan R, Brown R, Bray K, Parry G, Adam S, Sinclair R, Harvey S, Mays N, Rowan K. The provision of critical care outreach services in England: findings from a national survey. Journal of Critical Care 2007;22(3):212-8.

Gao H, Harrison DA, Parry GJ, Daly K, Subbe CP, Rowan K. The impact of the introduction of critical care outreach services in England: a multicentre interrupted time-series analysis. Critical Care 2007;11:R113.

4.1 Systematic review of CCOS

Abstract

Objective

The impact of critical care outreach services (CCOS) on patient and service outcomes was explored to inform development of a typology for CCOS.

Design

Following a sample search of Medline, 15 relevant electronic databases were systematically searched from 1996 to 2004. Searches for publications from nine key authors and citations of eight key articles were performed. Hand-searches of journals, bibliographies of reports and review articles, and conference abstracts were conducted. Relevant experts were contacted. A further two studies published after the review date were also included. Two reviewers assessed studies for inclusion, conducted quality assessment and extracted data. Data was synthesised using narrative techniques.

Measurements and results

Seventeen papers and six brief reports were selected for inclusion from a list of 1760 titles. As anticipated with a relatively new service such as CCOS, there were few controlled trials. There were two randomised controlled trials, 16 uncontrolled before and after studies, three quasi-experimental studies, one controlled before and after study and one post-only controlled study. The most frequent outcomes measured were mortality, length of stay, cardiac arrest rates, unplanned admission rates to critical care and critical care readmission rates.

Conclusions

Although improvements in patient outcomes were found, the evidence in this review is insufficient to demonstrate this conclusively. The many differences in CCOS delivery do not permit identification of service typology. Our findings point to a need for more comprehensive research of this expanding service in a UK context.

4.2 Descriptive national survey of CCOS

Brief introduction

The aim of the descriptive survey was to describe the development, introduction, implementation and current models for CCOS within acute NHS hospitals in England. This aim was achieved by a national, postal survey of NHS acute hospitals in England which routinely provide care for Level 1 patients (n = 239).

Methods

The methods for and results of the descriptive, national survey of CCOS are described in detail in Appendix 1. Briefly, in February 2005, one copy of the questionnaire was sent to each hospital, enclosing a stamped addressed envelope for replies. Completed questionnaires were received from 191 (79.9%) hospitals.

Results

Prevalence of outreach services

The majority (72.8%, n = 139) of respondents reported that their hospital was currently covered by a CCOS. This proportion was unchanged since the Modernisation Agency survey of 2002 (3).

One third of CCOS (32.8%, n = 45/137) reported covering additional hospitals within the Trust. In hospitals reporting no CCOS, 13.7% (n = 7/51) reporting having had CCOS in the past. Lack of resources, in terms of funding or staff, was reported as the reason for discontinuation by six responders. One hospital reported that the CCOS had been discontinued following a one-year pilot.

Aims of the CCOS

Respondents were asked to rank, in order of importance, the aims of their CCOS when first established. Most respondents (85.1%, n = 109/128) ranked either timely identification of patients with impending critical illness or averting admissions/ensuring more timely admissions to critical care as one of their most important aims. Only 8.6% (n = 11/128) ranked avoiding readmissions to critical care and only 5.5% (n = 7/128) ranked enabling discharges from critical care. Table 4.2.1 indicates the number of respondents who ranked each of the listed aims as one of the three most important. This suggested that, when first established, most CCOS prioritised one of the three objectives set by the Department of Health.

Activities of the CCOS

Table 4.2.2 illustrates how each of the broad elements of CCOS activity has evolved over time in the responding hospitals.

Table 4.2.1: Priority ranking of aims of CCOS on establishment of service (includes three most important only)

Aims of CCOS	N (%)
Timely identification of patients with impending critical illness	109/127 (85.8)
Averting admissions/ensuring timely admissions to critical care	102/127 (80.3)
Avoiding readmissions to critical care	56/128 (43.8)
Sharing critical care skills with staff on the wards and in the community	51/126 (40.5)
Enabling discharges from critical care	41/128 (32)
Supporting ward-based care through education at the bedside	40/127 (31.5)
Supporting ward-based staff through formal teaching	25/129 (19.4)

CCOS critical care outreach service

Staffing of the CCOS

Both the reported medical and nursing input to CCOS has been increasing over time. The reported main medical input was from critical care senior specialists (medical consultants) who contributed a mean (SD) of 0.7 (1.8) sessions per week. However, 71.1% (n = 91/128) of respondents reported having no medical consultant input to their CCOS.

CCOS remained a mainly nurse-based service, with the most predominant grades reported being F and G grades, contributing a mean (SD) of 0.9 (1.60) and 1.5 (1.7) whole time equivalents per week, respectively. 65.1% (n = 84/129) of respondents reported no nurse consultant input to their CCOS in 2004 and 41% (n = 57) reported no input from either a nurse consultant, an I grade or an H grade nurse.

Coverage and availability of CCOS

Figure 4.2.1 illustrates the reported proportion of adult wards in responding hospitals which were covered by the CCOS over time. One third of hospitals (33.8%, n = 45/133) reported providing telephone “hotline” advice 24 hours a day for 7 days per week. Fewer hospitals reported offering direct bedside clinical support (14.5%, n = 20/138) or follow-up of discharged level 2/3 patients (12.2%, n = 17) on the same basis.

Independent delivery of care by CCOS

While over 96% (n = 130/135) of CCOS reported providing clinical assessment, liaison with critical care, advice and intervention in support of the parent team, substantially less (62.2%, n = 84/135) reported intervening independently. This reported distinction between direct intervention and making recommendations about patient treatment is illustrated in Table 4.2.3 presenting the extent to which CCOS were involved in different clinical activities. The reported pattern of interventions is not uniform. The mean (SD) number of the eleven listed activities, recommended by CCOS is 8.1 (2.6) and the mean (SD) number performed by CCOS is 4.9 (2.5).

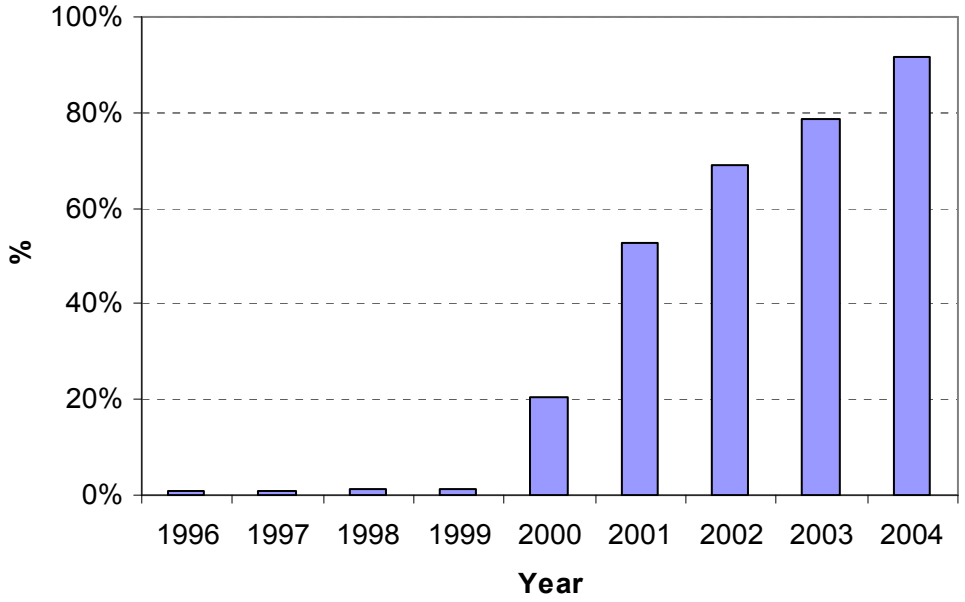
Table 4.2.2: CCOS activity from 1996 to 2004

		Year								
CCOS activity		1996	1997	1998	1999	2000	2001	2002	2003	2004
Direct bedside clinical support	n (%) N	2 (1.1) 186	2 (1.1) 186	2 (1.1) 186	5 (2.7) 186	42 (22.6) 186	96 (52.5) 183	118 (64.1) 184	126 (68.5) 184	134 (72.0) 186
Follow-up of patients	n (%) N	5 (2.7) 186	5 (2.7) 186	5 (2.7) 186	10 (5.4) 186	43 (23.1) 186	103 (55.4) 186	125 (67.2) 186	134 (72.4) 185	144 (77.8) 185
Telephone hotline advice	n (%) N	21 (11.8) 178	21 (11.8) 178	22 (12.4) 178	23 (12.9) 178	44 (24.7) 178	72 (40.4) 178	84 (47.2) 178	88 (49.4) 178	90 (50.6) 178
Use of TTs	n (%) N	1 (0.5) 185	1 (0.5) 185	1 (0.5) 185	3 (1.6) 184	35 (18.9) 185	84 (45.7) 184	115 (62.2) 185	141 (76.2) 185	156 (85.2) 183
Informal bedside teaching	n (%) N	8 (4.3) 186	8 (4.3) 185	10 (5.4) 186	13 (7.0) 185	47 (25.3) 186	104 (56.5) 184	130 (69.9) 186	137 (73.7) 186	144 (77.4) 186
Formal educational courses	n (%) N	5 (2.7) 184	5 (2.7) 184	6 (3.3) 184	8 (4.3) 184	38 (20.8) 183	94 (51.4) 183	122 (66.7) 183	135 (73.8) 183	150 (82.4) 182
Post discharge follow-up in outpatient clinics	n (%) N	5 (2.7) 183	5 (2.7) 183	5 (2.7) 183	9 (4.9) 183	14 (7.7) 183	22 (12.0) 183	36 (19.7) 183	44 (24.0) 183	50 (27.3) 183

		Year								
CCOS activity		1996	1997	1998	1999	2000	2001	2002	2003	2004
Audit and evaluation	n (%)	0 (0)	0 (0)	0 (0)	0 (0)	23 (12.3)	75 (40.1)	101 (54.3)	114 (60.6)	133 (71.1)
	N	188	188	188	188	187	187	186	188	187

CCOS Critical care outreach service, N total number of valid responses, TT physiological track and trigger warning system(s)

Figure 4.2.1: Proportion of adult wards covered by CCOS from 1996 to 2004



Future plans
Of the hospitals which reported not having a CCOS (n = 52), only a third (33.3%, n = 17/51) had plans to introduce a CCOS in the next six months. The majority of respondents (79.4%, n = 27) cited insufficient resources as the reason why a CCOS had not been planned. However, 23.5% (n = 8) did not perceive the need for a CCOS.

In hospitals reporting an existing CCOS, most 67.9% (n = 93/137) respondents anticipated changes to the overall structure and staffing of their CCOS within the next six months. The majority of changes related to expansion of, rather than reduction in, service delivery and CCOS integration with other support services rather than separation.

Table 4.2.3: Interventions reported as performed, recommended or performed and recommended by CCOS staff

CCOS interventions		Performed activity	Recommended activity	Performed and recommended activity
Investigations e.g. venupuncture, x-rays	n (%) N	54 (39.1) 138	40 (29.0) 138	44 (31.9) 138
Changes in patient positioning	n (%) N	78 (56.9) 137	7 (5.1) 137	52 (38.0) 137
Changes in oxygen therapy	n (%) N	75 (54.3) 138	8 (5.8) 138	55 (39.9) 138
Initiation of non-invasive ventilation	n (%) N	35 (27.1) 129	62 (48.1) 129	32 (24.8) 129
Changes in fluid management	n (%) N	28 (20.4) 137	68 (49.6) 137	41 (29.9) 137
Initiation of blood/colloid transfusion	n (%) N	26 (19.0) 137	91 (66.4) 137	20 (14.6) 137
Initiation of vasoactive infusions	n (%) N	4 (3.4) 116	100 (86.2) 116	12 (10.3) 116
Adjustment to medication	n (%) N	5 (3.8) 131	111 (84.7) 131	15 (11.5) 131
Adjustment to feeding/nutrition	n (%) N	13 (9.8) 132	103 (78.0) 132	16 (12.1) 132
Adjustment to pain management	n (%) N	11 (8.4) 131	99 (75.6) 131	21 (16.0) 131
Initiation of DNAR decision	n (%) N	11 (8.4) 131	105 (80.2) 131	15 (11.5) 131

CCOS critical care outreach service, N total number of valid responses, DNAR do not attempt resuscitation

4.3 Evaluation of CCOS

4.3.1 Study one – interrupted time series at the critical care unit level

Brief introduction

Our systematic review on the effectiveness of CCOS (Appendix 4) indicated that published research on the impact of CCOS was limited and there was insufficient evidence on effectiveness. The aim of this study was to undertake a multicentre, interrupted time-series analysis of the impact of CCOS at the critical care unit level. The two objectives were:

to explore the impact of CCOS at the simplest level by including a primary exposure variable for the presence or absence of CCOS in different models for three subgroups of admissions (all admissions to the unit, admissions from the ward and unit survivors discharged to the ward); and

to explore the impact of CCOS at a more in-depth level by including secondary exposure variables – activities (ward follow-up, use of physiological track and trigger warning systems etc.), coverage (24 hours/office hours, all/selected wards) and staffing (doctor/nurse-led, size) separately in different models for the above three subgroups of admissions.

Methods

Case Mix Programme Database (CMPD)

The CMPD is a high-quality clinical database of case mix, outcome and activity data on consecutive admissions to adult, general critical care units in England, Wales and Northern Ireland [14]. Data are collected by trained data collectors according to precise rules and definitions, and are validated both locally and centrally before being pooled into the CMPD. A total of 393,205 validated admissions to 172 critical care units between January 1996 and December 2004 were extracted from the CMPD.

The ICNARC physiology score is an acute illness severity score calculated from the ICNARC risk prediction model [15], based on physiological measurements from the 24 hours following admission to critical care. Admissions were classified as either medical, elective surgical, or emergency surgical, based on the direct source of admission to the unit and the NCEPOD classification of surgery.

Survey data and other sources

The results of our national survey of CCOS in England (Appendix 1) were used to: identify units with formal CCOS; to characterise the CCOS in terms of the activities undertaken, coverage and staffing; and to identify important time-dependent confounders. A total of 191 acute NHS hospitals in England completed the survey.

The following time dependent variables were identified from the survey and, where necessary, other sources:

Primary exposure was the presence of a formal CCOS in the hospital housing the critical care unit, defined as at least one member of staff with funded time dedicated to the CCOS (hospitals that were represented both in the CMPD and survey data were contacted for details of the date that the CCOS formally started, as this was not included in the survey).

Secondary exposures comprised the following categorical variables to characterise the CCOS.

Activity in eight binary variables:

- ward follow-up;
- outpatient follow-up;
- telephone advice;
- direct bedside clinical support;
- informal bedside teaching;
- formal educational courses;
- use of physiological track and trigger warning systems;
- audit and evaluation of activity.

Coverage in two categorical variables:

- 24 hours, 7 days a week / 12-23 hours, 7 days / < 12 hours, 7 days / selected days only;
- all wards / selected wards.

Staffing in two categorical variables:

- no medical involvement / some medical involvement (funded sessions allocated to the CCOS);
- small team (< 3 whole time equivalent staff per 10 level 3 or flexible level 3/2 beds) / large team (≥3 whole time equivalent staff per 10 level 3 or flexible level 3/2 beds).

All analyses were adjusted for the following confounding variables:

- number of level 3 beds (general and specialist);
- number of level 2 beds (general and specialist);
- number of flexible level 3/2 beds (general and specialist);
- presence of a standalone, general high dependency unit (HDU);
- teaching status of hospital;
- Foundation Trust status;
- tertiary referral centre;
- presence of a “hospital at night” service;
- presence of an acute pain team;
- presence of a nutrition team;
- availability of non-invasive ventilation on general wards;
- presence of an overnight ventilation facility in theatre/recovery;
- use of ALERT (or similar) course for ward staff;
- presence of a formal resuscitation policy.

Timings of the opening of standalone, general HDUs, granting of Foundation Trust status and initiation of “hospital at night” services were sought from

individual hospitals or from the Department of Health or Modernisation Agency websites, as these were not included in the survey.

Statistical analyses
The interrupted time-series analysis included all admissions in the CMPD from critical care units located in hospitals for which a completed survey form was received. Individual patient-level data in the CMPD were collapsed into a monthly time-series for each unit. Population-averaged panel-data models were fitted using a generalised estimating equation approach, with robust (Huber-White) variance-covariance estimates to account for clustering at the unit level [16], and an autoregressive correlation structure of order 1 within units over time.

Primary analysis was on the presence of a formal CCOS. Lagged effects over two months were included in the model as the effects of introducing a new service are not likely to be evident immediately following the introduction. Secondary analyses were on CCOS activities, coverage and staffing, as defined above.

A variety of potential outcomes that might reflect the impact of the CCOS objectives of averting admissions, ensuring timely admission and enabling discharge were investigated in three subgroups of admissions.

All admissions to the critical care unit:
- proportion of admissions direct from the ward

(averting admissions may lead to decrease).

Admissions to the critical care unit from a ward in the same hospital:
- proportion of admissions receiving cardiopulmonary resuscitation (CPR) within 24 hours prior to admission

(averting or ensuring timely admissions may lead to decrease);
- proportion of admissions out-of-hours (2200-0659)

(ensuring timely admission may lead to decrease);
- mean and distribution (standard deviation) of physiology score

(averting or ensuring timely admissions may lead to decrease/narrowing);
- proportion of admissions having all active treatment withdrawn

(averting admissions may lead to decrease);
- critical care unit mortality

(averting or ensuring timely admissions may lead to decrease).

Critical care unit survivors discharged to a ward in the same hospital:
- proportion of discharges occurring out-of-hours (2200-0659)

(enabling discharge may lead to decrease);
- proportion of discharges designated as “early discharge due to shortage of beds”

(enabling discharge may lead to decrease);

- proportion of patients readmitted to the unit within 48 hours of discharge

(CCOS follow-up may lead to decrease);
- ultimate acute hospital mortality

(CCOS follow-up may lead to decrease).

All analyses were adjusted for a linear time trend, seasonality (11 dummy variables for months February to December), and the fourteen (listed above), time-dependent, confounding variables. In addition, analyses of admissions out-of-hours were adjusted for unit occupancy, and analyses of unit survivors discharged to the ward in the same hospital were adjusted for age, ICNARC physiology score and surgical status.

Interactions between the categorical variables representing CCOS coverage and staffing were tested in the corresponding models.

A sensitivity analysis was conducted for the outcome of CPR prior to admission by including only those patients in hospital for at least 24 hours prior to admission, to exclude CPR occurring out-of-hospital (there is no reason to expect CCOS to reduce this latter group). A sensitivity analysis was also conducted for admissions having all active treatment withdrawn, restricting to active treatment withdrawal occurring within 48 hours of admission, as these may represent futile admissions that are more likely to be averted by a CCOS.

Statistical analyses were performed using Stata 9.2 (StataCorp LP, College Station, TX, USA).

Results

One hundred and thirty units were identified with both CMPD and survey data. Of these, 111 indicated the presence of a CCOS and were contacted to acquire the formal start date (month/year), 107 (96%) responded. The four units that did not respond, for which no formal start date for CCOS could be identified, were dropped from the analyses.

Missing data in the time dependent variables identified from the survey were replaced with the last value carried forward unless all values from 1996 to 2004 were missing in which case the unit was excluded. A further 18 units were dropped from the analyses for this reason.

A total of 108 (83%) of the original 130 units were included in the analyses, of which 79 (73%) had a formal CCOS starting between 1996 and 2004. There was a median of 36.5 (quartiles 25 to 47) months' data following the introduction of CCOS in these units. The 29 units with no formal CCOS or with a CCOS starting before 1996 or after 2004 were included as non-intervention sites to improve the modelling of time trends and confounders.

The characteristics of patients and potential outcomes investigated in the two sub-groups of admissions for analysis are described in Table 4.3.1.1.

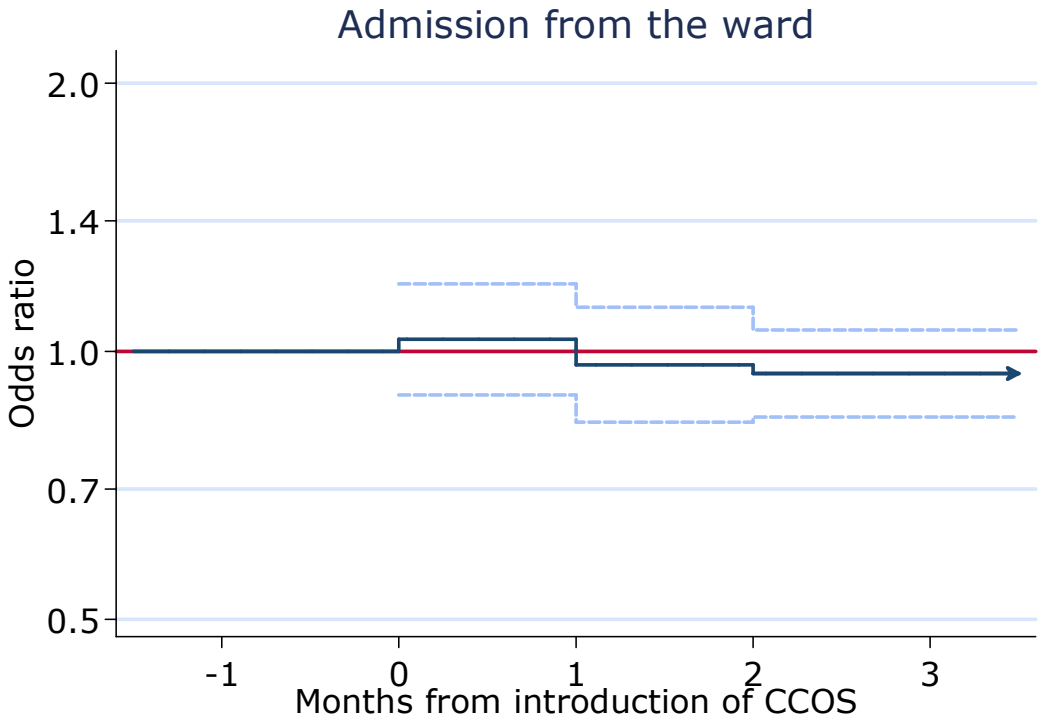
Table 4.3.1.1: Characteristics of admissions and potential outcomes investigated in sub-groups for analysis

	All admissions	Admissions from the ward*	Discharges to the ward*
Number of admissions, n (%)	240,884 (100)	56,082 (23.3)	138,160 (57.4)
Age (years), mean (SD)	59.3 (19.4)	60.1 (19.0)	58.6 (19.7)
Age (years), median (quartiles)	64 (48-74)	65 (50-74)	63 (46-74)
Male, n (%)	139,176 (57.8)	30,437 (54.3)	78,986 (57.2)
ICNARC physiology score, mean (SD)	18.2 (10.2)	21.5 (10.8)	14.5 (7.7)
ICNARC physiology score, median (quartiles)	17 (10-24)	20 (14-28)	13 (9-19)
Admission type, n (%)			
Non-surgical	139,376 (57.9)	56,082 (100)	66,214 (47.9)
Elective surgical	53,563 (22.2)	N/A	43,099 (31.2)
Emergency surgical	47,945 (19.9)	N/A	28,847 (20.8)
Hospital mortality	235,551 (32.6)	25,847 (46.9)	16,184 (11.7)
Outcomes for admissions from the ward*, n (%)			
CPR 24 hours prior to admission		5,349 (9.6)	
Admission out-of-hours (2200-0659)		16,312 (29.1)	
All active treatment withdrawn		8,670 (15.4)	
Unit mortality		18,040 (32.2)	
Outcomes for discharges to the ward*, n (%)			
Discharge out-of-hours (2200-0659)			8,870 (6.4)
Early discharge due to shortage of beds			5,440 (3.9)
Readmission within 48 hours			1,919 (1.4)

* Ward in the same hospital, SD standard deviation, ICNARC Intensive Care National Audit & Research Centre, CPR cardiopulmonary resuscitation

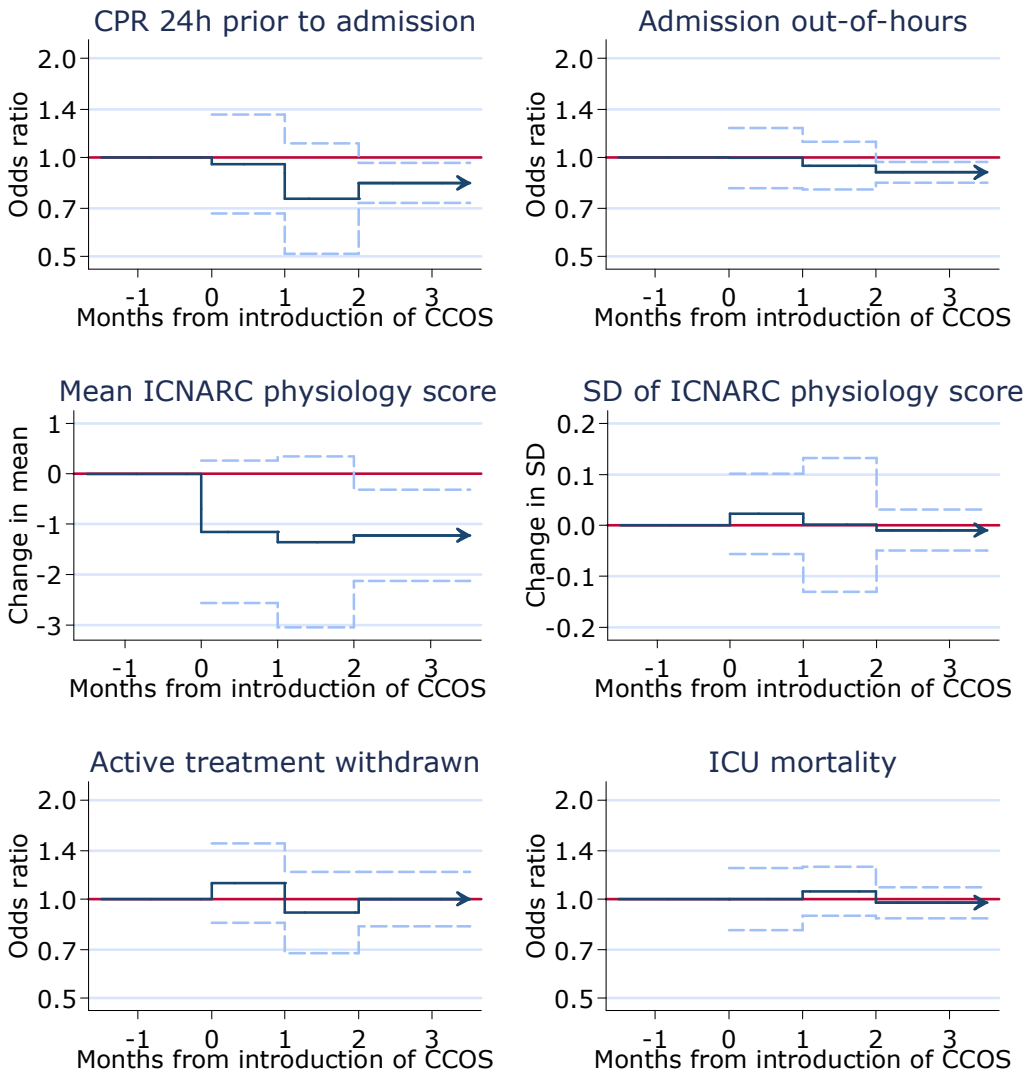
The effects of the presence of a formal CCOS and its lag over two months on the pre-defined outcomes for the three sub-groups of admissions are shown in Figures 4.3.1.1-3 (Appendix 5 has full details of all effect estimates).

Figure 4.3.1.1: Effect of a formal CCOS on the proportion of all admissions to the critical care unit admitted directly from the ward (effect estimate and 95% CI for the first, second and subsequent months following introduction of CCOS)



For all admissions to the critical care unit, there was no effect of the presence of a formal CCOS on the proportion admitted directly from the ward (Figure 4.3.1.1).

Figure 4.3.1.2: Effect of a formal CCOS on admissions to the critical care unit from a ward in the same hospital (effect estimate and 95% CI for the first, second, and subsequent months following introduction of CCOS)

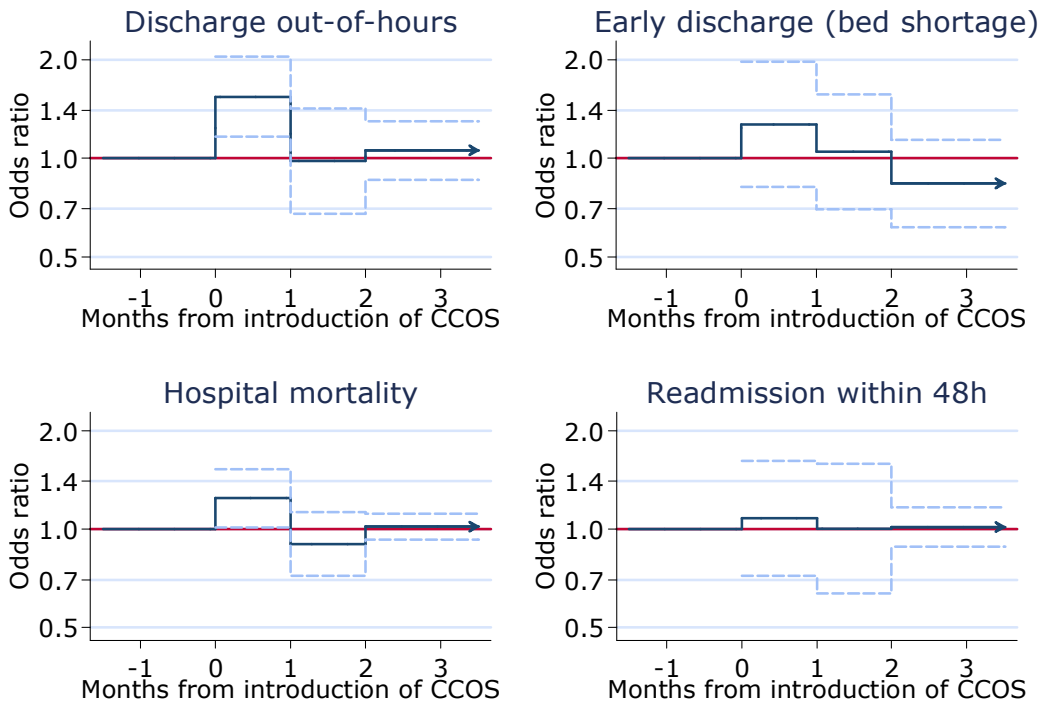


CPR cardiopulmonary resuscitation, CCOS critical care outreach service, ICNARC Intensive Care National Audit & Research Centre, SD standard deviation, ICU critical care unit (ICU or ICU/HDU)

For admissions to the critical care unit from a ward in the same hospital (Figure 4.3.1.2), the effect of the presence of a formal CCOS was associated with a significant decrease in CPR within 24 hours prior to admission, admission out-of-hours and mean ICNARC physiology score. In the third and subsequent months following the formal start date, the effect estimates (95% confidence interval) and p-values for these three outcomes were: odds ratio 0.84 (0.73 to 0.96), P=0.012; odds ratio 0.91 (0.84 to 0.97), P=0.012; and decrease in mean 0.30 (0.12 to 0.73), P=0.008, respectively. The sensitivity

analysis in patients in hospital for at least 24 hours prior to admission showed similar results for CPR within 24 hours prior to admission.

Figure 4.3.1.3: Effect of a formal CCOS on critical care unit survivors discharged to a ward in the same hospital (effect estimate and 95% CI for the first, second and subsequent months following introduction of CCOS)



CCOS critical care outreach service

For critical care unit survivors discharged to a ward in the same hospital (Figure 4.3.1.3), there was an apparent increase in out-of-hours discharges (and associated increase in hospital mortality) in the first month following introduction of CCOS though this apparent effect disappeared in the second and subsequent months. The sensitivity analysis in all active treatment withdrawal occurring within 48 hours of admission showed similar results for all active treatment withdrawal.

Details of the secondary analyses with the presence of CCOS activities, coverage and staffing can be found in Appendix 5 and are summarised below.

CCOS activities
The use of physiological track and trigger warning systems was associated with lower rates of CPR within 24 hours prior to admission (odds ratio 0.84, 95% confidence interval 0.72 to 0.98, P=0.049) and with the standard deviation of the ICNARC physiology score (decrease in standard deviation 0.06, 0.01 to 0.10, P=0.010). Certain other activities were associated with statistically significant changes in outcomes, but with no plausible rationale for causality. For example, the presence of an outpatient follow-up service was associated with characteristics of admissions from the ward.

CCOS coverage
There were some statistically significant differences between coverage categories but these were not consistent and did not show any expected "dose-response" pattern.

CCOS staffing
Some medical involvement in CCOS was associated with a lower proportion of ward admissions out-of-hours (odds ratio 0.92, 0.84 to 1.00, P=0.046) and reductions in all active treatment withdrawal (odds ratio 0.76, 0.59 to 0.97, P=0.026) compared with teams with no medical involvement. Larger teams were associated with a higher proportion of all admissions coming from the ward (odds ratio 1.18, 1.02 to 1.35, P=0.025), increased all active treatment withdrawal in admissions from the ward (odds ratio 1.29, 1.02 to 1.64, P=0.033), and with higher hospital mortality for patients discharged to the ward (odds ratio 1.11, 1.02 to 1.21, P=0.020) compared with smaller teams. The direction of causality in these associations is unclear.

There were no significant interactions between the variables representing CCOS coverage and staffing.

4.3.2 Study two – matched cohort analysis at the critical care patient level

Brief introduction

The aim of this study was to undertake a prospective evaluation, at the patient level, of the effect of visits from the CCOS both prior to admission to critical care on case mix and following discharge from critical care on outcomes using a matched cohort of patients admitted to/discharged from critical care not receiving visits from the CCOS. The objective was to evaluate prospectively the impact of CCOS, at the patient level, by comparing admissions receiving outreach with those that do not.

Methods

Case Mix Programme Database (CMPD)

The CMPD is a high-quality clinical database of case mix, outcome and activity data on consecutive admissions to adult, general critical care units in England, Wales and Northern Ireland participating in the Case Mix Programme, the national comparative audit of critical care. Data are collected by trained data collectors according to precise rules and definitions, and are validated both locally and centrally before being pooled into the database.[14]

Prospective CCOS data collection

The results of the national survey were used to identify acute hospitals with a CCOS. All hospitals with a CCOS and those that did not return a survey form but participated in the Case Mix Programme were invited to participate in the prospective data collection.

Data were collected for every visit performed by the CCOS. The data were either: (1) recorded on a paper form for central data entry at ICNARC; (2) entered into a custom-designed database in Microsoft Access or Excel; (3) extracted from a commercially available software tool (MedICUs Outreach, Mela Solutions Ltd, Gerrards Cross, Bucks); or (4) extracted from the local CCOS audit software, following approval of compatible data collection definitions. All data were validated centrally for illogical, inconsistent and missing values.

CCOS participating in the prospective data collection were required to update the information they had supplied in the national survey or, for those that had not previously responded to complete the survey form, to reflect the current service configuration as these data were to be used to calculate the staff costs of each CCOS.

Representativeness of data

The representativeness of CCOS participating in the prospective study compared to all CCOS in England was established by comparing the activities performed, staffing and coverage of participating CCOS with all CCOS responses from the national survey. The representativeness of the critical care units in hospitals participating in the prospective study was established by comparing unit size (number of beds), teaching status of the hospital, and regional distribution with all units participating in the Case Mix Programme.

Selection of cases
Patients identified by the CCOS as having been admitted to a critical care unit (ICU or ICU/HDU) at any time during their hospital stay were linked to the CMPD by their date of birth, sex, postcode and date of admission to hospital. Partial matches (on two or more fields) and imperfect matches (e.g. small differences in dates or postcodes) were examined in detail to ensure completeness of data linkage.

Two cohorts of critical care unit admissions (cases) were identified:

- patients receiving one or more visits from the CCOS prior to admission to the critical care unit;
- patients receiving one or more visits from the CCOS following discharge from the critical care unit.

Where a patient had more than one critical care unit admission meeting either of the above conditions, only the first such admission was included in the analysis. The same patient could be included in both cohorts if they received visits from the CCOS both prior to and following a critical care unit stay.

For sensitivity analyses, all analyses were repeated restricted to:

- patients receiving one or more visits from the CCOS prior to admission to the critical care unit where the last CCOS visit was recorded as directly resulting in admission to critical care and the patient was subsequently admitted to the critical care unit from the ward within 24 hours of the visit;
- patients receiving one or more visits from the CCOS following discharge from the critical care unit where the patient was discharged directly to the ward and the first CCOS visit was a scheduled visit occurring within 48 hours following discharge.

Selection of matched controls
For each case, two matched controls were selected (where possible) from two pools of potential control patients:

- an admission to the same critical care unit from the time period prior to the introduction of the CCOS in that hospital (*historic*);
- a concurrent admission to a different critical care unit in a hospital with no CCOS, but matched on size of unit and teaching status of hospital (*no CCOS*).

A third match was undertaken:

- an admission to the same critical care unit during the study period but not seen by the CCOS (*contemporary*).

However, in this matching, the problem of selection bias is inherently greater. For completeness and comparison, results for this match are presented in Appendix 5.

Matching CCOS visit(s) prior to admission
For cases receiving CCOS visit(s) prior to admission to the critical care unit, controls were selected matched on:

- age (closest match within 10 years);

- presence of any severe condition in the past medical history;
- primary reason for admission to the critical care unit (system and process tiers of the hierarchical ICNARC Coding Method[17]);
- source of admission/surgical status (categories from the ICNARC risk prediction model[15]);
- length of stay in hospital prior to admission to the critical care unit greater than or equal to the time from the last CCOS visit to critical care unit admission for the case (*exposure criterion*).

Matching CCOS visit(s) following discharge
For cases receiving CCOS visit(s) following discharge from the critical care unit, controls were selected matched on:

- age (closest match within 10 years);
- presence of any severe condition in the past medical history;
- primary reason for admission to the critical care unit (system tier of the ICNARC Coding Method);
- source of admission/surgical status (categories from the ICNARC risk prediction model);
- destination following discharge;
- ICNARC physiology score (closest match within 10 points);
- length of stay in critical care unit (0, 1, 2, 3-6 or 7+ days);
- length of stay in hospital following discharge from the critical care unit greater than or equal to the time from critical care unit discharge to the first CCOS visit for the case (*exposure criterion*).

Propensity matching
In addition, for each cohort of cases a propensity model was built by using logistic regression to model the factors predictive of receiving CCOS visits prior to admission/following discharge. Continuous factors were modelled using restricted cubic splines to allow a flexible, non-linear relationship between the factor and the propensity for CCOS visits.[18] The ability of the propensity models to discriminate between those that did and did not receive CCOS visits was assessed with the area under the receiver operating characteristic (ROC) curve.[19] The overall fit of the propensity models was assessed with two measures of explained variation, the sums-of-squares R-squared (R^2_{SS}) and the entropy R-squared (R^2_E).[20] These measures have been shown to be the most analogous to the R-squared from linear regression.[21] They are related to Brier's score (the mean square error between outcome and prediction)[22] and Shapiro's *R* (the geometric mean probability assigned to the true outcome),[23] respectively. The matching process was repeated based on the propensity (closest match within 5% in absolute value) and the exposure criterion.

Outcome variables for CCOS visit(s) prior to admission
For cases receiving CCOS visit(s) prior to admission to the critical care unit, the primary outcome was the ICNARC physiology score[15]. Secondary outcomes were length of stay in hospital prior to admission to the critical care unit, CPR within 24 hours prior to admission to the critical care unit, number of

organ dysfunctions, mortality in the critical care unit and before ultimate discharge from an acute hospital, and length of stay in the critical care unit.

Outcome variables for CCOS visit(s) following discharge
For cases receiving CCOS visit(s) following discharge from the critical care unit, the primary outcome was mortality before ultimate discharge from an acute hospital. Secondary outcomes were readmission to the critical care unit within 48 hours following discharge and length of stay in hospital following discharge from the critical care unit. As a sensitivity analysis, the outcome of readmission to the critical care unit within 48 hours was re-analysed excluding readmissions from high dependency units (HDUs) as the CCOS would have no control over these patients.

Subgroup analyses for CCOS visit(s) prior to admission
For cases receiving CCOS visit(s) prior to admission to the critical care unit, subgroup analyses looking for a difference in effect of CCOS (tests of interaction) were performed comparing cases whose last CCOS visit prior to admission to the critical care unit was scheduled (a planned visit, scheduled in advance) to those whose last visit was unscheduled (a visit requested by any member of the ward-based team that was not scheduled in advance).

Subgroup analyses for CCOS visit(s) following discharge
For cases receiving CCOS visit(s) following discharge from the critical care unit, subgroup analyses looking for a difference in effect of CCOS (tests of interaction) were performed comparing cases receiving CCOS visits both prior to admission to the critical care unit and following discharge from the critical care unit to those receiving post-discharge visits only.

Statistical analyses
Analyses of the ICNARC physiology score were performed by paired t-tests (for univariable analyses) or linear regression (for multivariable analyses) on the difference in score between case and matched control. The effect estimate from these analyses is the mean difference in physiology score between case and matched control.

Matched cohort analyses of binary outcomes (mortality, CPR, readmission) were performed using conditional fixed-effects Poisson regression with standard errors estimated by bootstrapping.[24] The effect estimate from these analyses is the matched pairs risk ratio, or relative risk.

Analyses of lengths of stay were performed by paired t-tests (for univariable analyses) or linear regression (for multivariable analyses) on the difference in the logarithm of the length of stay between case and matched control. The effect estimate from these analyses is the ratio of geometric means.

Analyses of cases receiving CCOS visit(s) following discharge from the critical care unit were adjusted for any residual differences between cases and matched controls by including the predicted log odds of hospital mortality from the ICNARC risk prediction model as an additional covariate in the regression models.

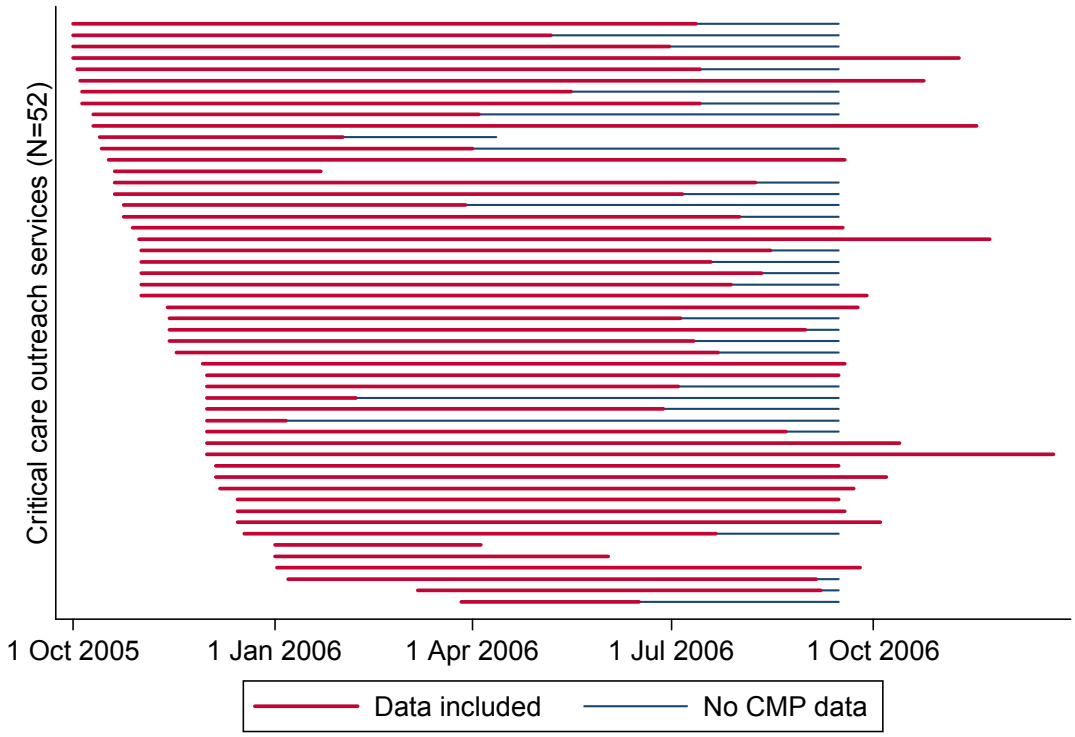
Statistical analyses were performed using Stata 9 (StataCorp LP, College Station, TX, USA).

Results

Participation in prospective data collection

In total, 109 CCOS in hospitals actively participating in the Case Mix Programme were invited to participate in the prospective data collection. Of these, 55 (50.5%) participated in the study. Three CCOS (5.5%) were excluded from the analyses as Case Mix Programme data covering the study period had not been received at the time of analysis. The median duration of prospective data collection was 10 months (quartiles 10 to 11 months, range 3 to 14 months). When linked with available data in the CMPD, the median period included in the study was 9 months (quartiles 7 to 10 months, range 1 to 14 months). Participation in the study is illustrated in Figure 4.3.2.1.

Figure 4.3.2.1: Participation in prospective data collection and linkage to the Case Mix Programme - each line represents one CCOS



Representativeness of data

The representativeness of the 52 participating CCOS compared with all CCOS returning survey forms is shown in Table 4.3.2.1. The participating CCOS tended to be larger, with greater medical involvement, a higher proportion of 24-7 services and performed a higher proportion of CCOS activities. The representativeness of the critical care units in these 52 hospitals compared with all adult, general critical care units in England participating in the Case Mix Programme is shown in Table 4.3.2.2. The

representativeness was good, with participation across all regions of England, all levels of teaching status, and all sizes of critical care units.

Table 4.3.2.1: Representativeness of participating CCOS

All values are number (%)		Participating	National survey
Number of CCOS		52	137
CCOS staffing:			
Size of team*	Small	20 (38.5)	54 (56.3)
	Large	32 (61.5)	42 (43.7)
Medical involvement†		23 (44.2)	34 (24.8)
CCOS coverage:			
100% coverage of wards		38 (73.1)	75 (76.5)
24-7 direct bedside support		10 (19.2)	14 (13.5)
CCOS activities:			
Use of TTs		50 (96.2)	126 (94.7)
Direct bedside support		49 (94.2)	104 (78.2)
Ward follow-up		50 (96.2)	112 (83.6)
Informal bedside teaching		49 (94.2)	110 (82.7)
Formal education		48 (92.3)	118 (89.4)

CCOS critical care outreach service(s), * small = <3 / large = ≥3 whole time equivalent staff per 10 level 3 or flexible level 3/2 beds, † any doctor with at least one funded session allocated to the CCOS, TT physiological track and trigger warning system(s)

Table 4.3.2.2: Representativeness of participating critical care units

All values are number (%)			Participating	CMPD
Number of critical care units			52	125
Old NHS Region	Eastern		6 (11.5)	10 (8.0)
	London		6 (11.5)	10 (8.0)
	North West		8 (15.4)	24 (19.2)
	Northern and Yorkshire		7 (13.5)	18 (14.4)
	South East		3 (5.8)	10 (8.0)
	South West		3 (5.8)	17 (13.6)
	Trent		8 (15.4)	16 (12.8)
	West Midlands		11 (21.2)	20 (16.0)
Hospital status		University	15 (28.9)	28 (22.4)
		University affiliated	7 (13.5)	22 (17.6)
		Non-university	30 (57.7)	75 (60.0)
Unit size (number of beds)		3-5	11 (21.2)	24 (19.2)
		6-7	11 (21.2)	41 (32.8)
		8-10	11 (21.2)	30 (24.0)
		11-14	12 (23.1)	20 (16.0)
		15+	7 (13.5)	10 (8.0)

CMPD case mix programme database, NHS national health service

Summary of outreach activity

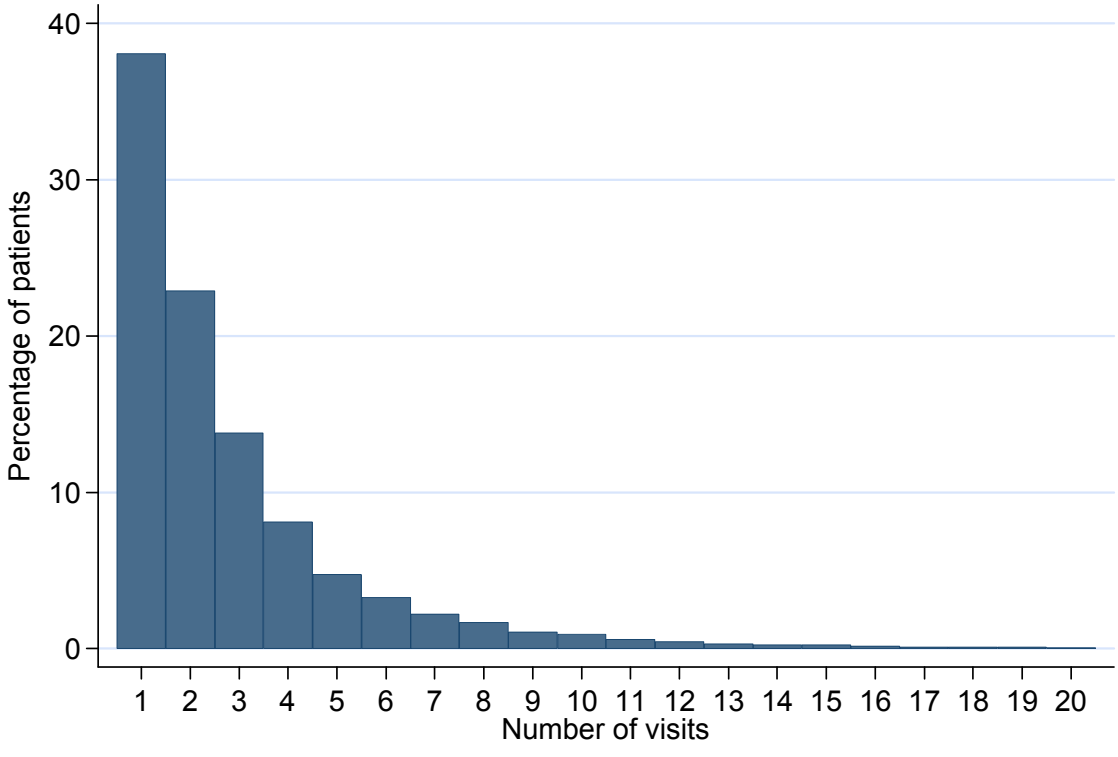
During the study period, the 52 CCOS performed 71,660 visits to approximately 23,234 patients (this figure was adjusted to account for some patients being allocated more than one patient identifier). This represents a mean of 3.1 CCOS visits per patient. The data collected on each patient visit by the CCOS are summarised in Table 4.3.2.3 and the distribution of number of visits per patient is displayed in Figure 4.3.2.2. A summary of the data collected from each visit is presented in Table 4.3.2.4. The distribution of these variables across CCOS is summarised in Table 4.3.2.5 to Table 4.3.2.7.

Table 4.3.2.3: Summary of patients receiving one or more CCOS visits

	All CCOS patients*
Number of patients	23,234
CCOS visits per patient, median (quartiles)	2 (1-4)
Admission to critical care unit (ICU/HDU), n (%)	10,404 (44.8)
DNAR at any time during hospital stay, n (%)	3,662 (15.8)
Hospital deaths, n (%)	5,729 (25.0)
Hospital length of stay (days), median (quartiles)	15 (8-30)

CCOS critical care outreach service(s), * figures adjusted to account for some patients being allocated multiple patient identifiers, ICU intensive care unit, HDU high dependency unit, DNAR do not attempt resuscitation

Figure 4.3.2.2: Distribution of number of CCOS visits per patient



169 patients (0.7%) with >20 visits not shown

Table 4.3.2.4: Summary of CCOS visits

All values are number (%)		CCOS visits
Number of visits		71,660
Day of visit	Monday	10,955 (15.3)
	Tuesday	11,022 (15.4)
	Wednesday	11,144 (15.6)
	Thursday	11,373 (15.9)
	Friday	11,403 (15.9)
	Saturday	8,487 (11.8)
	Sunday	7,276 (10.2)
Time of visit	00:00-00:59	526 (0.7)
	01:00-01:59	613 (0.9)
	02:00-02:59	544 (0.8)
	03:00-03:59	468 (0.7)
	04:00-04:59	409 (0.6)
	05:00-05:59	386 (0.5)
	06:00-06:59	721 (1.0)
	07:00-07:59	593 (0.8)
	08:00-08:59	3,316 (4.6)
	09:00-09:59	8,833 (12.3)
	10:00-10:59	9,598 (13.4)
	11:00-11:59	8,972 (12.5)
	12:00-12:59	6,273 (8.8)
	13:00-13:59	4,154 (5.8)
	14:00-14:59	5,281 (7.4)
	15:00-15:59	4,960 (6.9)
	16:00-16:59	4,365 (6.1)
	17:00-17:59	3,424 (4.8)

	18:00-18:59	2,621 (3.7)
	19:00-19:59	1,960 (2.7)
	20:00-20:59	870 (1.2)
	21:00-21:59	705 (1.0)
	22:00-22:59	1,074 (1.5)
	23:00-23:59	975 (1.4)
Type of visit	Scheduled	55,277 (77.2)
	Unscheduled	16,299 (22.8)
Level of care	0	14,086 (19.7)
	1	43,163 (60.4)
	2	12,757 (17.8)
	3	1,518 (2.1)
Visit outcome	Admission to critical care unit (ICU or ICU/HDU)	1,895 (2.7)
	Admission to separate HDU	763 (1.1)
	Discharge from CCOS care	20,846 (29.2)
	Ongoing care/follow up	47,376 (66.3)
	Patient died	629 (0.9)

CCOS critical care outreach service(s), ICU intensive care unit, HDU high dependency unit

Table 4.3.2.5: Distribution of number, type and level of care of visits across CCOS

		Median (IQR) [range] across CCOS
Number of visits per CCOS per year		1797 (1215-2750) [209-6161]
Type of visit (%)	Scheduled	78.0 (71.9-83.9) [32.3-94.9]
	Unscheduled	21.9 (16.1-27.9) [5.1-67.7]
Level of care (%)	0	18.0 (6.1-31.5) [0.2-83.8]
	1	57.2 (51.1-65.3) [15.2-92.4]
	2	14.5 (8.1-22.2) [0.8-51.3]
	3	1.0 (0.4-3.3) [0.1-9.5]

IQR interquartile range, CCOS critical care outreach service(s)

Table 4.3.2.6: Distribution of visits by day of week across CCOS stratified by provision of CCOS 7 days per week versus <7 days per week

Day of week (% of visits)	Median (IQR) [range] across CCOS	
	7 days per week	<7 days per week
Monday	13.8 (12.8-14.8) [10.5-19.3]	19.2 (16.7-21.0) [11.8-27.4]
Tuesday	14.4 (13.4-15.7) [9.0-22.8]	18.6 (16.6-21.1) [13.3-27.5]
Wednesday	14.7 (13.9-15.4) [12.1-21.5]	18.2 (17.2-20.6) [13.5-28.3]
Thursday	15.1 (14.3-16.1) [13.1-20.2]	19.4 (17.7-20.8) [11.1-24.8]
Friday	15.3 (14.4-16.6) [13.2-21.1]	17.5 (16.3-20.4) [11.8-24.8]
Saturday	14.5 (12.0-15.1) [2.1-18.9]	1.4 (0.4-10.6) [0.2-16.3]
Sunday	13.4 (11.6-14.4) [2.0-18.0]	0.7 (0.2-3.1) [0.1–15.1]

IQR interquartile range, CCOS critical care outreach service(s)

Linkage to the Case Mix Programme Database

Of 10,404 patients admitted to a critical care unit (ICU or ICU/HDU) at any time during their hospital stay, 7,078 (68.0%) were successfully linked to one or more admissions in the CMPD. Only 13 patients (0.1%) had insufficient data to complete the linkage and the remaining 3,313 patients were presumed to have been admitted to a standalone HDU, a specialist critical care unit, or a critical care unit (ICU or ICU/HDU) in another hospital. Of the 7,078 linked patients, 2,203 patients received one or more CCOS visits prior to admission to the critical care unit and 5,924 patients received one or more CCOS visits following discharge from the critical care unit (including 1,049 patients receiving CCOS visits both before and following a critical care unit stay).

Table 4.3.2.7: Distribution of visits by hour of day across CCOS stratified by provision of CCOS 24 hours per day versus 12–23 hours per day versus <12 hours per day

Hour of day of visit (%)	Median (IQR) [range] across CCOS		
	24 hours per day	12–23 hours per day	<12 hours per day
00:00	1.8 (0.2-3.1) [0.0-4.0]	0.0 (0.0-0.0) [0.0-0.1]	0.0 (0.0-0.0) [0.0-0.5]
01:00	2.1 (0.2-3.3) [0.0-4.4]	0.0 (0.0-0.0) [0.0-0.1]	0.0 (0.0-0.0) [0.0-0.5]
02:00	2.1 (0.4-3.1) [0.0-3.9]	0.0 (0.0-0.0) [0.0-0.2]	0.0 (0.0-0.0) [0.0-0.4]
03:00	1.6 (0.1-2.2) [0.0-3.6]	0.0 (0.0-0.0) [0.0-0.2]	0.0 (0.0-0.0) [0.0-0.2]
04:00	1.2 (0.3-1.8) [0.0-3.5]	0.0 (0.0-0.0) [0.0-0.0]	0.0 (0.0-0.0) [0.0-0.3]
05:00	1.3 (0.0-1.7) [0.0-3.1]	0.0 (0.0-0.0) [0.0-0.2]	0.0 (0.0-0.0) [0.0-0.4]
06:00	2.3 (0.2-3.8) [0.0-6.5]	0.0 (0.0-0.0) [0.0-0.2]	0.0 (0.0-0.0) [0.0-0.4]
07:00	1.3 (0.5-2.4) [0.0-6.4]	0.1 (0.0-0.1) [0.0-1.5]	0.0 (0.0-0.2) [0.0-1.3]
08:00	2.5 (2.1-2.9) [1.3-8.0]	8.2 (1.5-8.9) [1.0-11.5]	3.8 (1.5-7.1) [0.0-12.4]
09:00	6.9 (6.0-13.0) [5.6-20.2]	10.8 (9.1-12.8) [6.9-22.4]	13.4 (10.5-20.8) [1.3-36.0]
10:00	8.4 (7.3-13.8) [5.9-21.6]	9.4 (7.6-14.5) [7.0-22.4]	16.8 (14.6-20.2) [8.7-30.4]
11:00	7.4 (6.9-13.6) [4.8-16.6]	9.6 (9.0-12.7) [6.5-18.5]	14.9 (12.7-17.7) [9.7-41.3]
12:00	5.8 (4.9-7.7) [2.9-12.4]	8.4 (7.8-10.5) [7.2-13.0]	10.5 (8.0-13.0) [4.4-21.8]
13:00	4.6 (3.3-5.4) [2.0-7.5]	6.8 (6.2-7.6) [4.2-8.4]	6.8 (5.0-7.8) [1.8-13.1]
14:00	5.6 (5.5-5.9) [3.6-10.2]	7.9 (5.9-8.6) [5.0-11.3]	8.5 (7.6-10.4) [3.5-14.5]
15:00	4.8 (4.4-6.9) [3.8-8.3]	7.8 (6.5-8.6) [4.6-9.2]	7.2 (5.9-9.8) [2.8-18.3]
16:00	5.4 (5.0-6.6) [2.4-8.1]	6.8 (5.5-7.7) [4.3-9.5]	6.0 (3.3-8.2) [0.6-12.3]
17:00	4.6 (3.5-5.0) [2.1-8.7]	6.2 (4.4-7.1) [2.3-10.4]	2.7 (0.5-5.8) [0.0-10.1]
18:00	4.9 (2.9-5.4) [0.7-6.7]	6.3 (5.0-7.9) [2.0-8.5]	0.4 (0.0-2.9) [0.0-6.5]
19:00	3.4 (2.2-4.3) [0.2-5.6]	5.5 (3.7-8.3) [2.5-11.3]	0.0 (0.0-0.5) [0.0-5.8]
20:00	1.8 (1.3-3.7) [0.0-7.5]	1.1 (0.9-1.9) [0.0-2.3]	0.0 (0.0-0.1) [0.0-1.4]
21:00	3.2 (2.0-3.6) [0.0-4.4]	0.0 (0.0-0.2) [0.0-4.6]	0.0 (0.0-0.0) [0.0-0.9]
22:00	4.3 (1.4-5.4) [0.0-9.4]	0.0 (0.0-0.3) [0.0-3.7]	0.0 (0.0-0.0) [0.0-1.7]
23:00	4.3 (2.7-5.1) [0.0-7.5]	0.0 (0.0-0.1) [0.0-0.7]	0.0 (0.0-0.0) [0.0-1.1]

IQR interquartile range, CCOS critical care outreach service(s)

Matched cohort results – CCOS visit(s) prior to admission
Of the 2,203 patients receiving one or more CCOS visits prior to admission to the critical care unit, 11 were excluded for age less than 16 years and a further nine were excluded for missing primary reason for admission to the unit. This left 2,183 patients included in the matching process. Table 4.3.2.8 shows a comparison between the matched and unmatched cases for the two control pools. Eleven critical care units had no Case Mix Programme data prior to introduction of CCOS in their respective hospitals, and so 473 cases from these units were excluded from the historic control match. Between 60% and 90% of cases were successfully matched. Unmatched cases tended to be younger, with a higher proportion having one or more severe conditions in their past medical history. Acute severity of illness at critical care unit admission, measured by the ICNARC physiology score was similar for matched and unmatched cases, but unmatched cases had slightly higher hospital mortality.

Table 4.3.2.8: Comparison of matched and unmatched cases for CCOS visits prior to admission (individual matching)

	Matched	Unmatched
Historic match		
Patients, n (%)	1,022 (60.2)	675 (39.8)
Age, mean (SD)	63.0 (15.7)	59.3 (18.2)
Sex (male), n (%)	559 (54.7)	377 (55.9)
Severe past medical history, n (%)	152 (14.9)	232 (34.4)
ICNARC physiology score, mean (SD)	21.0 (9.6)	21.9 (10.2)
Ultimate hospital mortality, n (%)	437 (44.6)	316 (49.1)
No CCOS match		
Patients, n (%)	1,946 (89.7)	224 (10.3)
Age, mean (SD)	62.2 (16.4)	55.5 (19.5)
Sex (male), n (%)	1,094 (56.2)	110 (49.1)
Severe past medical history, n (%)	378 (19.4)	104 (46.4)
ICNARC physiology score, mean (SD)	21.9 (10.1)	21.3 (10.4)
Ultimate hospital mortality, n (%)	856 (45.9)	101 (49.3)

SD standard deviation, ICNARC intensive care national audit & research centre, CCOS critical care outreach service(s)

CCOS visits prior to admission - individually-matched results

Table 4.3.2.9 shows the results of the primary and secondary analyses. Results are shown for all matched cases and for the sensitivity analysis restricted to cases whose last CCOS visit was recorded as directly resulting in admission to critical care and who were subsequently admitted to the critical care unit from the ward within 24 hours of the visit.

Table 4.3.2.9: Individually-matched results for CCOS visits prior to admission

Primary analysis: ICNARC physiology score				
Match	Mean (SD)		Difference in means	
	Case	Control	Δ (95% CI)	P-value
Historic	21.3 (9.8)	22.3 (10.4)	−1.00 (−1.81, −0.19)	0.016
S	22.3 (10.0)	23.5 (10.3)	−1.16 (−2.41, 0.08)	0.068
No CCOS	21.9 (10.1)	21.9 (10.9)	0.03 (−0.61, 0.67)	0.93
S	23.1 (10.2)	22.8 (10.8)	0.27 (−0.68, 1.23)	0.57
Secondary analysis: prior length of stay in hospital				
Match	Median (IQR)		Ratio of geometric means	
	Case	Control	Ratio (95% CI)	P-value
Historic	3 (1-9)	2 (1-10)	1.04 (0.94, 1.16)	0.45
S	3 (1-8)	3 (1-10)	0.95 (0.79, 1.13)	0.55
No CCOS	3 (1-10)	2 (1-9)	1.16 (1.08, 1.25)	<0.001
S	3 (1-9)	3 (1-9)	1.06 (0.94, 1.20)	0.326
Secondary analysis: CPR within 24 hours prior to admission				
Match	Number (percentage)		Matched pairs risk ratio	
	Case	Control	RR (95% CI)	P-value
Historic	53 (5.3)	101 (10.1)	0.51 (0.39, 0.69)	<0.001
S	21 (4.6)	47 (10.3)	0.45 (0.28, 0.72)	<0.001
No CCOS	100 (5.2)	129 (6.7)	0.78 (0.62, 0.98)	0.043
S	44 (5.0)	61 (6.9)	0.73 (0.52, 1.04)	0.10
Secondary analysis: number of organ dysfunctions				
Match	Mean (SD)		Difference in means	
	Case	Control	Δ (95% CI)	P-value
Historic	2.3 (1.2)	2.3 (1.2)	0.01 (−0.09, 0.11)	0.87
S	2.4 (1.2)	2.4 (1.2)	−0.02 (−0.17, 0.12)	0.75
No CCOS	2.3 (1.2)	2.3 (1.2)	0.05 (−0.02, 0.12)	0.19

S	2.4 (1.2)	2.3 (1.2)	0.08 (−0.02, 0.19)	0.11
Secondary analysis: unit mortality				
Match	Deaths (percentage)		Matched pairs risk ratio	
	Case	Control	RR (95% CI)	P-value
Historic	334 (33.1)	352 (34.9)	0.95 (0.85, 1.06)	0.40
S	168 (36.8)	184 (40.3)	0.91 (0.78, 1.07)	0.29
No CCOS	648 (33.9)	591 (30.9)	1.10 (1.00, 1.20)	0.042
S	332 (37.4)	291 (32.7)	1.14 (1.01, 1.29)	0.041
Secondary analysis: hospital mortality				
Match	Deaths (percentage)		Matched pairs risk ratio	
	Case	Control	RR (95% CI)	P-value
Historic	446 (45.9)	488 (49.1)	0.95 (0.87, 1.04)	0.27
S	210 (47.6)	240 (53.5)	0.90 (0.80, 1.02)	0.12
No CCOS	867 (47.2)	845 (45.0)	1.05 (0.99, 1.13)	0.13
S	417 (49.1)	419 (48.1)	1.02 (0.93, 1.13)	0.64
Secondary analysis: unit length of stay				
Match	Median (IQR)		Ratio of geometric means	
	Case	Control	Ratio (95% CI)	P-value
Historic	3.5 (1.4-9.0)	2.7 (1.0-7.3)	1.24 (1.10, 1.40)	<0.001
S	3.5 (1.4-9.1)	3.2 (1.1-9.0)	1.17 (0.98, 1.41)	0.089
No CCOS	3.4 (1.3-8.8)	2.7 (1.0-7.4)	1.28 (1.17, 1.39)	<0.001
S	3.3 (1.3-9.0)	2.8 (1.1-7.9)	1.21 (1.06, 1.37)	0.005

ICNARC intensive care national audit & research centre, SD standard deviation, CI confidence interval, S sensitivity analysis, IQR interquartile range, CPR cardiopulmonary resuscitation, RR risk ratio

The mean ICNARC physiology score was 1 point lower for cases than matched controls in the historic match but there was no significant difference in the no CCOS match. Length of stay in hospital prior to admission was longer for cases than for matched controls, and this difference was significant in the no CCOS match. The proportion of patients receiving CPR within 24 hours prior to admission was significantly lower for cases than matched controls in both matches, with risk ratios ranging from 0.51 to 0.78. There was no significant difference in the mean number of organ dysfunctions.

Critical care unit mortality was higher for cases than for matched controls in the no CCOS match and this difference persisted, although it was not statistically significant, for hospital mortality. Length of stay in the critical care unit was longer for cases than matched controls and this difference was significant in both matches.

Subgroup analyses where the last CCOS visit prior to admission to a critical care unit was a scheduled visit were associated with a lower ICNARC physiology score (significant in the no CCOS match), longer prior length of stay in hospital (significant in the no CCOS match) and a lower probability of CPR prior to admission (significant in the no CCOS match). There were no significant differences in the other secondary outcomes (Table 4.3.2.10).

Table 4.3.2.10: Individually-matched results for CCOS visits prior to admission - subgroup analysis where last visit scheduled

Effect estimate (95% CI) [P-value]	Historic match	No CCOS match
ICNARC physiology score, difference in means	−0.52 (−2.19, 1.15) [0.54]	−1.32 (−2.62, −0.02) [0.046]
Prior hospital stay, ratio of geometric means	1.23 (0.99, 1.52) [0.063]	1.38 (1.19, 1.61) [< 0.001]
CPR prior to admission, matched pairs risk ratio	0.50 (0.21, 1.18) [0.11]	0.46 (0.26, 0.81) [0.007]
Organ dysfunctions, difference in mean number	−0.08 (−0.28, 0.12) [0.43]	−0.12 (−0.27, 0.03) [0.11]
Unit mortality, matched pairs risk ratio	0.87 (0.67, 1.10) [0.24]	0.95 (0.79, 1.14) [0.57]
Hospital mortality, matched pairs risk ratio	0.98 (0.82, 1.18) [0.87]	1.00 (0.87, 1.14) [0.96]
Unit length of stay, ratio of geometric means	1.20 (0.94, 1.53) [0.14]	1.13 (0.95, 1.35) [0.18]

CCOS critical care outreach service(s), Values are difference in effect of CCOS (interaction) associated with the last CCOS visit being scheduled, CI confidence interval, ICNARC intensive care national audit & research centre, CPR cardiopulmonary resuscitation

Propensity model

The propensity model was fitted on 21,794 critical care unit admissions with complete data for all factors included in the model, including 2,179 cases

receiving one or more visits from the CCOS prior to admission to the critical care unit (representing 99.4% of all cases). The results of the propensity model are shown in Appendix 5.

CCOS visits were least likely to have occurred prior to admission in the youngest and the oldest admissions to the critical care unit. Admissions with one or more severe past medical history conditions were more likely to have received CCOS visits prior to admission. Admissions from the ward were much more likely to have received CCOS visits prior to admission than admissions from any other source. There was also significant variation in propensity by reason for admission to the critical care unit, with the processes most commonly associated with CCOS visits being shock, respiratory collapse, diabetes, and respiratory infection. The propensity model had an area under the ROC curve of 0.785 (95% confidence interval 0.775 to 0.794) indicating acceptable discrimination of cases. However, the measures of explained variation were R2SS = 0.11 and R2E = 0.15 indicating that a relatively small proportion of the variation was explained by the model.

Matching on predicted propensity (to within 5%) resulted in successful matching of between 73% and 100% of cases (Table 4.3.2.11). For the historic match, unmatched cases had a higher proportion of severe conditions in the past medical history and slightly higher severity of illness and mortality. The propensity matching resulted in good balance between cases and matched controls on the factors included in the propensity model (Table 4.3.2.12).

Table 4.3.2.11: Comparison of matched and unmatched cases for CCOS visits prior to admission (propensity matching)

	Matched	Unmatched
Historic match		
Patients, n (%)	1,593 (73.1)	586 (26.9)
Age, mean (SD)	61.2 (17.0)	61.7 (16.5)
Sex (male), n (%)	863 (54.2)	334 (57.0)
Severe past medical history, n (%)	330 (20.7)	162 (27.6)
ICNARC physiology score, mean (SD)	21.2 (9.8)	23.5 (10.9)
Ultimate hospital mortality, n (%)	704 (46.1)	267 (48.5)
No CCOS match		
Patients, n (%)	2,179 (100.0)	0 (0.0)
Age, mean (SD)	61.3 (16.9)	N/A
Sex (male), n (%)	1,197 (54.9)	N/A

Severe past medical history, n (%)	492 (22.6)	N/A
ICNARC physiology score, mean (SD)	21.8 (10.2)	N/A
Ultimate hospital mortality, n (%)	971 (46.7)	N/A

SD standard deviation, ICNARC intensive care national audit & research centre, N/A not applicable

Table 4.3.2.12: Balance between cases and propensity-matched controls for CCOS visits prior to admission

Factor	Case	Control
Historic match		
Age, mean (SD)	61.2 (17.0)	62.5 (16.1)
Severe past medical history, n (%)	330 (20.7)	316 (19.8)
Source of admission, n (%)		
Ward	1,024 (64.3)	1,008 (63.3)
Critical care unit (ICU or ICU/HDU)	122 (7.7)	146 (9.2)
Theatre (elective)	90 (5.6)	119 (7.5)
Theatre (emergency)	213 (13.4)	209 (13.1)
A&E/other hospital/clinic or home	144 (9.0)	111 (7.0)
Reason for admission, n (%)		
Respiratory	569 (35.7)	604 (37.9)
Cardiovascular	279 (17.5)	299 (18.8)
Gastrointestinal	339 (21.3)	346 (21.7)
Neurological	109 (6.8)	135 (8.5)
Other	297 (18.6)	209 (13.1)
No CCOS match		
Age, mean (SD)	61.3 (16.9)	62.2 (16.3)
Severe past medical history, n (%)	492 (22.6)	437 (20.1)
Source of admission, n (%)		
Ward	1,487 (68.2)	1,470 (67.5)
Critical care unit (ICU or ICU/HDU)	131 (6.0)	134 (6.1)
Theatre (elective)	116 (5.3)	107 (4.9)
Theatre (emergency)	269 (12.3)	291 (13.4)
A&E/other hospital/clinic or home	176 (8.1)	177 (8.1)
Reason for admission, n (%)		
Respiratory	780 (35.8)	800 (36.7)

Cardiovascular	422 (19.4)	500 (22.9)
Gastrointestinal	432 (19.8)	356 (16.3)
Neurological	164 (7.5)	159 (7.3)
Other	381 (17.5)	364 (16.7)

SD standard deviation, ICU intensive care unit, HDU high dependency unit, A&E accident & emergency department, CCOS critical care outreach service(s)

CCOS visits prior to admission – propensity-matched results

Propensity matching produced similar results to the individual matching although with more statistically significant results due to the higher power resulting from a higher proportion of cases being matched successfully (Table 4.3.2.13). There was no significant difference in the primary outcome of a difference in the mean ICNARC physiology score in either of the matches. Prior length of stay in hospital was longer for cases than for matched controls. The proportion of patients receiving CPR within 24 hours prior to admission was lower for cases than for matched controls. The mean number of organ dysfunctions was fractionally higher for cases than for matched controls. Unit mortality was higher for cases in the no CCOS match, although there was no significant difference in hospital mortality. Unit length of stay was significantly longer for cases than for matched controls.

Table 4.3.2.13: Propensity-matched results for CCOS visits prior to admission

Primary analysis: ICNARC physiology score				
Match	Mean (SD)		Difference in means	
	Case	Control	Δ (95% CI)	P-value
Historic	21.2 (9.8)	21.4 (10.4)	−0.27 (−0.96, 0.42)	0.44
S	22.1 (9.9)	22.7 (10.5)	−0.74 (−1.86, 0.37)	0.19
No CCOS	21.8 (10.2)	21.8 (11.0)	0.01 (−0.60, 0.62)	0.97
S	23.0 (10.3)	23.0 (11.1)	0.05 (−0.90, 1.00)	0.92
Secondary analysis: prior length of stay in hospital				
Match	Median (IQR)		Ratio of geometric means	
	Case	Control	Ratio (95% CI)	P-value
Historic	3 (1-11)	2 (1-10)	1.14 (1.05, 1.24)	0.002
S	3 (1-8)	2 (1-8)	1.09 (0.94, 1.25)	0.26
No CCOS	4 (1-12)	3 (1-10)	1.21 (1.12, 1.30)	<0.001
S	3 (1-9)	2 (1-8)	1.21 (1.07, 1.36)	0.002
Secondary analysis: CPR within 24 hours prior to admission				
Match	Number (percentage)		Matched pairs risk ratio	
	Case	Control	RR (95% CI)	P-value
Historic	83 (5.2)	174 (11.0)	0.47 (0.37, 0.61)	<0.001
S	32 (4.8)	79 (12.1)	0.40 (0.27, 0.59)	<0.001
No CCOS	119 (5.5)	177 (8.1)	0.68 (0.55, 0.84)	<0.001
S	50 (5.1)	93 (9.8)	0.51 (0.37, 0.71)	<0.001
Secondary analysis: number of organ dysfunctions				
Match	Mean (SD)		Difference in means	
	Case	Control	Δ (95% CI)	P-value
Historic	2.3 (1.2)	2.2 (1.2)	0.06 (−0.02, 0.14)	0.15
S	2.4 (1.2)	2.3 (1.2)	0.06 (−0.07, 0.19)	0.37
No CCOS	2.3 (1.2)	2.3 (1.2)	0.03 (−0.04, 0.10)	0.43

S	2.4 (1.2)	2.4 (1.2)	0.06 (−0.05, 0.16)	0.27
Secondary analysis: unit mortality				
Match	Deaths (percentage)		Matched pairs risk ratio	
	Case	Control	RR (95% CI)	P-value
Historic	519 (32.6)	516 (32.4)	1.01 (0.91, 1.11)	0.94
S	244 (36.5)	261 (39.8)	0.92 (0.80, 1.05)	0.23
No CCOS	724 (33.2)	645 (29.6)	1.12 (1.03, 1.22)	0.008
S	364 (37.4)	305 (32.0)	1.18 (1.05, 1.33)	0.008
Secondary analysis: hospital mortality				
Match	Deaths (percentage)		Matched pairs risk ratio	
	Case	Control	RR (95% CI)	P-value
Historic	704 (46.1)	731 (46.6)	0.99 (0.92, 1.06)	0.79
S	310 (48.4)	335 (52.1)	0.92 (0.83, 1.02)	0.13
No CCOS	971 (46.7)	958 (45.1)	1.05 (0.98, 1.11)	0.18
S	456 (49.5)	452 (48.5)	1.03 (0.94, 1.13)	0.52
Secondary analysis: Unit length of stay				
Match	Median (IQR)		Ratio of geometric means	
	Case	Control	Ratio (95% CI)	P-value
Historic	3.3 (1.3-8.7)	2.6 (1.0-7.1)	1.26 (1.14, 1.38)	<0.001
S	3.2 (1.4-8.8)	2.9 (1.0-7.4)	1.23 (1.05, 1.43)	0.008
No CCOS	3.3 (1.3-8.7)	2.7 (1.0-7.2)	1.27 (1.17, 1.38)	<0.001
S	3.3 (1.3-9.0)	2.8 (1.0-7.7)	1.22 (1.07, 1.40)	0.002

ICNARC intensive care national audit & research centre, SD standard deviation, CI confidence interval, S sensitivity analysis, IQR interquartile range, CPR cardiopulmonary resuscitation, RR risk ratio

The results from the sensitivity analyses, restricted to patients whose last CCOS visit was recorded as directly resulting in admission to critical care and who were subsequently admitted from the ward within 24 hours of the visit, were all consistent with the main analyses.

Subgroup analyses where the last CCOS visit prior to admission to a critical care unit was a scheduled visit was associated with significantly lower mean ICNARC physiology score and mean number of organ dysfunctions and with a

longer length of stay in hospital prior to admission to the critical care unit (Table 4.3.2.14). A scheduled visit was also associated with a lower rate of CPR prior to admission (significant for the historic match only).

Table 4.3.2.14: Propensity-matched results for CCOS visits prior to admission - subgroup analysis where last visit scheduled

Effect estimate (95% CI) [P-value]	Historic match	No CCOS match
ICNARC physiology score, difference in means	−1.59 (−2.98, −0.20) [0.025]	−1.44 (−2.67, −0.21) [0.021]
Prior hospital stay, ratio of geometric means	1.45 (1.23, 1.71) [<0.001]	1.30 (1.13, 1.51) [<0.001]
CPR prior to admission, matched pairs risk ratio	0.47 (0.26, 0.84) [0.012]	0.65 (0.39, 1.06) [0.085]
Organ dysfunctions, difference in mean number	−0.17 (−0.33, 0.00) [0.050]	−0.16 (−0.30, −0.02) [0.024]
Unit mortality, matched pairs risk ratio	0.84 (0.68, 1.03) [0.091]	0.86 (0.72, 1.02) [0.079]
Hospital mortality, matched pairs risk ratio	0.95 (0.82, 1.10) [0.49]	0.88 (0.77, 1.01) [0.062]
Unit length of stay, ratio of geometric means	1.11 (0.92, 1.35) [0.28]	1.04 (0.88, 1.23) [0.63]

CCOS critical care outreach service(s), Values are difference in effect of CCOS (interaction) associated with the last CCOS visit being scheduled, CI confidence interval, ICNARC intensive care national audit & research centre, CPR cardiopulmonary resuscitation

Matched cohort results – CCOS visit(s) following discharge

Of the 5,924 patients receiving one or more CCOS visits following discharge from the critical care unit, 13 (0.2%) were excluded as they were aged less than 16 years and a further 24 (0.4%) were excluded due to inconsistencies in the Case Mix Programme data. This left 5,887 patients included in the matching process. Table 4.3.2.15 shows a comparison between the matched and unmatched cases for the two control pools. 1,479 cases admitted to the 11 critical care units with no Case Mix Programme data prior to the introduction of CCOS in their respective hospitals were excluded from the historic match. Between 40% and 73% of cases were successfully matched. Unmatched cases again tended to be younger and more severely ill, with a

higher proportion having one or more severe conditions in their past medical history, higher mean ICNARC physiology score and higher mortality.

Table 4.3.2.15: Comparison of matched and unmatched cases for CCOS visits following discharge (individual matching)

	Matched	Unmatched
Historic match		
Patients, n (%)	1,743 (39.5)	2,665 (60.5)
Age, mean (SD)	63.5 (16.0)	58.2 (18.2)
Sex (male), n (%)	1,008 (57.8)	1,467 (55.0)
Severe past medical history, n (%)	143 (8.2)	577 (21.7)
ICNARC physiology score, mean (SD)	14.1 (6.9)	16.1 (8.2)
Ultimate hospital mortality, n (%)	174 (10.3)	278 (10.9)
No CCOS match		
Patients, n (%)	4,309 (73.2)	1,578 (26.8)
Age, mean (SD)	60.6 (17.5)	56.6 (18.4)
Sex (male), n (%)	2,446 (56.8)	867 (54.9)
Severe past medical history, n (%)	470 (10.9)	475 (30.1)
ICNARC physiology score, mean (SD)	15.3 (7.7)	15.7 (8.4)
Ultimate hospital mortality, n (%)	426 (10.2)	170 (11.4)

SD standard deviation, ICNARC intensive care national audit & research centre, CCOS critical care outreach service(s)

CCOS visits following discharge - individually-matched results
Table 4.3.2.16 shows the results of the primary and secondary analyses. Results are shown for all matched cases and for the sensitivity analysis restricted to cases discharged directly to the ward and receiving a scheduled CCOS visit within 48 hours of discharge.

Mortality at ultimate discharge from an acute hospital was lower for cases than for matched controls in both matches with a risk ratio around 0.86. This difference was statistically significant in the no CCOS match. The relationship was stronger (risk ratio ~0.75 and significant in both matches) in the sensitivity analysis. There was no significant difference between cases and matched controls in readmissions within 48 hours of discharge. However, when restricted to the sensitivity analysis, readmissions were significantly lower (risk ratio ~0.45) in both matches. Excluding readmissions from HDU from this definition did not alter these results. Length of stay in hospital following discharge from the critical care unit was significantly shorter for cases than for matched controls in both matches.

Subgroup analyses where patients received CCOS visits prior to admission in addition to following discharge were associated with increased hospital stay following discharge in the no CCOS match. There were no associations with any of the other outcomes in any of the matched cohorts (Table 4.3.2.17). The low rates of readmissions combined with small sample sizes resulted in difficulties in estimating interactions in these models.

Table 4.3.2.16: Individually-matched results for CCOS visits following discharge

Primary analysis: hospital mortality				
Match	Deaths (percentage)		Matched pairs risk ratio	
	Case	Control	RR (95% CI)	P-value
Historic	174 (10.3)	220 (12.7)	0.85 (0.70, 1.02)	0.085
S	124 (9.5)	175 (13.1)	0.76 (0.61, 0.94)	0.012
No CCOS	426 (10.2)	497 (11.7)	0.87 (0.78, 0.98)	0.022
S	286 (8.8)	388 (11.7)	0.75 (0.64, 0.87)	<0.001
Secondary analysis: readmissions within 48 hours				
Match	Deaths (percentage)		Matched pairs risk ratio	
	Case	Control	RR (95% CI)	P-value
Historic	34 (2.0)	43 (2.5)	0.80 (0.50, 1.29)	0.36
S	15 (1.1)	34 (2.5)	0.44 (0.23, 0.84)	0.012
No CCOS	85 (2.0)	106 (2.5)	0.80 (0.60, 1.06)	0.13
S	34 (1.0)	73 (2.2)	0.46 (0.31, 0.71)	<0.001
Secondary analysis: readmissions within 48 hours not from HDU				
Match	Deaths (percentage)		Matched pairs risk ratio	
	Case	Control	RR (95% CI)	P-value
Historic	29 (1.7)	40 (2.3)	0.72 (0.43, 1.22)	0.22
S	15 (1.1)	33 (2.5)	0.46 (0.24, 0.88)	0.020
No CCOS	73 (1.7)	96 (2.2)	0.87 (0.78, 0.98)	0.022
S	34 (1.0)	73 (2.2)	0.46 (0.31, 0.71)	<0.001
Secondary analysis: length of stay in hospital following discharge				
Match	Median (IQR)		Ratio of geometric means	
	Case	Control	Ratio (95% CI)	P-value
Historic	11 (6-20)	12 (7-22)	0.89 (0.84, 0.95)	<0.001
S	10 (5-18)	11 (7-21)	0.86 (0.80, 0.93)	<0.001
No CCOS	11 (6-21)	12 (6-25)	0.89 (0.86, 0.93)	<0.001

S	10 (5-19)	11 (6-23)	0.88 (0.84, 0.92)	<0.001

RR risk ratio, CI confidence interval, S sensitivity analysis, HDU high dependency unit, IQR interquartile range

Table 4.3.2.17: Individually-matched results for CCOS visits following discharge - subgroup analyses where CCOS visit prior to admission in addition

Effect estimate (95% CI) [P-value]	Historic match	No CCOS match
Hospital mortality, matched pairs risk ratio	0.93 (0.55, 1.59) [0.80]	1.03 (0.76, 1.39) [0.85]
Readmission within 48 hours, matched pairs risk ratio	0.82 (0.01, 48.12) [0.93]	0.74 (0.28, 2.00) [0.56]
Readmission not from HDU, matched pairs risk ratio	0.91 (not estimable) [1.00]	0.74 (0.26, 2.11) [0.58]
Post-discharge hospital LOS, ratio of geometric means	0.89 (0.73, 1.07) [0.22]	1.16 (1.03, 1.30) [0.013]

CCOS critical care outreach service(s), Values are difference in effect of CCOS (interaction) associated with receiving CCOS visits prior to admission in addition to following discharge, CI confidence interval, HDU high dependency unit, LOS length of stay

Propensity model
The propensity model was fitted on 15,562 patients discharged alive from the critical care unit to any location in the same hospital and with complete data for all factors included in the model. These included 5,743 cases receiving one or more CCOS visits following discharge (representing 97.6% of all 5,887 potentially eligible cases). The results of the propensity model are shown in Appendix 5.

Age and the presence of severe conditions in the past medical history were not associated with the propensity to receive CCOS visits following discharge. Patients with the lowest acute severity of illness were least likely to receive CCOS visits. Surgical admissions (admitted directly to the unit from theatre and/or recovery) were most likely to receive CCOS visits and patients transferred in from another critical care unit (ICU or HDU) were least likely. Patients with a reason for admission affecting the endocrine system were most likely to receive CCOS visits and those with a musculoskeletal condition were least likely. Patients staying in the unit for at least one night were more likely to receive CCOS visits than those admitted and discharged on the same day. Patients discharged to the ward were more likely to receive CCOS visits than those discharged to any other destination. The area under the ROC curve for the propensity model was 0.550 (95% confidence interval 0.541 to 0.559) indicating discrimination of cases that is little better than by chance. The measures of explained variation were R2SS = 0.008 and R2E = 0.006. These suggest the propensity model does not explain the decision to follow-up certain patients and that matching on propensity (or individual matching on these factors) will do a poor job of controlling for selection bias.

Between 66% and 98% of cases were successfully matched on predicted propensity (within 5%) (Table 4.3.2.18). Unmatched cases in the historic match had more severe conditions in the past medical history, but had similar acute severity of illness and lower mortality. The balance between cases and matched controls on factors included in the propensity model was good (Table 4.3.2.19).

CCOS visits following discharge – propensity-matched results
The propensity-matched results were again similar to those from the individually-matched analyses. Hospital mortality was significantly lower for cases than matched controls in the no CCOS match (odds ratio 0.84) and this result was stronger (odds ratio ~0.68) and significant in both matches when restricted to the sensitivity analysis of cases discharged to the ward and receiving a scheduled CCOS visit within 48 hours of discharge (Table 4.3.2.20).

Table 4.3.2.18: Comparison of matched and unmatched cases for CCOS visits following discharge (propensity matching)

	Matched	Unmatched
Historic match		
Patients, n (%)	3,782 (65.9)	1,961 (34.1)
Age, mean (SD)	60.7 (17.6)	57.3 (18.1)
Sex (male), n (%)	2,120 (56.1)	1,122 (57.2)
Severe past medical history, n (%)	517 (13.7)	395 (20.1)
ICNARC physiology score, mean (SD)	15.3 (7.7)	15.6 (18.1)
Ultimate hospital mortality, n (%)	411 (11.1)	184 (9.5)
No CCOS match		
Patients, n (%)	5,634 (98.1)	109 (1.9)
Age, mean (SD)	59.6 (17.9)	55.9 (17.2)
Sex (male), n (%)	3,182 (56.5)	60 (55.0)
Severe past medical history, n (%)	866 (15.4)	46 (42.2)
ICNARC physiology score, mean (SD)	15.3 (7.9)	17.5 (6.0)
Ultimate hospital mortality, n (%)	583 (10.5)	12 (11.1)

SD standard deviation, ICNARC intensive care national audit & research centre, CCOS critical care outreach services

There was no significant difference in readmissions within 48 hours. In the sensitivity analysis, the rate of readmissions within 48 hours was significantly lower for cases than for matched controls in both matches, with odds ratios ranging from 0.26 to 0.57. These results did not change when readmissions from HDU were excluded. CCOS visits following discharge were associated with a significantly shorter length of stay in hospital in both matches in both the main and sensitivity analyses.

Subgroup analyses where patients received CCOS visits prior to admission in addition to post-discharge were associated with increased hospital mortality (odds ratio 1.52 to 2.04) and longer length of stay in hospital following discharge (Table 4.3.2.21). The low rate of readmissions meant that interaction terms on these outcomes could not be reliably estimated.

Table 4.3.2.19: Balance between cases and propensity-matched controls for CCOS visits following discharge

Factor	Case	Control
Historic match		
Age, mean (SD)	60.7 (17.6)	60.1 (17.9)
ICNARC physiology score, mean (SD)	15.3 (7.7)	15.3 (7.8)
Source of admission, n (%)		
Ward	886 (23.4)	818 (21.6)
Critical care unit (ICU or HDU)	196 (5.2)	236 (6.2)
Theatre (elective)	1,166 (30.8)	1,235 (32.7)
Theatre (emergency)	886 (23.4)	857 (22.7)
A&E/other hospital/clinic or home	648 (17.1)	636 (16.8)
Destination following discharge, n (%)		
Ward	3,130 (82.8)	3,126 (82.7)
Intermediate care	136 (3.6)	111 (2.9)
HDU	504 (13.3)	506 (13.4)
ICU	8 (0.2)	38 (1.0)
Recovery	4 (0.1)	1 (0.0)
No CCOS match		
Age, mean (SD)	59.6 (17.9)	60.0 (17.8)
ICNARC physiology score, mean (SD)	15.3 (7.9)	16.0 (17.8)
Source of admission, n (%)		
Ward	1,313 (23.3)	1,314 (23.3)
Critical care unit (ICU or HDU)	253 (4.5)	252 (4.5)
Theatre (elective)	1,779 (31.6)	1,641 (29.1)
Theatre (emergency)	1,241 (22.0)	1,429 (25.4)
A&E/other hospital/clinic or home	1,048 (18.6)	998 (17.7)
Destination following discharge, n (%)		
Ward	4,913 (87.2)	4,506 (80.0)

Intermediate care	159 (2.8)	78 (1.4)
HDU	540 (9.6)	1,033 (18.3)
ICU	11 (0.2)	4 (0.1)
Recovery	11 (0.2)	13 (0.2)

SD standard deviation, ICNARC intensive care national audit & research centre, ICU intensive care unit, HDU high dependency unit, A&E accident & emergency department

Table 4.3.2.20: Propensity-matched results for CCOS visits following discharge

Primary analysis: hospital mortality				
Match	Deaths (percentage)		Matched pairs risk ratio	
	Case	Control	RR (95% CI)	P-value
Historic	411 (11.1)	465 (12.4)	0.90 (0.78, 1.04)	0.15
S	247 (9.6)	336 (13.3)	0.67 (0.55, 0.82)	<0.001
No CCOS	583 (10.5)	718 (12.9)	0.84 (0.75, 0.94)	0.003
S	377 (9.0)	462 (12.6)	0.68 (0.58, 0.81)	<0.001
Secondary analysis: readmissions within 48 hours				
Match	Deaths (percentage)		Matched pairs risk ratio	
	Case	Control	RR (95% CI)	P-value
Historic	83 (2.2)	68 (1.8)	1.26 (0.91, 1.74)	0.17
S	21 (0.8)	48 (1.9)	0.42 (0.78, 1.50)	0.004
No CCOS	121 (2.1)	152 (2.7)	0.80 (0.63, 1.02)	0.071
S	42 (1.0)	100 (2.7)	0.26 (0.17, 0.42)	<0.001
Secondary analysis: readmissions within 48 hours not from HDU				
Match	Deaths (percentage)		Matched pairs risk ratio	
	Case	Control	RR (95% CI)	P-value
Historic	65 (1.7)	62 (1.6)	1.10 (0.75, 1.60)	0.64
S	19 (0.8)	48 (2.0)	0.42 (0.23, 0.76)	0.004
No CCOS	103 (1.8)	126 (2.2)	0.82 (0.63, 1.06)	0.13
S	26 (0.7)	98 (2.7)	0.27 (0.17, 0.42)	<0.001
Secondary analysis: following discharge hospital length of stay				
Match	Median (IQR)		Ratio of geometric means	
	Case	Control	Ratio (95% CI)	P-value
Historic	11 (6-22)	12 (7-25)	0.90 (0.86, 0.94)	<0.001
S	10 (5-18)	11 (6-22)	0.90 (0.85, 0.96)	0.001
No CCOS	11 (6-22)	13 (6-27)	0.86 (0.83, 0.89)	<0.001

S	10 (5-19)	11 (5-23)	0.90 (0.86, 0.95)	<0.001

RR risk ratio, CI confidence interval, S sensitivity analysis, HDU high dependency unit, IQR interquartile range

Table 4.3.2.21: Propensity-matched results for CCOS visits following discharge - subgroup analyses where CCOS visit prior to admission in addition

Effect estimate (95% CI) [P-value]	Historic match	No CCOS match
Hospital mortality, matched pairs risk ratio	1.63 (0.99, 2.66) [0.053]	2.04 (1.43, 2.91) [<0.001]
Readmission within 48 hours, matched pairs risk ratio	1.01 (0.00, 21017) [1.00]	0.63 (0.00, 244.9) [0.88]
Readmission not from HDU, matched pairs risk ratio	1.01 (0.00, 50672) [1.00]	0.62 (0.00, 507.9) [0.89]
Post-discharge hospital LOS, ratio of geometric means	1.21 (1.01, 1.44) [0.036]	1.28 (1.10, 1.48) [0.002]

CI confidence interval, CCOS critical care outreach service(s), Values are effect estimate for the difference in effect of CCOS associated with receiving CCOS visits prior to admission in addition to following discharge, HDU high dependency unit, LOS length of stay

4.4 Economic evaluation of CCOS

Brief introduction

The economic evaluation was carried out solely for cases receiving CCOS visits following discharge from the critical care unit. Evaluating the cost-effectiveness of all other aspects of CCOS activity, including responding to requests for assistance from the ward and formal or informal education of ward staff was beyond the scope of this study.

Methods

Costing CCOS visits

Costs were assigned to each CCOS from the national survey (Appendix 1) based on whole time equivalent staff—including medical, nursing and allied health professional staff with dedicated time allocated to the CCOS.

Costs were obtained from the Unit Costs of Health & Social Care, 2006.[25] Costs included wages/salary, salary on-costs, overheads and capital overheads but not pre-registration qualification costs. Non-London weightings were used for all hospitals.

This exercise was repeated for those CCOS participating in the prospective data collection using updated staffing information. The annual staff costs were compared to the annual number of visits performed, calculated as the number of visits performed during the study divided by the duration (in years) of participation in the study. The cost per visit for each CCOS was calculated as the annual staff cost divided by the annual number of visits.

For cases receiving CCOS visits following discharge from the critical care unit and matched controls, costs were assigned to each patient based on:

- the number of CCOS visits (cases only) following discharge from the critical care unit, costed as above using the CCOS-specific cost;
- the number of additional days of critical care following the original discharge from the critical care unit, costed at £1716 per calendar day based on the Healthcare Resource Group (HRG) for level 3, adult, general critical care;
- the number of days of ward care following the original discharge from the critical care unit, costed at £220 per calendar day based on an average across HRGs for non-elective excess bed-days.

Cost-effectiveness analysis

The difference in the mean cost per patient between cases and matched controls was assessed using matched pairs t-tests for both individually-matched and for propensity-matched controls.

The incremental cost (difference in mean cost per patient) was plotted against the incremental effectiveness estimate (absolute risk reduction for mortality before ultimate discharge from an acute hospital) in the cost-effectiveness plane for 10,000 bootstrap samples of the original data.

For both matches, a cost-effectiveness acceptability curve (CEAC) was constructed from these bootstrap samples indicating the probability that CCOS visits following discharge from critical care units is cost-effective against the willingness to pay (value of the ceiling incremental cost-effectiveness ratio as cost per hospital death averted).

Sensitivity analyses
The following sensitivity analyses were performed as both one-way and worst-case scenario analyses:

- CCOS with outlying values for the cost per visit excluded from the analyses;
- mean cost per visit used for all patients in place of the CCOS-specific cost;
- cost per day of critical care varied to the cost of a day of level 2 care and to the weighted average of days of level 2 and level 3 care (£1345 and £1607, respectively);
- cost per day of ward care varied to the 5th and 95th percentiles across the relevant HRGs (£179 and £353, respectively);
- restricted to cases discharged direct to the ward and receiving a scheduled CCOS visit within 48 hours of discharge (as for the sensitivity analysis of the effectiveness results).

Results

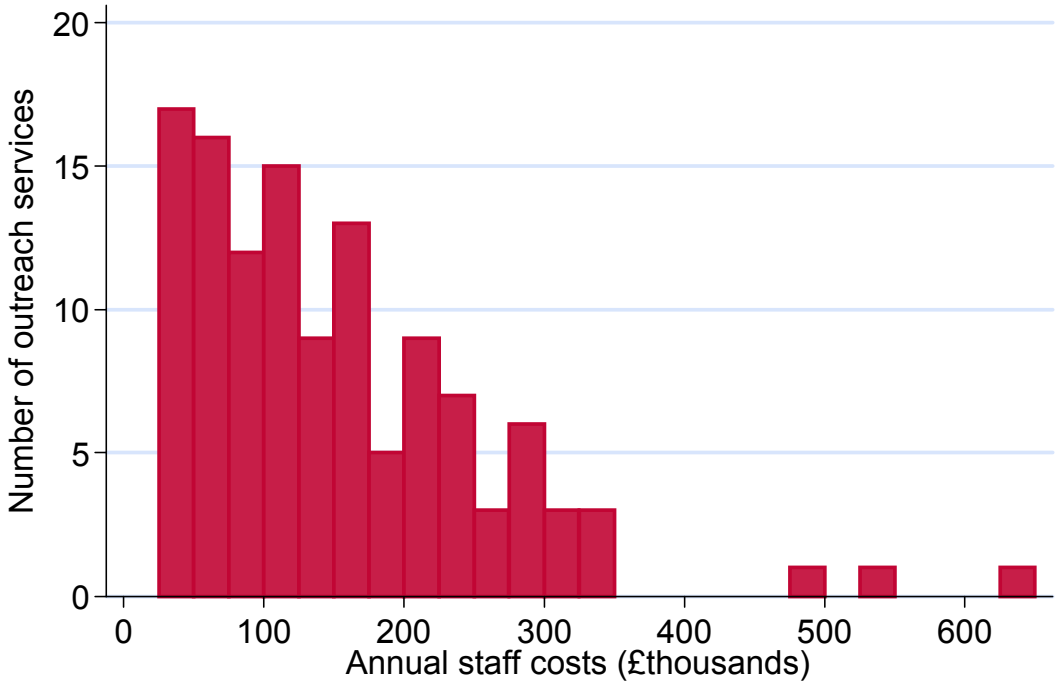
Costing CCOS visits
The median annual staff cost across all 121 CCOS that completed the national survey with sufficient, complete data to cost the service was £125,800 (IQR £72,300 to £212,600) (Figure 4.4.1).

The median annual staff cost for CCOS participating in the prospective cohort analysis was £146,200 (quartiles £93,400 to £222,900) (Figure 4.4.2).

Figure 4.4.3 shows the annual number of patient visits performed by each CCOS plotted against the annual staff costs.

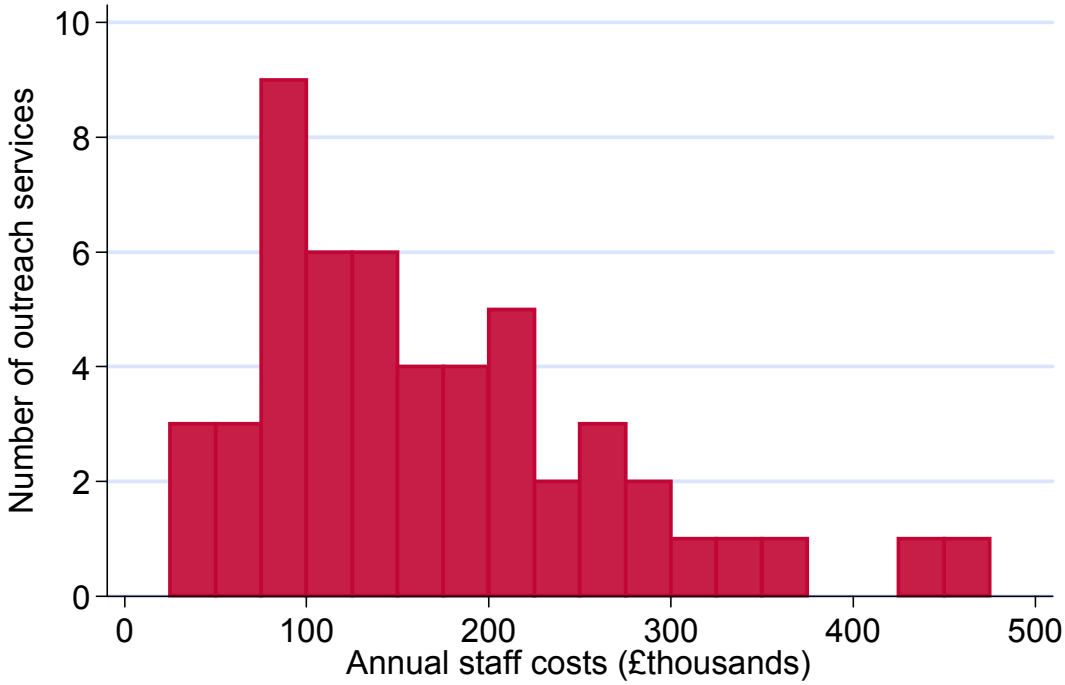
The mean cost per patient visit was £115, median £86, quartiles £61 to £113 (Figure 4.4.4). For the majority of CCOS the costs per visit were tightly clustered but a few CCOS gave outlying values in excess of £200 per visit and up to a maximum of £659.

Figure 4.4.1: Histogram of annual staff costs for all CCOS returning completed national survey forms



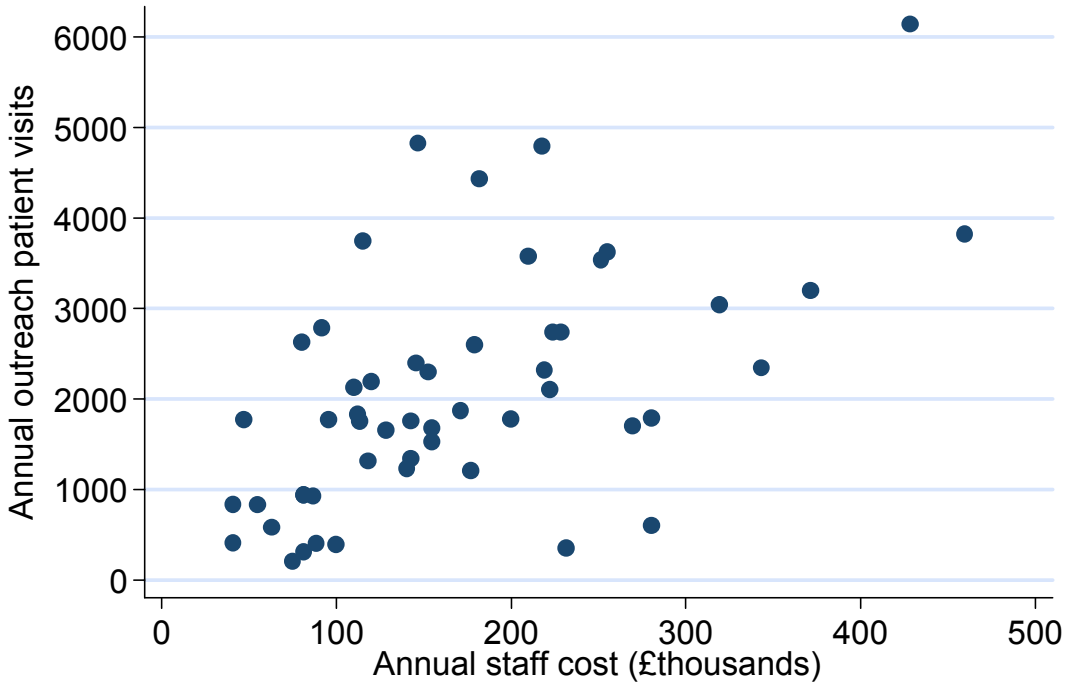
For 121 outreach services that completed the survey and with complete data to calculate costs
Based on non-London costs from Unit Costs of Health & Social Care 2006

Figure 4.4.2: Histogram of annual staff costs for CCOS participating in prospective evaluation



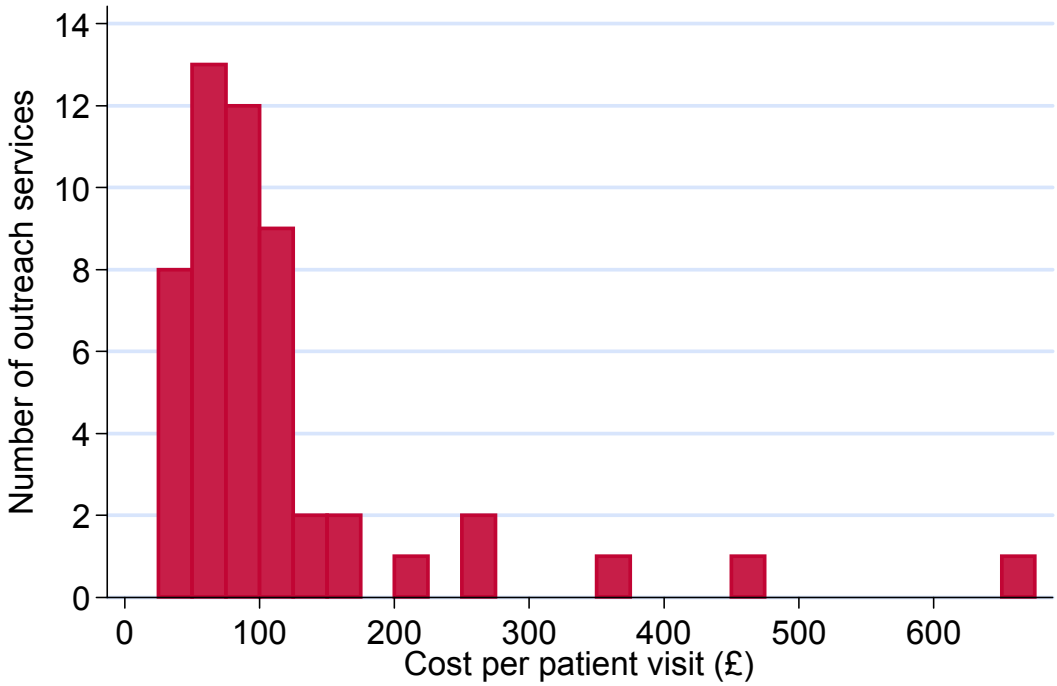
For 52 outreach services participating in prospective cohort analysis
Based on non-London costs from Unit Costs of Health & Social Care 2006

Figure 4.4.3: Annual CCOS visits versus annual staff costs



For 52 outreach services participating in prospective cohort analysis
Based on non-London costs from Unit Costs of Health & Social Care 2006

Figure 4.4.4: Histogram of costs per patient visit



For 52 outreach services participating in prospective cohort analysis
Based on non-London costs from Unit Costs of Health & Social Care 2006

Cost-effectiveness analysis (individual matching)
Cases received a mean of 2.78 to 2.96 visits from the CCOS following discharge from the critical care unit, depending on matching. The mean number of days in the critical care unit (following original discharge from the critical care unit) was higher for cases than matched controls but the mean number of days in hospital (not in critical care) was lower (Table 4.4.1). Table 4.4.2 translates these into mean costs per patient based on the base case costing – CCOS visits costed on a CCOS-specific basis, £1716 per day for days of critical care and £220 per day for days of hospital (non-critical care) care. The cost of CCOS visits (£229 to £238) comprised on average approximately 4% of the total costs for the cases. The difference in mean total cost per patient between cases and matched controls ranged from −£289 to -£34 but none of these differences were statistically significant (Table 4.4.3).

Table 4.4.1: Breakdown of costing data

Match	Mean CCOS visits		Mean ICU days		Mean hospital days	
	Case	Control	Case	Control	Case	Control
Historic	2.78	0	0.76	0.68	16.3	19.3
No CCOS	2.96	0	0.78	0.65	17.7	20.0

CCOS critical care outreach service(s), ICU intensive care unit

Table 4.4.2: Breakdown of mean cost per patient

Match	CCOS visits		ICU days		Hospital days	
	Case	Control	Case	Control	Case	Control
Historic	£229	£0	£1303	£1161	£3597	£4257
No CCOS	£238	£0	£1345	£1108	£3888	£4396

CCOS critical care outreach service(s), ICU intensive care unit

Table 4.4.3: Difference in mean cost per patient

Match	Cost per patient, mean (SD)		Difference in costs (Case – Control)	
	Case	Control	Δ (95% CI)	P-value
Historic	£5129 (8674)	£5418 (8570)	−£289 (−£860, £282)	0.32
No CCOS	£5470 (9620)	£5504 (8482)	−£34 (−£400, £331)	0.85

SD standard deviation, CI confidence interval

The cost-effectiveness plane and CEAC based on 10,000 bootstrap samples of the data for both matches are shown in Figure 4.4.5 to Figure 4.4.8. Both matches show a high probability that CCOS visits following discharge from critical care are cost effective, regardless of willingness to pay. For the historic match, CCOS dominates (i.e. greater effectiveness at lower cost) in 82% of bootstrap samples and for the no CCOS match, CCOS dominates in 57% of bootstrap samples. These indicate that even at a cost threshold of £0 (no willingness to pay) there is a greater than 50% chance that CCOS are cost effective. At a threshold of £30,000 per hospital death averted, the probability that CCOS are cost effective is estimated at 27%.

Figure 4.4.5: Cost-effectiveness plane (10,000 bootstrap samples) for historic match

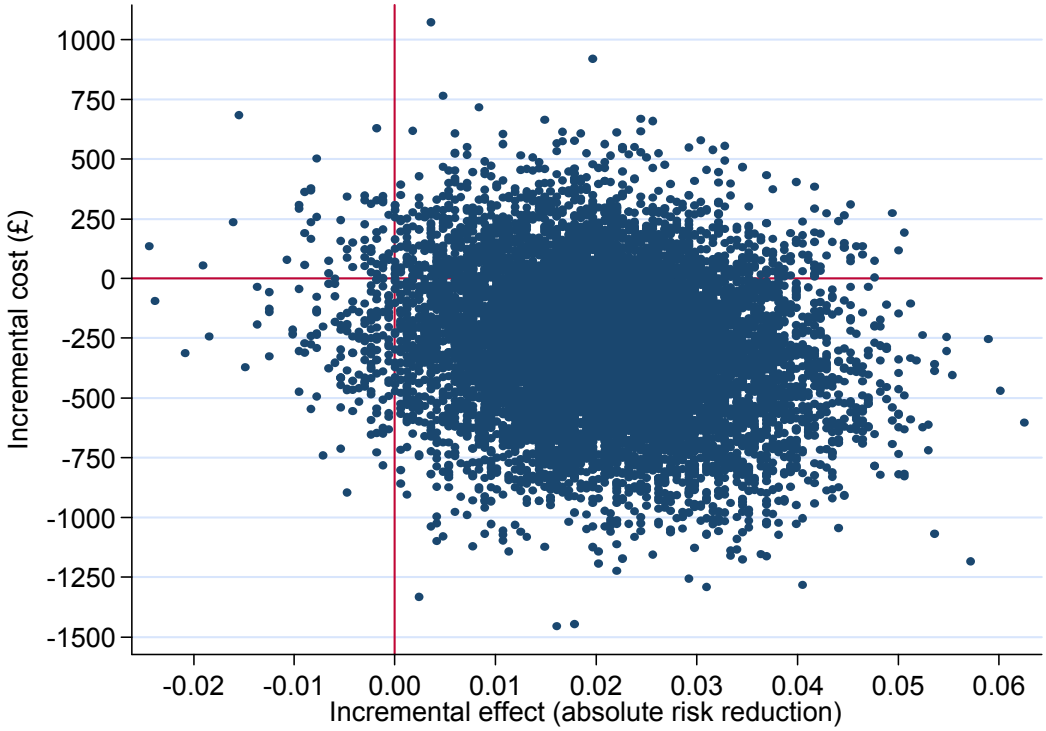


Figure 4.4.6: Cost effectiveness acceptability curve for historic match

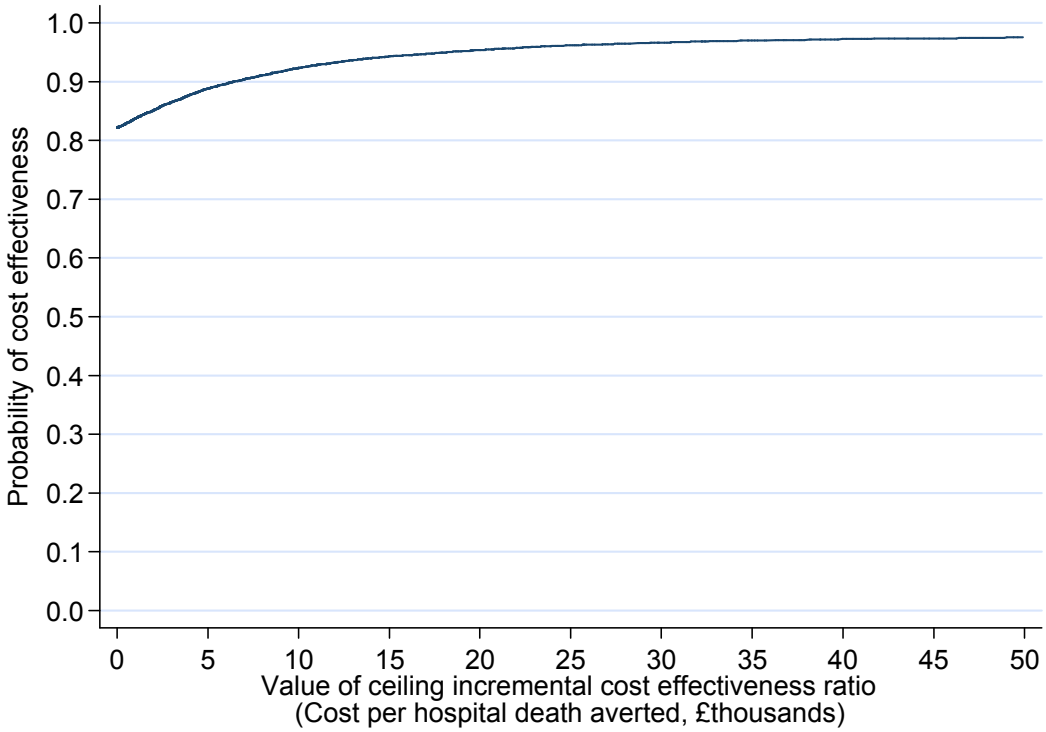


Figure 4.4.7: Cost-effectiveness plane (10,000 bootstrap samples) for no CCOS match

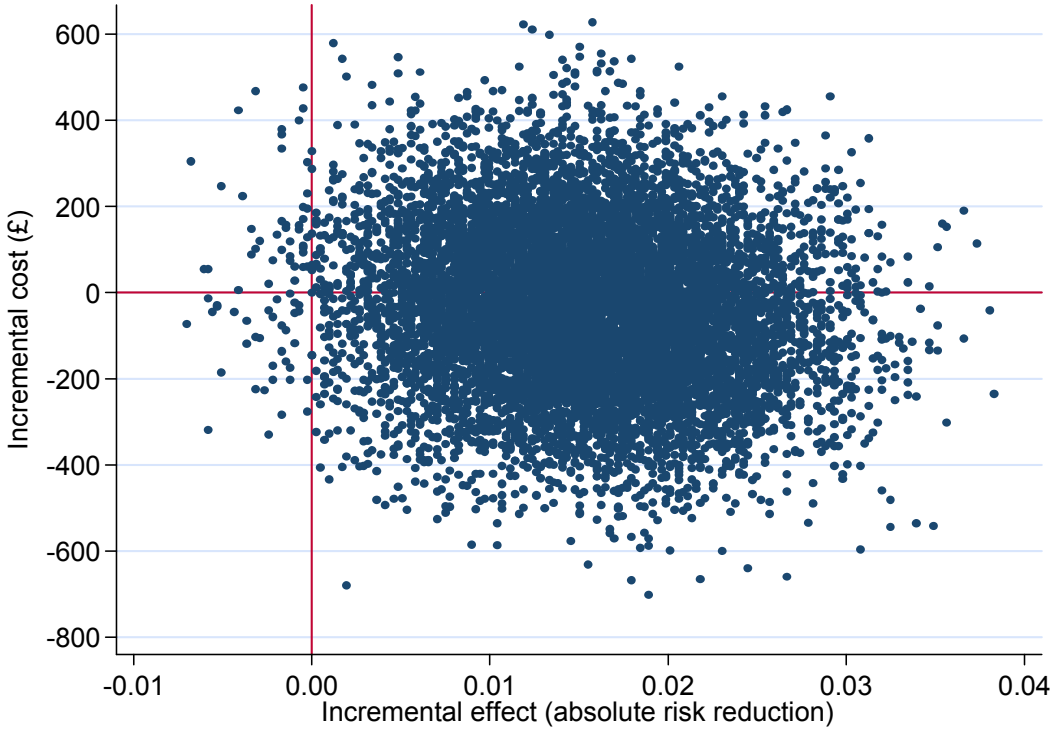
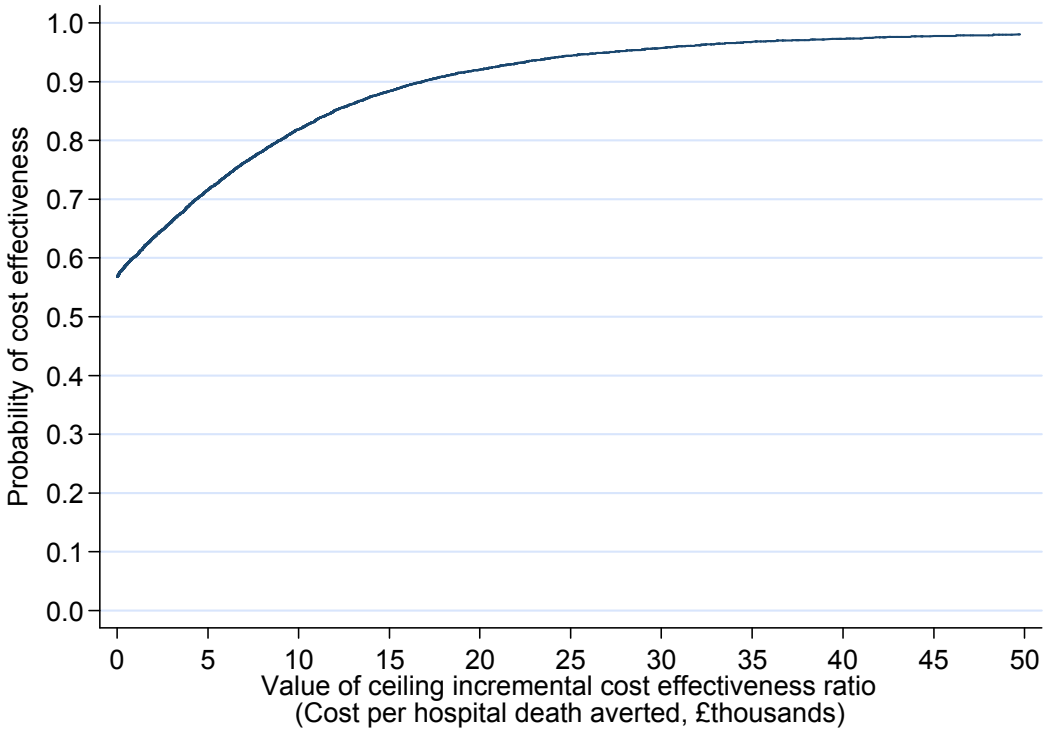


Figure 4.4.8: Cost-effectiveness acceptability curve for no CCOS match



Sensitivity analyses (individual matching)
Figure 4.4.9 and Figure 4.4.10 show the CEACs for each of the seven sensitivity analyses and the worst case scenario - which consisted of the combination of the analysis using the mean cost per visit and costing hospital days at £179 compared with the base case.

Sensitivity analyses:

- excluding CCOS with outlying costs per patient visit (greater than £200);
- using the mean cost per visit (£115) in place of CCOS-specific values;
- using a cost per critical care day of £1345 (HRG for level 2 care in a general unit);
- using a cost per critical care day of £1607 (weighted average of HRGs for level 2 and level 3 care in a general unit);
- using a cost per hospital day of £179 (5th percentile across HRGs for non-elective excess bed days);
- using a cost per hospital day of £353 (95th percentile across HRGs for non-elective excess bed days);
- restricting to cases discharged to the ward and receiving a scheduled visit from the CCOS within 48 hours of discharge.

For the historic match, even in the worst case scenario, CCOS visits following discharge from the critical care unit were found to have a 60% probability of cost effectiveness at a threshold of £0, and a 94% probability of cost effectiveness at a threshold of £30,000 per hospital death averted.

For the no CCOS match, the worst case scenario gave a 50% probability of cost effectiveness at a threshold of £13,000 and an 86% probability of cost effectiveness at a threshold of £30,000 per hospital death averted.

The analysis restricting to cases receiving a scheduled visit within 48 hours of discharge to the ward, showed an extremely high probability of cost effectiveness in both matches with CCOS dominating in 99.0% and 99.8% of bootstrap samples, respectively.

Figure 4.4.9: Cost-effectiveness acceptability curves from sensitivity analyses for historic match

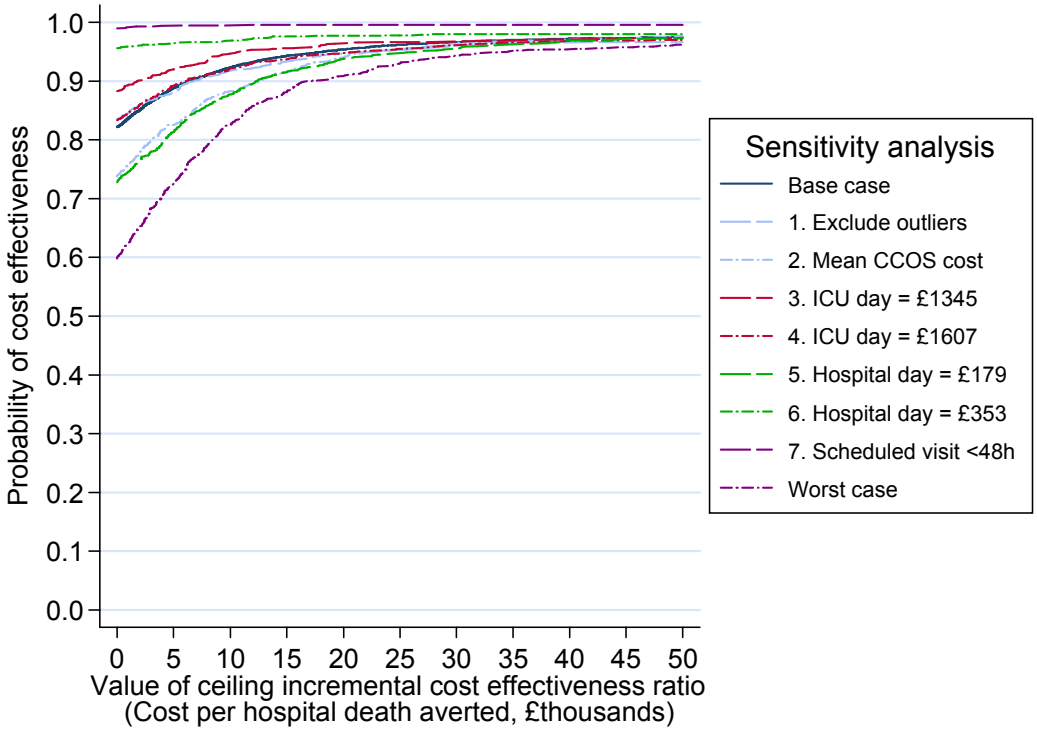
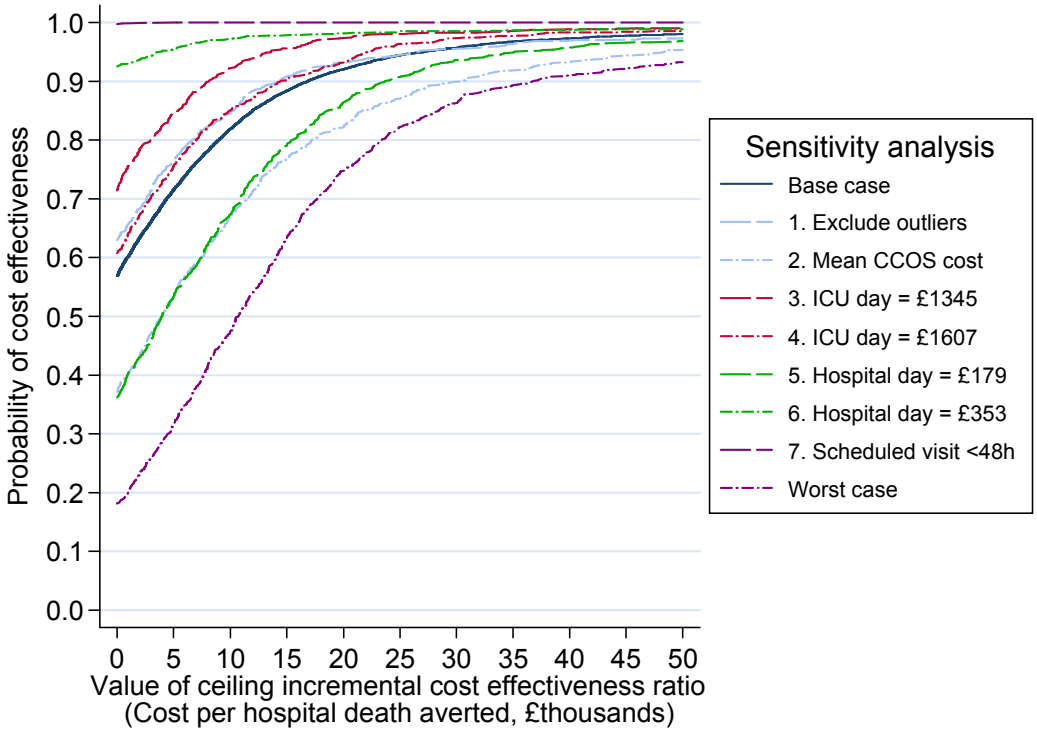


Figure 4.4.10: Cost-effectiveness acceptability curves from sensitivity analyses for no CCOS match



Cost-effectiveness analysis (propensity matching)
The cost comparisons using propensity matching were similar to those from the individually matched results (Table 4.4.4 to Table 4.4.6). However, with a larger proportion of cases successfully matched and therefore a larger sample size, the differences in mean total cost per patient were statistically significant for the no CCOS match (favouring CCOS).

Table 4.4.4: Breakdown of costing data

Match	Mean CCOS visits		Mean ICU days		Mean hospital days	
	Case	Control	Case	Control	Case	Control
Historic	2.70	0	0.82	0.65	17.5	20.3
No CCOS	2.86	0	0.81	0.77	18.0	21.3

CCOS critical care outreach service(s), ICU intensive care unit

Table 4.4.5: Breakdown of mean cost per patient

Match	CCOS visits		ICU days		Hospital days	
	Case	Control	Case	Control	Case	Control
Historic	£232	£0	£1400	£1114	£3842	£4468
No CCOS	£230	£0	£1389	£1349	£3966	£4690

CCOS critical care outreach service(s), ICU intensive care unit

Table 4.4.6: Difference in mean total cost per patient

Match	Cost per patient, mean (SD)		Difference in costs (Case – Control)	
	Case	Control	Δ (95% CI)	P-value
Historic	£5473 (9495)	£5582 (9199)	−£109 (−£515, £297)	0.60
No CCOS	£5584 (9648)	£6039 (9430)	−£456 (−£798, −£113)	0.009

SD standard deviation, CI confidence interval

The cost-effectiveness analyses using propensity matching were also similar to those from the individually matched analyses (Figure 4.4.11 to Figure 4.4.14). Both matches showed a high probability that CCOS visits following discharge from critical care are cost effective, regardless of willingness to pay. For the no CCOS match, CCOS almost entirely dominates with both lower cost and greater effectiveness in 99.5% of bootstrap samples.

Figure 4.4.11: Cost-effectiveness plane (10,000 bootstrap samples) for propensity historic match

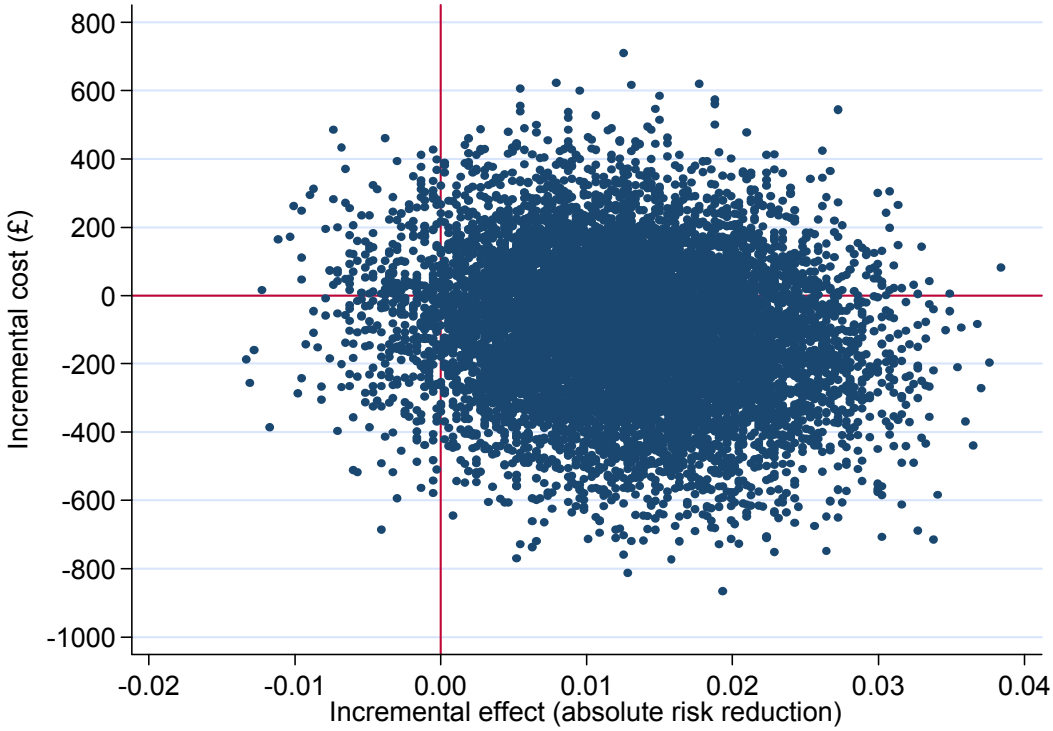


Figure 4.4.12: Cost-effectiveness acceptability curve for propensity historic match

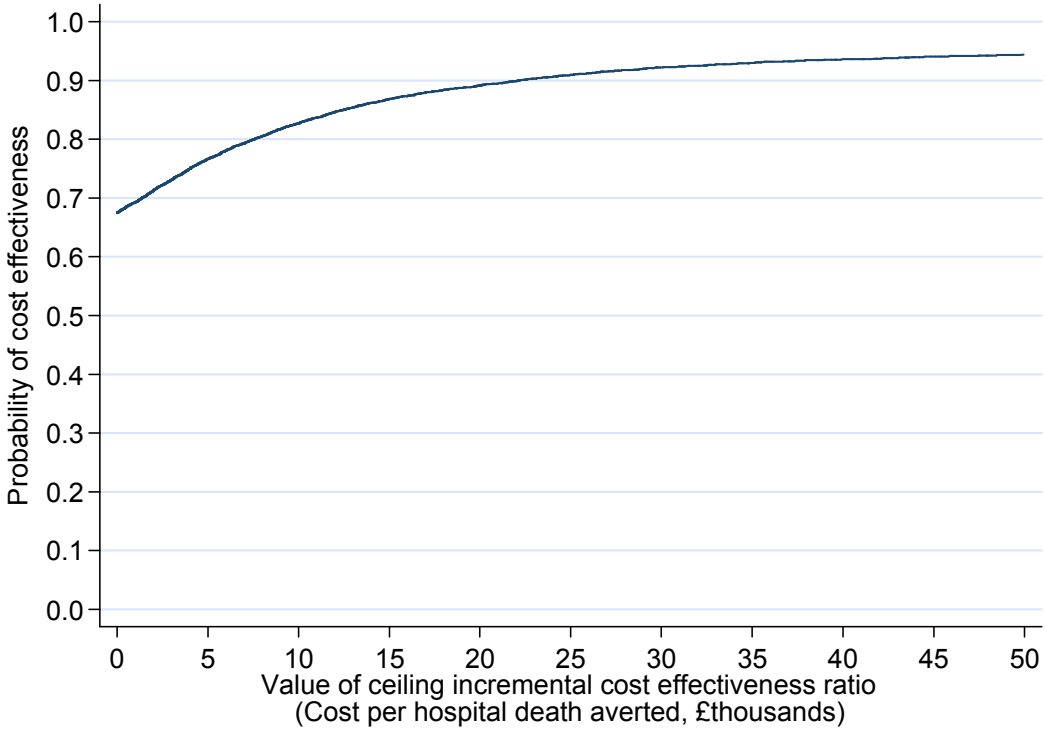


Figure 4.4.13: Cost-effectiveness plane (10,000 bootstrap samples) for propensity no CCOS match

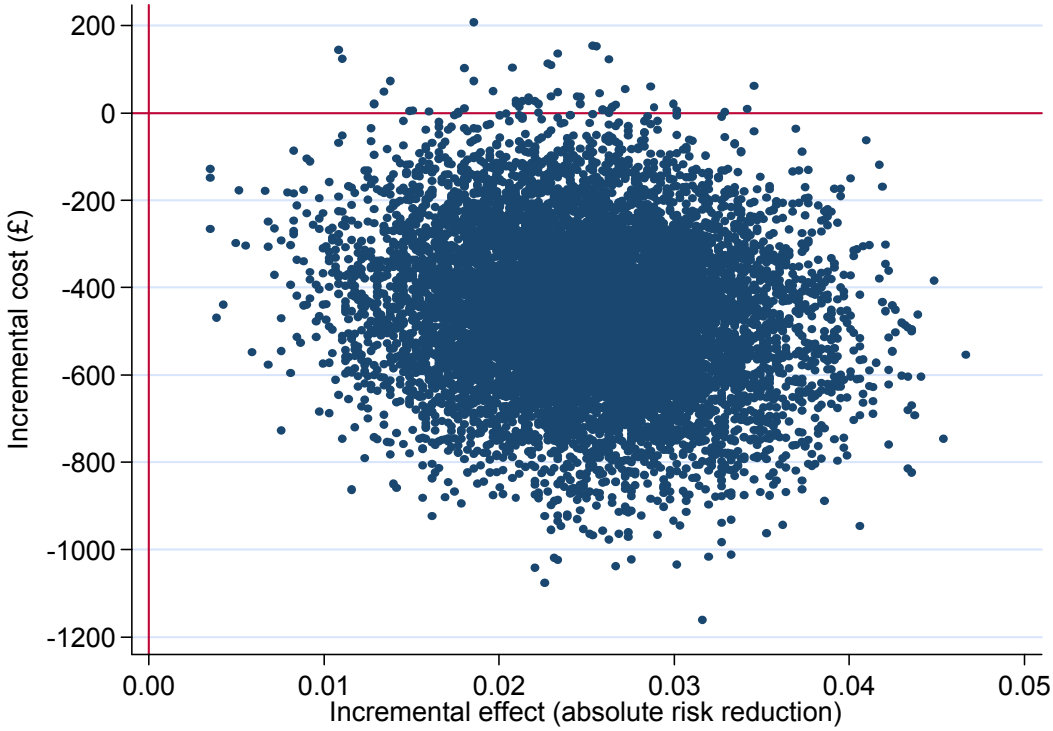
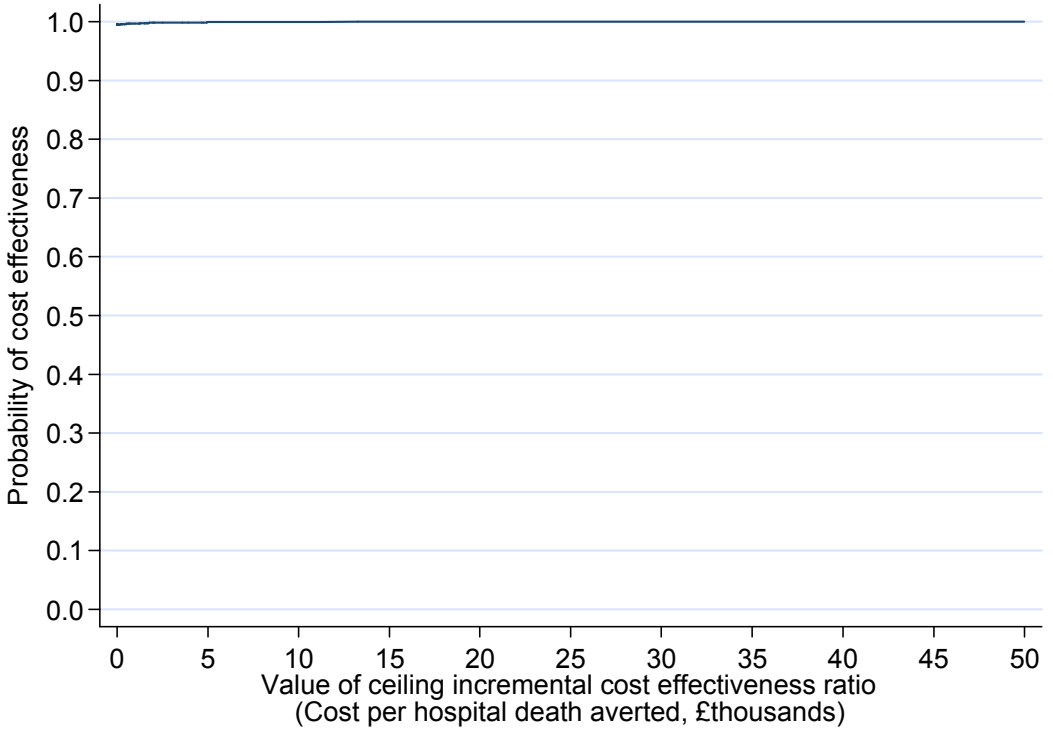


Figure 4.4.14: Cost-effectiveness acceptability curve for propensity no CCOS match



5. Qualitative evaluation of CCOS

Brief introduction

The aim of this study was to characterise, using qualitative research methods, the impact of the introduction, development, incremental implementation and current models/organisation of CCOS within acute NHS Trusts in England. This aim was achieved by obtaining, describing and analysing the perspectives of a wide range of participants and stakeholders, such as intensive care clinicians (doctors and nurses), ward staff (doctors, nurses and allied health professionals), managers, hospital chaplains, patients and their relatives.

Methods

While care was taken in the design of the sampling frame for sites and in the identification of participants to interview, this was not for the purpose of statistical generalisation. The sites and individuals are not *statistically representative* of their respective populations rather the sites were selected to exhibit the range of variation (along several key dimensions) of the population (CCOS in all hospitals); individuals were selected so that key stakeholder groups would be included.

Selection of sites

The sampling strategy was to be *maximum variation*, that is, "purposefully picking a wide range of variation on dimensions of interest" (Patton, 1990: 182). The reason for this is that we wanted to capture, so far as was possible, the widest range of CCOS activities. The dimension of greatest interest – that is, the dimension most likely to have an effect on the routine practices and activities of the CCOS – was considered to be the stated purpose of the CCOS. The population data for the sampling frame were derived from the national survey (Appendix 1).

The definition of a sampling frame involved two sets of criteria. The primary criterion was the CCOS stated purpose (avert admissions, enable discharges, share skills). The secondary criteria were related to the CCOS itself and the kind of hospital in which it was located (ward coverage, staffing – any medical involvement, staffing – numbers of nurses, operating hours, status of hospital, tertiary referral centre or not and number of level 2/3 beds. Information on these criteria was obtained from the national survey.

Naively, we had initially expected to have three groups for the stated purpose. However, the CCOS did not generally have only one main purpose; they could espouse one, two or three of the essential objectives. Logically, this would yield seven categories. However, a factor analysis of the data revealed that there were four distinct groupings of CCOS, according to the *relative* prioritisation they gave to their stated aims ("avert", or pre-critical care unit (ICU) care, was called the "admission model"; "enable", or post-critical care unit (ICU) care, was called the "discharge model"; "share" was called the "education model").

The four groups were as follows:

- highest priority is discharge, low on education and low on admission (n=7);
- highest priority is education, low on discharge and low on admission (n=12);
- highest priority is admission, education is a medium priority and discharge is a low priority (n=68)
- highest priority is admission, low on education and low on discharge (n=31).

It was planned to select two from each of these four groups, making a total of eight hospitals. Effectively, each group was made into a list, with two hospitals selected from each list. Before the eight hospitals in the sample was finalised, we ensured that different types of site, as represented by the dimensions in the secondary selection criteria, were all represented.

The secondary selection criteria were analysed to ensure that the sites in our sample would cover a range of values for each criterion. Thus the number of sites in our sample was as follows:

- ward coverage - 100% (n=6)/less than 100% (n=2);
- medical involvement - some formal medical involvement (n=4)/no formal medical involvement (n=4);
- number of nurses - four or less WTE nurses (n=6)/more than 4 WTE nurses (n=2);
- operating hours - less than seven days per week and 24 hours per day (n=3)/seven days per week but not 24 hours per day (n=3)/seven days per week and 24 hours per day (n=2);
- status of hospital - teaching (n=4)/non-teaching (n=4);
- tertiary referral centre - yes (n=4)/no (n=4);
- number of critical care level 2/3 beds - less than ten (n=1)/between 10 and 20 (n=3)/more than 20 (n=4).

Thus we hoped we would be able to detect any differences in stakeholder views or working practices which were related fundamentally to these factors.

Ethics

Multi-centre Research Ethics (MREC) Committee approval was granted, and the MREC accorded the study “No Local Investigator” status. Local R&D approval was sought at each site prior to investigation. All research participants were fully informed of the purpose of data collection and if they wished were given time to consider whether they wanted to be interviewed. Interviewees were provided with information sheets prior to interviewing and there was no covert data collection.

Selection of participants and interviewees
At each of the eight sub-study sites, non-participant observation was undertaken to identify which staff had exposure to the CCOS. Stakeholders were identified whose perspectives could contribute to an understanding of the multi-faceted impact of CCOS; the aim in sampling was to maximise the range of perspectives of stakeholders. Participants interviewed included staff of the CCOS (leaders and staff), critical care staff (medical, nursing, AHPs and management), ward staff (medical, nursing, AHPs and management), former critical care unit patients, their relatives and friends and chaplains (including bereavement counsellors).

A total of 115 interviews were completed with 122 individuals, as shown in Table 5.1 and Figure 5.1.

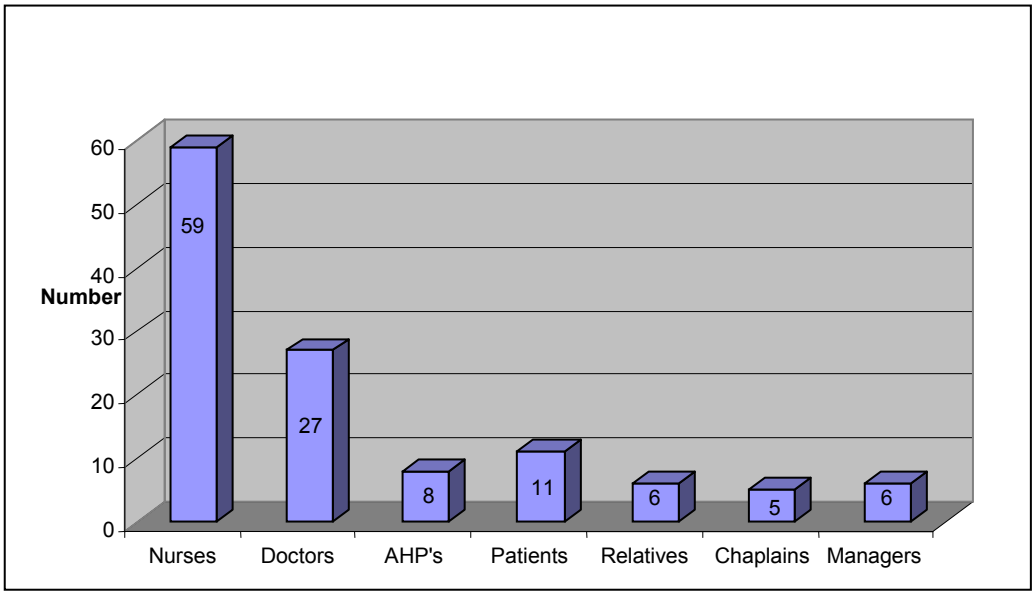
Table 5.1: Interview sample

Occupation (Grade)	CCOS	Critical care unit	Ward	Total
Nurse (I)	**2**	**1**	**1**	**4**
Nurse (H)	**4**	**0**	**1**	**5**
Nurse (G)	**8**	**5**	**5**	**17**
Nurse (F)	**3**	**5**	**10**	**16**
Nurse (E)	**0**	**4**	**6**	**10**
Nurse (D)	**0**	**2**	**2**	**4**
Subtotal: qualified nurses	***17***	***16***	***25***	**56**
Student nurse	**1**	**0**	**0**	**1**
Health care assistant	**0**	**0**	**2**	**2**
Subtotal: all nurses and Health Care Assistants	***18***	***16***	***27***	**59**
Doctor (Consultant)	**2**	**9**	**7**	**14**
Doctor (SpR)	**0**	**5**	**1**	**6**
Doctor (junior)	**0**	**4**	**3**	**7**
Subtotal: medical staff	***2***	***18***	***11***	**27**
Allied Health Professional	**3**	**1**	**6**	**8**
Subtotal: all clinical staff	***23***	***35***	***44***	**94**
Manager	**2**	**3**	**3**	**6**
Subtotal: health care workers excluding chaplains	***25***	***38***	***47***	**100**
Chaplain				**5**
TOTAL: health care workers including chaplains				**105**
Patient				**11**
Relative				**6**
Subtotal: Patients and Relatives				**17**
TOTAL				**122**

Ward includes areas such as high dependency units, emergency departments and trauma wards as well as hospital wards. Nurse (I) includes Nurse Consultant. Nurse (H) includes Matron. Doctor (SpR) includes Clinical Fellows. Doctor (junior) includes House Officers, Pre-registration House Officers and Senior House Officers. Managers were from Directorates

such as Anaesthetics or Critical Care. Sum of individual columns may exceed Total as some individuals appear in more than one category, CCOS critical care outreach service(s). All interviews with relatives were conducted with the patient present

Figure 5.1: Interview sample



Data collection and analysis
The principal data collection method was semi-structured interviews with key stakeholders. One researcher conducted all the interviews. (The main purpose of non-participant observation at each site was to identify these stakeholders; the experience of this phase of the study also helped to improve rapport between the researcher and interviewees and helped to contextualise and corroborate interview data). Collection of interviews data was conducted in parallel with its analysis, informed by the method of constant comparison whereby later periods of data collection were progressively focused on issues identified. Midway through the period of data collection, a project meeting reviewed the emerging analytical themes and clarified the foci of future interviews (partly in consideration of the publication in September 2005 by the Critical Care Stakeholder Forum of *Quality Critical Care: Beyond Comprehensive Critical Care*).

Three distinct topic guides were designed since not all interviewees would have the same experiences, perspectives and understandings. In particular, while patients' (and relatives') views are very important, it is to be expected that they would have more limited experience of the CCOS than hospital staff. The topic guides (Appendix 6) were used flexibly, that is, the questions were used as prompts to guide the interview in a conversational style, rather than as a questionnaire instrument. For example, where an interviewee had specific knowledge only of follow-up services, the questions tended to be more focused on those services. A practical consideration was interviewing people at their place of work: some interviews had to be curtailed; interrupted; or abandoned due to other work pressures or clinical emergencies.

CCOS staff and critical care unit staff had a specific set of questions including those on the CCOS development, changes in working practices, how the CCOS had changed over time and what future plans existed. Ward staff and Allied Health Professionals, such as physiotherapists, were expected to know less about how the CCOS had developed or how they operated and were therefore asked more questions related to the impact on the area where they worked. Interviews with patients, relatives and hospital chaplains tended to be less structured than the others as this group were asked a very limited set of questions based on their own individual knowledge and experiences.

Some questions were interpreted differently by different interviewees. The clearest example of this is a question "Was the CCOS set up to be proactive or reactive?" Many described their CCOS as being clinically proactive (in terms of preventing readmission) or clinically reactive (in terms of responding to crisis calls about deteriorating patients); educationally proactive (in terms of providing knowledge and training on the ward and in the classroom environment) or educationally reactive (in terms of not providing enough or not providing it early enough). Some felt that their CCOS was sometimes reactive and sometimes proactive; furthermore some reported that their CCOS had changed since initial development. In analysis, the range of interpretations was regarded as an advantage rather than a problem.

Interviews were tape-recorded and transcribed. The transcriptions were checked for accuracy and imported into N6 qualitative data analysis software. Analysis identified themes and topics in the data, and a coding-frame developed iteratively which was ultimately applied to the whole dataset. The themes and topics identified are illustrated by quotations from interview transcripts (with some additional commentary gleaned from researcher observations). To retain anonymity, quotations are only used where respondents are not identifiable (for example, where themes and comments were common to a large proportion of interviewees).

It had been anticipated that the main differences in perspective would be those of ward staff as compared with critical care unit staff. In analysis, this was found to be broadly true only for medical staff. Other staff (nurses, AHPs and managers) from different locations tended to share common viewpoints about the differential impact of CCOS. The similarity of viewpoints (including, for example, similarity of examples given by interviewees) among non-medical staff gives greater confidence in the analysis.

Results

The results are structured into two main themes: first, CCOS the intervention and second, the impact of CCOS.

Results – CCOS the intervention

CCOS were not a uniform entity, a factor which makes the design of a straightforward evaluation difficult. The salient features of CCOS fell under four headings: origins/development; objectives; operation; and personnel.

Results – origins/development of CCOS

Why CCOS was established

Most of the CCOS in our sample were established in response to national policy developments: interviewees either referred to the document *Comprehensive Critical Care* or used the phrase "critical care without walls". Several interviewees proudly reported that their CCOS (or aspects of it) was already operating prior to the publication of *Comprehensive Critical Care* – in one case for a decade. These interviewees added that the publication of *Comprehensive Critical Care* enabled a stronger footing for the CCOS (e.g. an increase in funding) and some suggested that the CCOS had grown out of locally conducted research.

The reasons why the CCOS was developed were often closely related to the policy aims outlined in *Comprehensive Critical Care*: the implementation of physiological track and trigger warning systems; the facilitation of timely critical care unit admission and discharge; sharing skills with nursing staff on the wards; promotion of patients' recovery and rehabilitation. Several interviewees described restricting their aims to particular recommendations in *Comprehensive Critical Care*. For example, one consultant reported that the CCOS focused on patient follow-up as they had high mortality rates following discharge from the critical care unit:

> *It would seem rather a waste if we were putting a lot of effort to getting someone out of intensive care and they went on to die on the wards.* [Consultant, Critical care unit]

The establishment of the CCOS was sometimes planned to fulfil specific local aims, for example, to ease the workload of doctors or to take better care of level two and three patients. A number reported that, at their inception, they wanted their CCOS to be either clinically or educationally proactive.

Another driver for a CCOS was the improved scientific knowledge about critical illness coupled with a perceived lack of individual skills and know-how, especially on the general wards. This is illustrated in the following, rather polemical, statements of a Consultant Anaesthetist:

> *The traditional way of running a surgical ward was that you had very junior doctors working with very junior nurses and everyone was scared stiff by a major surgical case or a case with complications and, in lots of areas, the traditional medical therapists were rubbish. Fluid balance has always been done abysmally for decades and you, more or less, got away with it most of the time but it's always been abysmal. Pain management has been abysmal for decades, oxygen therapy is poorly understood and, from my understanding, it's pretty clear now that an awful lot of peri-operative deaths or peri-operative major life-threatening events have predicting episodes, you know, six hours before you arrest something happens that should ring the alarm bells and traditionally it hasn't. You know, as junior doctors twenty years ago, we all failed to respond to patients who had a transient drop in*

> *level of consciousness and so on. There's a much better awareness now, that these are problems that should be nipped in the bud, and it would prevent critical events and death.*
> [Consultant Anaesthetist, Pain Team]

There were additional pressures which were perceived to lead to the development of CCOS. These were highlighted as shortages of critical care unit beds, changes in the population profile of hospital patients and deterioration in skill levels on the wards. The change in the population profile of hospital patients is thought to have partly arisen out of a wider range of surgical procedures, as described by this Consultant Anaesthetist:

> *My perception is that the hospital population has changed over the last ten - twenty years, so we are increasingly dealing with more elderly people with multi-system failure… The demands on the medical side for intensive care use have increased. On top of that, the surgical range of procedures that are now available has increased enormously and, where surgeons before would not, perhaps, have operated, they now operate and expect and rely on the intensive care and the anaesthetists to be able to get the patients through surgery.*
> [Consultant Anaesthetist]

The loss of certain skills from the staff on the wards was mentioned frequently. Somewhat ironically, the loss of experienced nurses to specialist services was used as a justification for CCOS:

> *They need outreach because they don't have the qualified nurses on the wards. [The CCOS are] doing what more qualified nurses should do, you know, who have had the training and then the experience to actually recognise these things… I think you have lost, in the last five years, a lot of the skilled nurses to the specialist roles that have been developed and again that detracts from the ward.*
> [F Grade Nurse, Ward]

Establishing the CCOS

In most cases a small CCOS was initially developed by critical care unit staff (with fairly minimal funding); in some cases initiated by a Consultant, while in others, a nurse had been prominent. All of the CCOS we looked at were developed with at least one senior (usually H or I Grade) nurse heading up the CCOS although, in some cases, the individual who was regarded as the original driving force had subsequently left. In several cases, it appeared that a great deal of discussion had taken place with senior staff around the hospital as to how the CCOS should be established, whether it should be nursing or medically led, whether it should be primarily educational or clinical, and so on.

A number of interviewees reported that their CCOS was set up to be clinically proactive, that is, preventing critical care unit admissions or readmissions and facilitating early treatment on the wards (with the ultimate intention of saving lives). The roles of the CCOS were sometimes seen as requiring different

approaches. For example, one CCOS nurse noted that following-up critical care unit discharges could be regarded as necessitating a proactive approach, whereas supporting patients before admission to a critical care unit was more likely to be reactive. Preventing re-admission (i.e. post-critical care unit care) was often seen as a completely different role to that of recognising and treating sick or deteriorating patients, or preventing an admission to the critical care unit. It was noted, though, that the relational activity of sharing skills could (and probably should) overlap with direct clinical support:

> *[The service was set up to] go out and help nurses to recognise a deteriorating patient and give them the skills how to manage that patient rather than an interventional service where you're contacted about a deteriorating patient and go in there… I know that was the premise of the people that were running it, they hoped at one point they would be able to step back and then, you know, the ward staff would be able to take it from there.*
> [E Grade Nurse, Critical care unit]

Whatever the main aim in setting up the CCOS, a certain level of enthusiasm and determination were required. One CCOS Nurse Consultant described "selling" and "marketing" the CCOS which, combined with making best use of limited resources, is reminiscent of "entrepreneurial" activity.

> *I was very conscious the wards would feel that the service was needed of an evening, of a night time and at the weekend. I knew that but I knew we only had the funding for the week service and I wanted to develop a service that was accessible to anybody … anyone could bleep us… I hoped that when the two girls came onto outreach they could have some empathy for the ward nurses and speak up on behalf of the patient and the nurses.*
> [I Grade Nurse, CCOS]

One CCOS nurse suggested that being visible and helpful on the wards enabled her to raise awareness of the CCOS, what they do and encourage staff to contact the CCOS, when necessary. One medical consultant felt that junior doctors at her hospital needed to be provided with more information regarding the role of the CCOS, suggesting that more proactive advertising of the CCOS may improve communication and interaction with the CCOS. The need for such an entrepreneurial approach was witnessed at several sites; with both nurses and doctors being passionate about the development of their CCOS. Indeed, during observations at all of the case study sites, it was found that the junior doctors most in favour of the CCOS had been provided with appropriate knowledge of the CCOS and had the opportunity to use it effectively; of those not in favour, many had little knowledge of the CCOS or limited contact with them.

Challenges to establishing the CCOS

It was frequently reported that the perceptions of ward staff had caused difficulties for the CCOS. For example, some ward staff had initially been defensive of their work and mistrusted the CCOS nurses. Ward staff were

concerned about being blamed, judged or "policed" by the CCOS; they were also concerned that CCOS staff would take over the care of sick patients and so ward staff would lose their skills. These comments revealed how effective "marketing", mentioned in the previous section, was needed to promote the CCOS and allay the fears of staff on the wards.

There were also inaccurate perceptions of what the CCOS was for and a lack of understanding of their remit. Many ward staff were unaware of what particular tasks CCOS nurses were permitted to do – a notable example is that CCOS nurses were able to write in medical notes (normally, specifically a medical task). For their part, CCOS nurses reported that the initial negative perceptions of ward staff were dealt with by building relationships; good communication and familiarity helped to ensure that ward staff were aware of the proper role of the CCOS.

Other CCOS nurses reported active resistance to the CCOS on the part of the doctors. Examples of this were seen throughout the periods of observation as well as being reiterated during informal conversations. At times, there was an uncomfortable relationship between doctors (especially some senior doctors) and CCOS nurses. One CCOS nurse described a "tradition" of a difficult relationship between critical care unit doctors and other hospital doctors, which was inherited by the CCOS:

> *The medics were much more resistant I think particularly in the medical high dependency because [they didn't think] we could add to their care… there is a tradition about the relationship between medics and critical care unit staff and doctors and I think they still saw us as part of the critical care unit coming down to alter their package of care*
> [Nurse Consultant, CCOS]

A small number of interviewees referred to staffing issues, which they related to lack of resources (itself a common theme) or sickness problems. The need to have a strong leader who adopted a structured approach and had the drive and energy to move the CCOS forward was also mentioned. One interesting problem was that CCOS were often composed of specialist nurses, as explained by the senior nurse below:

> *[Previously] the team had to manage themselves. Some of the problems with that is that they're all at the same grade which means there was no natural leader, no [management] support*
> [I Grade Nurse, Critical care unit]

Results – objectives of CCOS

According to Comprehensive Critical Care, CCOS have three essential objectives: avert admissions; enable discharges; and share critical care skills. The aims and objectives of the case study hospitals were generally consistent with those identified in Comprehensive Critical Care. At least two CCOS appeared to have adapted their objectives after the completion of the national survey questionnaire (Appendix 1); some CCOS reported being in a constant

state of evolution. Of course, the reality of many busy hospitals is that a variety of clinical or organisational needs may impinge on a CCOS, and a range of other roles can become subsumed under the banner of CCOS.

The overriding aim of all the CCOS was to improve patient care (this was mentioned in many interviews and informal discussions). The precise way that this was applied varied with some CCOS attempting to accomplish all three principal CCOS objectives and others choosing to focus on particular aspects of patient care. For example, at one site it was felt that sick patients were identified and managed well on the wards, therefore the CCOS primarily focused on post-critical care unit follow-up. The perception from several sites was that having an "interventional" role (i.e. taking over patient management) would be to the long-term detriment of the general wards; one reason being that nurses and junior doctors on the wards would lose, or perhaps never develop, appropriate clinical skills.

Averting admission

The broad aim of averting inappropriate admissions to critical care encompassed a number of objectives and activities, including (at least) the following: providing timely treatment and assessment on the ward (e.g. "bringing critical care to the ward"); facilitating the discussion of DNAR decisions; identifying sick patients by use of TTs; preventing patient deterioration; gate-keeping for the critical care unit; and ensuring consistent provision of basic nursing interventions on the ward. As in *Comprehensive Critical Care*, within this aim we also include the aim of ensuring timely admission to the critical care unit. A number of interviewees suggested the prevention of critical care unit admissions was the main objective of the CCOS.

Discussion of DNAR decisions would encourage doctors to think about whether certain types of treatment are appropriate for patients with particular disorders, for example, the ventilation of patients with advanced respiratory disease. In such cases, the role of the CCOS was in part informing doctors on the ward of the limitations of critical care.

> *It does, all too often, happen that patients are incredibly ill and it may be that there is a perception that those patients should be transferred to the intensive care unit and we will... make them better... [but] in some of these patients intensive care will be inappropriate, so [an aspect of outreach] is to make people more aware of the limitations of what intensive care can do so, if the patient is at the end stage of advanced lung disease, the intensive care would do nothing other than prolong their dying and it would be inappropriate to do that, in my view* [Consultant Anaesthetist]

Several interviewees saw the prevention of critical care unit admission as directly linked to the provision of better care on the wards, since TTs would enable ward staff to manage patients better and identify problems sooner.

> *The main role is to prevent admissions to critical care unit by using the trigger scores to identify deteriorating patients. [Nurses] would act sooner because the doctors are always busy, you can go in there and do the things and relieve the symptoms from getting worse and prevent an admission to the critical care unit.*
> [G Grade Nurse, CCOS]

In some cases it was suggested that the ward staff act as the basis of calling on the CCOS; in other cases it was suggested that the CCOS monitor the TT scores directly - they could then ensure that protocols for the early treatment of deteriorating patients were adhered to.

Another objective for the CCOS was to alert junior doctors to sick patients who would then ensure appropriate treatment was initiated. It was felt that CCOS would have authority to ensure that extra medical help was obtained, when needed. Similarly, they would also have authority to encourage ward staff to liaise with the HDU and the critical care unit in a timely fashion. Several junior doctors recognised their own limitations when it came to treating sick patients but were concerned about the development of their own skills and felt that the CCOS role should remain one of assessment. Not all interviewees agreed with the idea that initiating treatment should be a medical prerogative only; another role envisaged for the CCOS would be to actually undertake necessary clinical activity:

> *The original objective of the team was to actually really be autonomous practitioners who come on the ward and assess, treat and evaluate and care for critically ill patients outside of the critical care unit area.*
> [Matron, CCOS]

Enabling discharge

All the CCOS reported that one of their objectives was to enable critical care unit discharge to the ward and prevent critical care unit readmissions. This was commonly referred to as “follow-up”. In some hospitals, there was apparently a degree of overlap between CCOS follow-up (i.e. in-hospital post-critical care unit care) and critical care unit follow-up clinics (i.e. post-hospital rehabilitation for former critical care unit patients). The overlap between these two kinds of follow-up was in the promotion of rehabilitation to improve quality of life after critical care, while the patient was still in hospital. The following quotation is from a physiotherapist who was a member of the CCOS.

> *I think the main objective is to send our patient out... we can follow them through, through Clinic, or through a Rehab Class and give them a better quality of life... if they have a problem they've got someone to turn to…*
> [Physiotherapist, CCOS]

One CCOS reported that, as they had a limited budget, they decided to focus on one main objective: CCOS follow-up with a particular objective of reducing re-admissions to the critical care unit. Indeed, reducing re-admissions was a

commonly stated aim. With this in mind, critical care unit consultants sometimes considered the CCOS as an extension of the critical care unit:

> *They are the eyes and ears of us once our patients have left [the critical care unit] and that's very important. Our re-admission rate fell very substantially when outreach started*
> [Consultant, Critical care unit]

Some interviewees suggested that bed shortages had led to increased pressure to discharge critical care unit patients early, thus making well co-ordinated post-critical care unit follow-up care essential.

One consultant anaesthetist suggested the role of the CCOS was to provide a screening service for the critical care unit, acting as "gate keepers" for critical care unit doctors.

> *For operative patients, it's usually the anaesthetist [who] screens for whether or not they think an intensive care bed is indicated, but for critically ill, non-operative, I think the outreach is a way of prioritising cases on the wards for admission*
> [Consultant Anaesthetist, Pain Team]

Sharing skills

All study sites were involved, to some extent, in staff teaching or training. (note that this is the case despite half of the sample of sites marking their educational priority as *low* in the national survey). The teaching and training involved either the transfer of practical skills in a ward based environment or the formal transfer of knowledge in a classroom situation. A wide range of health care occupations appeared to benefit from formal or informal training provided by the CCOS, although some interviewees, (primarily doctors, but also ward and critical care unit nurses and physiotherapists) were not aware of any educational provision or training provided by the CCOS.

The mode of "sharing skills" varied between hospitals: some had extensive formal teaching programmes while others conducted mostly *ad hoc* bedside teaching. Some hospitals had separate clinical educators, loosely affiliated to CCOS, who undertook these skills-sharing activities. A number of CCOS staff taught on formalised programmes while some conducted additional "on-ward" training or lunch-time teaching sessions. The extent of formal education conducted could be affected by several factors; at one study site a minimal amount of teaching and training took place as the CCOS stated they were too busy with clinical commitments. Many interviewees commented that the CCOS at their hospital conducted both formal and informal training.

Formal teaching comprised critical care courses and several CCOS contributed to these (e.g. ALERT, AIM, ALS, HELP). Much CCOS educational provision concentrated on the teaching of basic nursing skills: recording patient observations and fluid charts; recognition of a deteriorating patient; and using and interpreting TTs. More specialised training was also provided: tracheostemy care; blood gas analysis; managing chest drains;

managing sepsis; managing non-invasive ventilation (e.g. CPAP). There were also Health Care Assistant assessment skills study days. The formal training conducted by CCOS usually consisted of a regular rolling programme of lectures; for three CCOS, clinical educators were involved. One CCOS reported that the majority of training was conducted by a local university.

All CCOS conducted some informal education and skill sharing on the wards. Informal training, or *ad hoc* skills sharing, covered similar subjects to those identified above. It was usually undertaken in a ward setting, at a patient's bedside or on the ward, at the request of the senior nurse. A frequent comment was that conducting training on the ward was more effective than formal training; one reason was that clinical pressures, staff shortages and time constraints meant that it was difficult to release nurses for formal training. Ward staff generally regarded the main objective of the CCOS as the transfer of critical care skills to staff on the ward.

One senior CCOS nurse suggested that health professionals felt empowered when they acquired knowledge about the critical care of patients. However, it was a problem getting staff to take the time to make the most of the opportunity to acquire that knowledge.

> *Sometimes, when [the CCOS] are there [the ward nurses] get frightened that we're going to ask them questions they don't know the answers to and sometimes, as I said, they've got ten other patients to look after or they've got to do the drug round, they've got this, that or the other to do but then they don't learn the skills.*
> [Nurse Consultant, CCOS]

Several CCOS nurses noted that it was important that the CCOS did not discourage ward nurses from taking opportunities to learn.

Most important objective

In the latter part of this research, CCOS and critical care unit staff were asked which objective they considered to be the most important. Interviewees generally stated that education, that is, training and sharing skills (including teaching basic nursing skills) on the wards was the most important aspect of the CCOS. One CCOS even had the goal of eventually not being needed although, as this nurse describes, such an ambition was thwarted by increasingly sick patients:

> *I hoped that one day outreach would be less needed, I figured that we could work our way out by training the ward staff… I thought by [teaching] the medical students and nursing staff… giving them the support they acknowledged they needed, we wouldn't be needed and the early warning score would run itself, we wouldn't actually be needed but it's not working like that because the patients are getting sicker so we are going to be needed and if it's going to continue and change the objectives constantly need changing too.*
> [G Grade Nurse, CCOS]

In contrast, one nurse added that the most important objective was the general, additional support provided to doctors and nurses. An HDU registrar suggested it was to identify which wards needed more help and to support and spend more time with them. Other interviewees felt that the most important aspect of the CCOS was their ability to identify sick patients early and respond quickly, either in initiating timely intervention or identifying whether or not patients are appropriate for critical care.

It was apparent that CCOS could experience a fundamental tension between sharing skills and providing support. For example,

> *I think the ward nurses find [the CCOS nurses] very knowledgeable and will ring them and ask for help for things that they wouldn't want to ring the doctor... I think that [skill sharing] is quite underestimated because…the wards are notoriously short staffed and they're run by very junior nurses …*
> [G Grade Nurse, Critical care unit]

Results – operation of CCOS

Day-to-day additional objectives
Although the formal objectives of each study site had remained the same, a proportion of interviewees suggested there had been notable changes in CCOS' working practices. As noted by one physiotherapist, it is perhaps inevitable that priorities had to change with needs on the ward. It emerged during the study period that each CCOS had a number of other informal objectives in addition to the main three recommended by *Comprehensive Critical Care*. Additional roles, described both in the semi-structured interviews, informal discussions and observed in practice, included tracheostomy care, patient transfers and even mental health.

> *We've taken on a huge amount more than what was first the objectives from Comprehensive Critical Care and I think that sometimes just meeting service needs, in particular the tracheostomy remit [officially providing tracheostomy care to the hospital], which is something that we've taken on as a team across the Trust… has become sort of quite a big chunk of our workload.*
> [G Grade Nurse, CCOS]

CCOS staff were often involved in patient transfers. Busier hospitals, with a higher demand for level two or 'level three beds, were more likely to require patients to be transferred within or out of the hospital. In observation, nurses from CCOS were involved in the preparation of patients for transfer or accompanying patients if they had to leave the hospital. This duty traditionally fell to critical care unit staff but sometimes the only available staff were the CCOS. Views on whether this was an appropriate role for the CCOS were mixed especially as preparing a patient for transfer was a lengthy procedure often tying a CCOS nurse up for an extensive period of time leaving fewer nurses to cover the other demands of the job.

CCOS could also be expected to deal with mental health problems, as mentioned by this critical care unit nurse who was describing her time as a CCOS nurse:

> *Part of my remit was assisting peoples' mood. Post-ICU depression and anxiety is very high…I've got no qualification whatsoever in mental health nursing, I just use very basic tools to assess that and then refer on. Maybe I should have had more qualifications or experience in that. A lot of it was like a reactive depression but I needed skills in that, as well as critical care, because I was just as likely to turn up to find a patient unmotivated and depressed and unwilling to get out of bed as, you know, urine output and tachycardiac and low blood pressure.*
> [E Grade Nurse, Critical care unit]

Providing support

Support for nurses and doctors on the wards could include provision of equipment, setting-up equipment, taking over patient care or running a ward when nurses attended training. In general, taking over patient care was seen as the most necessary activity. Senior doctors often reported that junior doctors no longer worked sufficient hours to build up their clinical skills quickly and felt they lacked the level of skill needed to care for sick patient therefore they required a great deal of support from the CCOS. Some criticism was made of junior medical staff: one SpR simply stated that junior doctors "no longer pulled their weight". Several consultants were in favour of the general trend towards more skilled nurse specialists:

> *I mean, in real life, we'd all rather be seen by a senior, experienced, properly trained and well motivated nurse than by a half trained, don't care junior doctor.*
> [Consultant Anaesthetist, Pain Team]

This consultant suggested that lack of skill, confidence and motivation were common among junior doctors, with more motivated CCOS nurses able to plug the gap.

The appropriate level of support was quite difficult to determine. On the one hand, supervising care could be seen as an appropriate activity. On the other hand, it was doubtful whether taking over the care of the sick patient when the ward was busy or staff were overstretched (a common suggestion) was a proper role for the CCOS. An even less appropriate role would be covering for ward staff absences, although this was mentioned:

> *We had an incident on this ward that all the staff went to a funeral… the outreach team came up to support the ward…I think, two years ago even, we wouldn't have had that. They came, offered their services and, you know, thank you. And I think that shows the support we have from them and how we get on so well with them because they didn't have to*.
> [G Grade Nurse, Ward]

In the day-to-day running of a CCOS, there can be a fine line between support as direct patient management and support as encouraging and facilitating others to manage the patient. A selection of CCOS interviewees felt that the CCOS' primary role was that of facilitators of appropriate care. Thus, they were concerned to encourage ward staff to take control of their own patient, making a judgement as to the right point at which to step back and let ward staff take charge (since ward staff may have more knowledge in a specialist area). A similarly difficult judgement entailed deciding when a patient on a ward could be left in the care of ward staff, in order to provide support elsewhere:

> *I think there are times when you need to go back to support people and, I think, it's what support you give them. You can go back… and say right, you get yourselves a drink, I will just keep an eye on these…telling them that… there are times you will have to go and they will have to come back from what they're doing and take over… If you're just based on one ward because they're really busy, the rest of the wards and the rest of the hospital isn't getting a CCOS…*
> [Bed manager]

A few interviewees from the wards reported that the CCOS always gave helpful, informal advice by 'phone if they were not able to attend although, CCOS nurses never referred to this as being a "telephone hotline". Senior ward nurses, at most study sites, stated that they were aware they could call the CCOS for advice and felt happy to do so even if they didn't have a sick or "triggering" patient on the ward.

Of course, providing support to ward staff needs to be done with sensitivity and tact, not least because there may be interested third parties. As one senior CCOS nurse stated, the perception of relatives has to be managed carefully:

> *It's a very fine line… almost making relatives think "oh no the ward nurses don't know what they are doing so you need to come in and keep an eye on our relatives". So, I'm watchful about what I say when I talk to relatives about my role in relation to their relatives because I think there is a real risk that you might undermine the ward staff massively if you are too forthright… At the end of the day, they are still sitting on that ward and outreach aren't with them 24 hours, so you've got to have a little bit of trust that the ward staff can look after them.*
> [Matron, CCOS]

Operating hours

None of the CCOS visited had established a 24-hour service at their inception and the majority had initially, quite restricted hours of operation. One CCOS actively sought a 24-hour service very early in its history and, altogether, three went on to develop a 24-hour CCOS, although two of these operated a night service only occasionally (when a nurse was available for the night shift). Many of the other CCOS expanded their operating hours, for example, from 5 to 7 days per week or increasing their daytime hours.

CCOS' operating hours were a significant issue for a number of interviewees, with some conflicting opinions. Many suggested that CCOS without a 7-day per week/24-hour service needed to extend their working hours as their flexibility suffered as a result. Several interviewees thought that a 24-hour CCOS was impractical or unnecessary or too high an expectation (due to funding constraints). When ward-based interviewees were asked what they would do if the CCOS were not operating, the majority stated that they would just follow their established working patterns (on-call doctors or critical care unit staff) if they needed help out-of-hours.

One medical consultant felt that the skills and knowledge of the CCOS were missed during the night, making a case for a 24-hour CCOS:

> *Our doctors here are very busy at night with very sick patients and trying to run the intake as well. I don't think the patients in here get a great deal. When we had Night Nurse Practitioners, who were experienced nurses working in an autonomous role you know across [the whole hospital], I think life was a bit safer at night here. I think there is definitely a place for more senior nurses at nights for the sick patients.*
> [Consultant, Medicine]

A physiotherapist suggested that a good role for CCOS at night would be as a single point of contact, fielding bleeps and 'phone calls and diverting them to the most appropriate place, when necessary. This "gate-keeping" and triaging type of service is what happened at two of the study sites visited (although, they were not too sure whether this was an appropriate role for them).

It was suggested that CCOS nurses frequently worked over their established hours; this was corroborated during the observational research where individual CCOS nurses often worked beyond the end of their allocated shift.

Equipment

Staff of the CCOS and critical care unit were asked about the availability of equipment. A large proportion of interviewees felt that they, as a service, either had adequate equipment available, or could use critical care unit equipment, or could access the hospital equipment library. One CCOS was well-resourced with a variety of monitors and equipment to hand. Another stated that basic equipment was easy to access but problems sometimes arose if specialist critical care equipment was needed. Some resource and budgetary issues arose in connection with the provision of critical care equipment on the wards:

> *If there are patients on [needing] anything above the normal basic patient care, the wards do not have it all and so we tend to borrow from the critical care area… We will cross-charge them for big items…but the smaller things, the tubings and the connectors and sometimes the drugs and things, we don't charge them so it's going to impact on the critical care budget.*

[I Grade Nurse, CCOS]

The impact on critical care budgets did not go unnoticed by critical care unit managers:

> *Equipment-wise, [the CCOS] just go into our store room and just pick up what they need and go out… and the budget here is sky-rocketing through the roof. I'm trying to account for why it's sky-rocketing so I've started clamping down on the outreach team. They now fill in a costing book and then I can now cross cost the wards for it.*
> [Manager, Critical care unit]

Another issue which was mentioned was a shortage of basic equipment on wards (and a lack of financial resources to purchase more). As this bed manager commented, insufficient equipment on wards may result in patients being admitted to the critical care unit rather than being supported on the wards:

> *There are only two BIPAP machines and, if you've got two people on them, then there isn't anything else to attach the patient to so they're going to have to go [to the critical care unit]…*
> [Bed manager]

Other study sites reported that items like a ready made up, vascular tray would be useful, while one emergency department nurse suggested that wards, where patients commonly receive support from the CCOS, should ensure they already stock the type of equipment that would be likely to be required.

The availability (or lack of availability) of equipment was sometimes compounded by lack of time, or lack of skills to monitor the equipment, as required.

> *It's not so much equipment, sometimes it's…the number of patients that they're looking after…there's a huge amount of stuff that you're relying on the trained nurses to do and, if you've got a very sick patient that's having hourly urine output, hourly CVP measurements and stuff, there really isn't the numbers of staff on the wards to allow them to be able to manage those patients as intensively - if they do spend all that time with a sick patient, then the other thirty patients on the ward are not getting as much care.*
> [Consultant, Medicine]

> *It's pointless monitoring a patient if no-one understands what it means. So, we've got our own equipment, as much as we could afford really at the time, and we educate people in how to use it when we can.*
> [F Grade Nurse, CCOS]

Ward coverage

CCOS at all of the study sites covered all adult wards although, during observations, it became clear that there were some areas less frequently visited. Interviewees suggested that there was a clear difference between medical and surgical patients in terms of the input required from the CCOS:

> *I think in medical wards you tend to get sicker patients and I think they tend to be sicker for longer. I think people have surgery, recover, go home, I think it's more of a finite process… but with medical patients I think they can be in hospital for longer and they can be more acute, more acutely ill for longer, so I think outreach is probably biased towards the medical and the medical assessment unit*
> [Student Nurse]

This was reiterated by a critical care unit consultant who suggested that surgical patients received better clinical management following an operation, whereas medical patients often have no fixed diagnosis; they can fall between consultants of different specialties:

> *The general "bread and butter" medical patient, if he doesn't need a cardiologist or rheumatologist or gastroenterologist, he's in no-man's land and that's a role which clearly has been recognised*
> [Consultant, Critical care unit]

The most commonly visited areas, within the medical directorate, were medical admissions and medical short-stay wards. Patients with a variety of different conditions required a lot of CCOS input, the most common being haematology and renal patients (care of the elderly and obstetrics and gynaecology wards were less frequently attended).

Interviewees from the CCOS also suggested that they were called to certain areas because of a lack of skills on the ward or, more frequently, because it was just where the sickest patients were. A critical care unit manager suggested that, in addition to medical patients being far sicker than surgical patients, there were lower staffing levels on medical wards, the staff were less specialised and were therefore less prepared generally for acutely ill patients who may require critical care.

Some variation in the types of wards visited was attributed to the population profile. For example, patients at one study site, which was in a highly industrialised area, tended to be more likely to present with chest complaints (e.g. COPD, bronchitis). Patients with respiratory conditions were frequently seen if the hospital did not have a self-contained, respiratory unit. Whether a hospital contained a tertiary referral centre for a specific disorder or not was also thought to affect the requirements for CCOS.

Informal conversations with staff from areas where critical care skills were routinely needed (e.g. emergency department and coronary care unit) revealed that they felt better prepared and qualified for caring for very sick patients. They suggested that they needed less help or input from the CCOS.

However, at several sites, ward and CCOS nurses claimed that patients in the emergency department were poorly assessed using TTs (it may be that many emergency departments feel pressure to move patients out quickly). Some interviewees also claimed that post-coronary care unit patients missed out on crucial follow-up care.

Contact with other services

CCOS staff reported having contact with a variety of staff within the hospital but, for the majority, their remit ended once the patient was discharged home. Only one CCOS, that had a direct role in running follow-up clinics, had contact with professionals in the community, usually follow-up nurses, provided GP letters or dealt with referrals.

Some CCOS reported that they had contact with other services within the hospital and were able to make direct referrals to specialists for patients attending follow-up clinics, if they had ongoing medical problems. They also made referrals to psychiatric services, GP counselling services and psychologists although these contacts were few and far between. At only one study site, was there any contact with community social services.

Of the hospital chaplains who were interviewed as part of this study, the majority had only a vague idea who the CCOS were and had very little contact with the service. Some stated that they were aware of the CCOS having seen them working either on the wards or in the critical care unit or high dependency unit. One chaplain reported taking referrals from the CCOS, which had requested pastoral care for family members. It seemed that only one chaplain had any real understanding or knowledge of what the CCOS did.

TTs

In some cases, one of the primary responsibilities of the CCOS had been to implement the scoring system across the wards. The types of TT and response algorithm varied between sites (e.g. Patient at Risk (PAR) score, Early Warning Score (EWS); Modified Early Warning Score (MEWS), locally devised score). TTs were usually used across all hospital wards although the degree to which they were implemented and integrated into routine practice varied. There were some areas identified where they were often not used, for example, the critical care unit, the high dependency unit, the emergency department and other high dependency areas such as the coronary care unit.

The majority of interviewees were in favour of the use of TTs and these are summarised in Section 3 of this report.

Response algorithms/protocols

Response algorithsms/protocols were usually related to the use of the TT and the procedures to follow when faced with a deteriorating patient. Occasionally, there were protocols in relation to the discharge of patients from the critical care unit. The level of protocolisation varied from hospital to hospital. Some CCOS had rigidly enforced protocols whereas others had very loose protocols.

At sites with protocols related to the TTs, interviewees were usually aware of what procedures to follow if they were concerned about a patient or if their score was outside normal parameters. This was usually to contact the doctor responsible for the patient's care and the CCOS. Some reported that they had to contact the doctors first, who would subsequently contact the CCOS, while others would contact both simultaneously. Junior nurses usually suggested that they would not contact the CCOS themselves (despite the CCOS stating that anyone could call them if they were concerned) but would pass on the information to senior ward staff who would then contact them.

One study site followed very clear documented protocols which were very rigidly adhered to. At the site itself, this was not considered to be a bad thing and did not, as is evidenced in the conversation below, detract from the overall response to the CCOS by the nurses on the ward:

> *They're rightly not flexible about the policy (so) they can't say "well it's OK this time" because then it muddies waters and confuses people and the policies should just be applied and that's it…And they've stuck very firmly to that but they're supportive of us and they don't come in with a big stick and say this ward's terrible, you didn't follow the policy.*
> [F Grade Nurse, Ward]

One physiotherapist suggested that, if a CCOS was too reliant on protocols, it could prevent staff from calling them for advice. She commented that the CCOS needed to be able to help inexperienced staff prevent patient deterioration so waiting until a patient is above a certain threshold only delays the initiation of treatment they will probably need later.

Audit

Audit was described in *Comprehensive Critical Care* as being essential to "justify investment and evidence of a high standard of clinical care" although no specific recommendations were made regarding how audit should be conducted in relation to CCOS.

All CCOS felt the need to justify the money spent on them. They hoped that this could be achieved through audit (and hopefully producing tangible evidence that they were effective).

> *We've been under a lot of pressure to justify the, in my opinion, minimum investment that has gone into outreach in this Trust and yet, you know, we've been under a lot of pressure to justify our outcomes and our activity, even though we've received a lot less investment than a lot of other places that have appeared to me to do less than we do…We've, rightly or wrongly, felt the pressure, that this is a service that may be disbanded to save money or to open another ICU bed or something like that*
> [Consultant, CCOS]

By way of contrast, another CCOS was positively encouraged to audit, present and publish on subjects of particular interest to themselves in order to

continue with their own professional development. Some Trusts appeared to be more eager than others for their CCOS to justify the money spent on them. At some hospitals, where CCOS were considered innovative, there was a general pride in the CCOS and what they were doing, at others, it felt as though CCOS were fighting to survive.

> *We've audited… everything!*
> [Consultant, CCOS]

Interviewees reported auditing many aspects of CCOS practice. The most commonly reported audits were of: TTs; observation charts; critical care unit referrals, admissions and readmissions; cardiac arrest rates; and mortality. Three CCOS had audited staff and consultant perceptions of CCOS. Other audits included: the case mix of patients seen; CCOS referrals and response times; critical care unit refusals and bed availability; ventilation; DNARs; the use of the central line on the wards; patient quality of life post-critical care; patient length of stay (in the critical care unit and hospital); and numbers of level 1, 2 and 3 patients in the hospital and where they were located.

Audit results were usually produced internally although some were presented at Trust, Network or national meetings and some research had been published. Three CCOS employed audit clerks or administrative support to enable them to collect data.

Factors affecting successful operation of CCOS
Commonly mentioned enablers and barriers were: communication; visibility within the hospital; senior medical support; hospital-wide collaboration; team leadership; and resources.

Good communication was reported as being the most important facilitator for the majority of interviewees, either in terms of passing on clinical information verbally across a multidisciplinary CCOS or to promote and “market” the CCOS within the hospital:

> *I think you need very good communication. I mean you never get everybody on board but I think you have to have the key players on board because, if you get hostility say from of a section of the physicians or medics or divisions that you're going to be working closely with, you're going to have a real uphill struggle for quite a long time*
> [Matron, CCOS]

In contrast, poor communication was felt to be the most significant barrier, in terms of how CCOS nurses were perceived by nurses on the wards:

> *Sometimes, perhaps in the communication styles the way that they communicate with the ward staff can sometimes create barriers and that may be part of the reason why sometimes some of the ward staff move away because they feel that they will be either interrogated or maybe criticised by the outreach staff…Sometimes, because they can*

> *be quite brusque in their communication partly because you're dealing with critically ill patients and so you need to be very efficient and effective but sometimes I think that may be perceived wrong*
> [Physiotherapist]

So, being efficient and effective and getting the job done (i.e. providing critical care on the wards) needed to be tempered with a good communication style. One interviewee suggested that being too protocol driven hindered the CCOS as it affected their ability to be flexible and build up good relationships with ward staff. Interviewees also suggested that the visibility of the CCOS on the wards was an important way of getting known and promoting the CCOS.

The support of senior doctors was mentioned by several interviewees as very important. It was suggested that having a dedicated CCOS doctor would enhance the service giving CCOS Nurses more authority to initiate care and communicate with the medical and surgical services on the wards. In addition, CCOS nurses (even very senior nurses) felt, at times, that they lacked credibility on the wards or were simply not listened to.

Most CCOS nurses were happy with the input they received from the critical care unit doctors but recognised that they too had limited time that they could give the CCOS due to the demands of the unit. One CCOS nurse suggested that, if they had a doctor on the team, communication between consultants might be improved. In contrast, one Pain Team consultant was more than happy to accept the judgement of specialist nurses, so long as they were acting under delegated authority:

> *The consultants in intensive care are generally… fairly well respected…I think if the consultants there give the outreach team their authority so, you know, "we believe in these people and you should use them" then, as far as [an] anaesthetist is concerned, that gives them a very good reference, a mandate… If I were a headstrong junior doctor, I would be inhibited from being too rude to outreach because I wouldn't be too surprised to get a 'phone call from [the critical care unit consultant] the next day saying what are you doing upsetting my nurses?*
> [Consultant Anaesthetist, Pain Team]

The need for close working relationships across various teams and groups, in the hospital as a whole, was identified by a number of interviewees:

> *We need to have the backing of everyone. We're a nursing team but we need support of people like pharmacy, physiotherapists, our medical colleagues because we are all, sort of, striving for the same thing and I think you know there has to be the whole element of teamwork because we can't do it on our own and, likewise, they can't do it on their own. So, really, it's that bridging, bringing everyone together and working as a service for one outcome which is the patient*.
> [H Grade Nurse, CCOS]

Many interviewees expanded on this theme suggesting that, without support and close multidisciplinary liaison, the CCOS would not be able to operate and much of the CCOS' strength was in facilitating this and acting as a link between different teams.

Good leadership within the CCOS was also mentioned. Some interviewees described their CCOS as being too reactive due to a lack of effective leadership and a lack of guidance in running the service. One interviewee felt that having too few critical care beds acted as a barrier between CCOS and critical care unit staff, as the CCOS was often perceived as bringing more work to an already busy critical care unit.

Results – CCOS personnel

Nursing staff

The staffing numbers of the CCOS varied from 2 to around 14 nurses, all of whom were F grade or above, with the majority being from a critical care background. CCOS interviewees reported that nurses were recruited in a number of different ways; some were permanent while others held rotational posts. At one hospital, the CCOS had no permanent staff being staffed entirely with rotational, critical care unit nurses who spent 50% of their time on CCOS. Some interviewees felt that providing permanent staffing for the CCOS could deplete critical care unit staffing levels so some CCOS sought to avoid that by creating these rotational posts or by recruiting staff from other areas of the hospital. One senior CCOS nurse described how she wanted to make CCOS an attractive job opportunity:

> *I knew I wanted to rotate senior staff onto the team. I knew I didn't want a fixed team because I wanted there to be a form of promotion, so that staff who had been here a long time, five years, there was somewhere for them to go because there might not be Sisters' posts but at least they knew that they could go on the outreach team and develop their clinical skills and they would be rewarded by having a short-term promotion, so I knew that would be a good idea.*
> [I Grade Nurse, CCOS]

At four sites, senior ward nurses had been incorporated into the CCOS either because CCOS managers wished to diversify in the way the CCOS was staffed or because an existing team was disbanded. Several CCOS felt this was a positive and successful move although some staff had reservations.

Doctors/Allied health professionals

Two CCOS had consultants who were officially part of the CCOS, although other services had some access to consultants. All CCOS suggested that medical input would be a major asset. The CCOS were mostly nurse-led with support from the critical care unit doctors (to a greater or lesser degree).

Two CCOS had a physiotherapist as part of the staff complement and one had an occupational therapist and speech and language therapist conducting weekly sessions as part of the CCOS.

Two CCOS reported that they would like to increase the number of, or enlist doctors and allied health professionals in order to strengthen the CCOS, in particular, its multidisciplinary character. The multidisciplinary approach was also discussed by a number of CCOS staff including this Consultant:

> *The typical medical model is - a consultant swans in and says this is what I do and there are lots of juniors scrabbling around… We're not doing that. There's a lot more communication with me about the patient from the therapists who don't get that in any other environment… I think it's an interesting model. I suspect it's the model of the future for the NHS. I think this hierarchical medical model and even hierarchical nursing model is not going to work, you know, and it will be multidisciplinary but it does produce some challenges and certainly produces conflict as well.*
> [Consultant, CCOS]

In contrast, one critical care unit manager did not feel that having allied health professionals would add anything to the CCOS:

> *I haven't come across physiotherapists yet that I would want to have as a full-time member of the team although they can have a lot to contribute. I think we can perform the basic physiotherapy on eight out of ten occasions, maybe even nine out of ten occasions, and can offer so much more than a physiotherapist, [who] in my view, seem to be rather less widely skilled. So, although I can ask a physiotherapist to ventilate somebody's chest, what they're not going to do is think about their nutrition or their bloods or their IV access whereas my team can do most, if not all, of the physiotherapy stuff to a fair standard*.
> [Manager, Critical care unit]

Relationship with the critical care unit

Most CCOS nurses had a critical care unit background and the majority of interviewees felt that CCOS nurses should retain their personal association with the critical care unit for several reasons. First, in terms of clinical skills, it was felt that keeping in touch with the critical care unit would help keep individuals up-to-date with new developments in critical care medicine. Second, it would help to retain credibility with ward staff. Third, communication between the CCOS and critical care unit nurses would help critical care unit staff to understand what work is like on the wards. Interviewees suggested that rotating on to the critical care unit would provide these opportunities. An additional benefit was that CCOS staff would feel part of a bigger team.

Some CCOS already had rotational posts while others thought that it would be a good idea. One critical care unit manager suggested that, as well as retaining clinical skills, a CCOS/critical care unit rotation would encourage appreciation of working one-to-one with patients in a supportive environment. The idea that critical care unit nurses were protected and insulated in the critical care unit and that they need to break away from that environment to

understand what it was like to work on the wards was discussed numerous times:

> *You can become very isolated in there, like ivory towers, and think "well, why hasn't this been done, it's so obvious" but they forget that, you know, a ward nurse, for instance, has a hundred and one different things to think about …because they have to try and organise everything from food to district nursing to god knows what whereas, in intensive care, you're just focussing on the physical really…*
> [F Grade Nurse, CCOS]

One CCOS nurse felt that the CCOS had become isolated from the critical care unit since they had acquired dedicated office space away from the unit; suggesting it was important for the CCOS to remain geographically close, as well as communicating well with their colleagues on the critical care unit.

Interviewees referred to the need for staff on the critical care unit to provide the appropriate support for the CCOS nurses, when required, and also to ensure that the CCOS nurses did not become isolated from the critical care department or division within the organisation. One critical care unit consultant also identified a need to protect the CCOS by encompassing them within the critical care unit in order to ensure their long-term survival:

> *…unless they were very well supported, they would be vulnerable because they wouldn't have necessarily the back-up of a large and respected department behind them. Autonomous groups are always vulnerable especially when people are trying to squeeze budgets. I think if they're part of the critical care unit, then they can make sure they're all moving in the same direction. I think it's important and also they're supported by the critical care unit, they're part of us, and if they, kind of, get into difficulties, they can be defended by us because you are asking outreach nurses to go out on a limb and make decisions, without direct consultant support*
> [Consultant, Critical care unit]

Clinical background of CCOS staff

In hospitals where ward nurses were part of the original development of the CCOS, staff had no difficulty accepting their abilities or position. However, this was not the case where the CCOS was very much an extension of the critical care unit.

Several CCOS voiced concerns about having inexperienced staff or staff without a critical care background. They often felt their main priority was to ensure all of their staff were sufficiently confident with critical care skills. Ward staff, especially doctors, commented that they would notice if a member of the CCOS was less confident and that this might discourage them from calling the CCOS.

Some of the CCOS nurses without a critical care background did not feel adequately prepared or trained when they first joined the CCOS, as the following two quotations indicate:

> *I didn't really have much induction into the post and (management) do know, from other people who have been in post, it's very much a learning on the job, critical care initiation. And, in the past, there has been people who haven't been able to cope with going to a deteriorating patient on the ward, did not have the skills to manage the patient at that point…*
> [E Grade Nurse, Critical care unit]

> *It makes me very stressed and quite anxious and I do worry a lot that I'm making the right decisions. And it's very difficult when you're going out to see a patient that you've never met before and you, kind of, have to make decisions based on what you find there, just from reading the notes or from what staff tell you. It's not like you've looked after the patient for a week, you know you've got something to follow, but it's quite difficult, it's quite daunting and I find it very nerve wracking…*
> [H Grade Nurse, CCOS]

However, most felt that subsequently they had gained sufficient skills, and that ultimately problems can be overcome with sufficient training and support

> *I think when [the positions on the CCOS were] advertised, people were sort of wondering how [these nurses] got the position or put forward in this position because they haven't got particular qualifications or experience of airway management or you know, a high dependency person…some people felt quite disheartened and obviously maybe the ICU staff should have more of a priority… I came here but I didn't have any ICU background, so I think you know, we all have to be willing to be trained and improve our skills.*
> [E Grade Nurse, Critical care unit]

Interviewees often suggested that it was important that CCOS nurses were senior because they were likely to be more mature and confident. Senior critical care unit nurses would be more likely to understand the diverse array of problems having spent time on the critical care unit (for example, nightmares). However, as the CCOS nurse below elucidates, critical care skills alone may not be enough.

> *We're very much ward-based … we set up the team with a mixture of ICU nurses and ward nurses of senior grade and that has given an absolute perfect balance because a lot of intensive care staff here have no idea what the wards are like and you cannot do an outreach job if you don't know what the hospital's like and you've not worked on the wards. It's impossible, in my opinion, to do that job.*
> [G Grade Nurse, CCOS]

Some interviewees felt that the skills of nurses without a critical care or high dependency background were not as strong; even though all CCOS nurses had received additional training in order to fulfil the requirements of the post. Many CCOS staff felt it was necessary to have worked, over a period of time, in a critical care or high dependency unit to gain practical experience although others felt that critical care experience could be gained in other areas of the hospital (other than the critical care unit) such as recovery or emergency assessment units (though some skills would not be learnt i.e. supporting ventilated patients). Some felt that, in their hospital, those skills not learnt were required so rarely so as not to be a significant detriment to the CCOS as a whole. One CCOS nurse described why she wanted HDU and critical care unit nurses on her CCOS and in what ways this choice was successful:

> *I knew that I wanted one from either side so that we evened out the balance…One from HDU and one from ICU and I didn't know which of the two would be the better at the outreach. And looking back now, it's the high dependency nurses that have excelled a little bit on the outreach because they are used to working with the medics and all the different specialities and they're used to the routines that the surgeons have and they know the ward staff, which put the ICU nurses at a disadvantage, to some extent. Because they purely look after their patients and don't have the degree of management and the care and so it turned out the HDU nurses seemed to have more of the skills really for outreach. I also wanted a rotational team because I think ICU nurses tend to forget what it's like on the wards and the pressures they have on the wards.*
> [I Grade Nurse, CCOS]

Another interviewee suggested that CCOS nurses were over-qualified for their role now and that there was a place for recruiting more junior members of staff, as a training and development exercise (especially when part of the job involves training ward nurses on basic nursing care, auditing and doing some basic patient follow-up tasks).

> *I think you could make a case for saying they're over-qualified for the job now. I think, when it started, it was important to establish confidence and you needed people who were very, very skilled, very experienced. I think you can make a case for saying a more junior nurse could do the job as well with support from someone more senior*
> [Consultant, Critical care unit]

Overall, interviewees felt that their CCOS had a mixture of skills and strengths which complemented one another and that the desirable skills and knowledge were more likely to be found in those with more experience, whether they were from the ward or the critical care unit. It was also recognised that the CCOS is still a new and developing service and that there was little guidance from the policy documents as to who should be recruited to a CCOS. Consequently, all staff, from the critical care unit or elsewhere, have not only had to develop the necessary skills within that role but also had to ascertain what those necessary skills actually were.

Personal attributes

As discussed in the previous section, it was generally felt that CCOS staff were well qualified, skilled and knowledgeable. A number of other desirable attributes were mentioned.

All interviewees agreed that it was important to ensure that the CCOS were highly skilled and knowledgeable in order to command respect around the hospital, to be able to support ward staff, and to empower them to do jobs for themselves (for example, suctioning tracheostomies - a job, at times, left to the CCOS).

> *I suppose it's empowering ward nurses to become, to feel, more confident, more trained, so that they can manage critically ill patients and they know when to call*.
> [G Grade Nurse, Critical care unit]

The interpersonal skills and communication styles of CCOS staff were felt to be extremely important:

> *Attitude is very important… So, that's the management bit; leadership skills, management skills, motivation, negotiation and all those things.*
> [G Grade Nurse, CCOS]

All interviewees agreed that staff of the CCOS should be friendly, open and supportive in order to facilitate good working relationships but also be able to challenge and change working practices. During the observational research, there were many examples where CCOS nurses seemed to not want to challenge ward staff or make an issue about incomplete observation charts or incomplete TTs, perhaps for fear of upsetting them. CCOS nurses muttered about incomplete or inaccurate patient observation charts (or directly explained to the researcher why they felt angry or frustrated) however, they were observed challenging the nurses responsible on only a few occasions. This can be interpreted as needing to keep good relationships with ward nurses (as many nurses did not take this kind of criticism well). On the whole, CCOS nurses were well received and highly thought of and many did not want to risk this relationship.

> *I'm very conscious of not upsetting the staff…I understand that they have a lot of things to do on the ward and I don't want to alienate them. I come across as trying to be helpful and supportive but I also know that there are times on the wards that things that shouldn't be overlooked are overlooked and things that should be done are not done and, at that point, I deal with that at the time… Everyone knows me now, they know that I'm not going to cause trouble, or pick on people, or criticise people, but they also know that we're there to do a job and that's when we start to change practices.*
> [I Grade Nurse, CCOS]

Interviewees from the wards certainly felt that if the CCOS had a bad personal approach this would be a very significant barrier. This could be especially true for junior doctors:

> *A lot of the time, you can see we don't know what we're doing, we're still learning, and you don't want someone to come in and make you feel that small, you want to learn from them…Especially, in front of people… I think, especially with junior doctors, when you just have to be careful not to make us feel incompetent.*
> [PRHO]

Most CCOS staff were aware of the sometimes precarious position they were in and most were very diplomatic in their interactions.

Interviewees and informal participants often commented that maturity and experience were the most essential attributes for the CCOS to have. Doctors felt that, in order to trust the opinions of CCOS staff, they needed to know that they were experienced, highly trained and mature and had sound judgement and knew when to pass matters on to more experienced staff. These skills were thought to be essential in order for the CCOS to retain its credibility on the wards. One critical care unit manager, though, mentioned the perennial tension between developing a CCOS (i.e. giving people the chance to develop outreach skills) and actually delivering it.

Motivation for joining the CCOS

CCOS staff commented on why they had chosen to be involved in the CCOS. Most reported that they joined the CCOS because they wished to gain insight in to what happened on the wards, in particular, learning from the experiences of post-critical care unit patients. Some senior nurses mentioned career progression or short-term promotion. In a few cases, nurses mentioned the attraction of not having to work night shifts. One nurse, who held a rotational post, joined the CCOS because it gave her the chance to see critical care from the "other side", without all the monitors and specialist equipment that they have on the critical care unit; she also felt that it helped her forge links with the ward staff. On the other hand, some were drawn by the stimulating nature of critical care on the wards (referred to as "the sharp end").

One critical care unit nurse, in contrast, chose not to be involved with the CCOS. He suggested that he liked the controlled atmosphere of the critical care unit and would find the unpredictability of the wards frustrating, especially when he saw things being done inefficiently.

CCOS staff were likely to say that there had been a positive impact on their own career development:

> *There was also a sense of this is career development, it's another pathway for people to grow skills and knowledge and you know, expand their career… So, I think that was seen as a positive, this is another avenue I can pursue, without having to leave critical care, because fundamentally I think a lot of critical care nurses like what they*

do. But you may get to a point, certainly at senior levels, you think, where do I go from here? I don't want to be management, I want to keep my clinical, so what's out there for me and I think, in some ways, though I can't prove it, I think it's retained people here who would otherwise have left.
[H Grade Nurse, CCOS]

Results – the impact of CCOS

The impact of CCOS is structured into: the impact on the wards; the impact on the critical care unit; the impact on patients and their family; and the impact on sharing skills.

Results – the impact of CCOS on the wards

The impact of the CCOS on the ward is examined - first, by the contact between CCOS and various kinds of ward staff and second, by exploring the support provided. Third, the negative, positive and any perceived lack of impact are examined and finally, the changing relationship between the ward and the critical care unit is discussed.

Contact between CCOS and ward staff

Contact with nurses
Nurses' main contact with the CCOS was usually by bleep or telephone; particularly valued was the nurse-nurse contact. Some nurses reported that they would ring the CCOS if they required specialist nursing advice, especially if they felt they couldn't get it from a junior doctor.

> *If it was general advice, I mean, a nurses' point of view as to what sort of oxygen system is best, or that sort of thing, then they're specialist skills that the doctor wouldn't know about.*
> [E Grade Nurse, Ward]

Some ward nurses suggested that they would most commonly contact the CCOS if they had a deteriorating patient and, especially, if they might require admission to the critical care unit. CCOS suggested that the doctors would interact with them if they required a critical care unit review as the CCOS were the gate keepers to the critical care and high dependency units.

> *If the doctor needed to get a patient transferred to ICU they often call the outreach nurses, that gate-keep, to help liaise with the doctors and the team.*
> [F Grade Nurse, Ward]

Junior nurses or HCAs often reported having face-to-face contact with the CCOS when they were on the wards conducting a ward round or reviewing a patient. They were much less likely to ring or bleep the CCOS, preferring informal contact. Several CCOS maintained that anyone, however junior, could ring them if they were worried; however, in observations it was noted that ward etiquette meant that lower grade nurses felt that it was not their place to ring the CCOS. They were more likely to report their concerns to a senior nurse who would then decide whether, or not, to contact them.

All ward staff commented that staff of the CCOS provided excellent verbal advice and written records of their contact with patients on the ward. There

were many examples of clear, concise and detailed entries in patient notes and it was also very clear that CCOS had written the note (some services even had their own CCOS stickers which they appended to the notes). The disparity between the quality and legibility of doctors' notes and CCOS notes was readily apparent.

Contact with allied health professionals
AHPs or members of the Acute Pain Team reported that their usual contact with the CCOS was either when they had a shared patient or they were visiting a patient they felt needed a critical care unit review, in which case, they would usually directly bleep the CCOS to request they visit the patient. Other than this, contact was on an intermittent basis. All of the AHPs interviewed felt that they had a good working relationship with the CCOS and that information pertinent to their work was passed on appropriately and efficiently.

Contact with junior doctors
Junior doctors' contact with the CCOS was often on an informal basis unless it was in relation to a patient who had a high TT score. Where this was the case, the response algorithm or protocol was followed which usually meant that the ward nurses should call the junior doctor from the team providing care for the patient. In some cases, nurses were advised to call the CCOS at the same time especially if they felt the junior doctor was not making a timely response. It became apparent, during informal discussions with junior doctors, that CCOS nurses were often already with a patient by the time they arrived. This was not always regarded as a problem. Similarly, many junior doctors also reported that they did not always get a timely response when they tried to contact their senior doctors and, occasionally, would contact the CCOS if their consultant was unavailable.

For some doctors, working with the CCOS and having them on hand was a good thing and they appreciated the extra input and expertise the CCOS provided. Others, however, found it somewhat embarrassing and irritating that ward nurses might have called the CCOS first; one or two expressed anger at the thought that they were overlooked or called only as an afterthought. Ward nurses often made derogatory comments about the level of skills and knowledge of the junior doctors and, on several times, they were observed contacting the CCOS before calling the junior doctor. On many occasions, CCOS nurses attended sick patients long before the junior doctor arrived although they were alerted at the same time.

Contact with senior doctors
Consultants evaluated the CCOS in quite different ways. Many found the CCOS invaluable in providing a supervisory role, namely, being aware of where the sick patients were and generally keeping an eye on them without overburdening the critical care unit:

> *Usually, when I've got an acutely unwell patient on the ward, particularly if I think they need an HDU or an ICU bed, I go via the outreach team and get them to come up and assess the patient… The*

> *other time I've been involved with them is, if we've got an unwell patient that needed managing on the ward. If there were central lines, and we have had some problems with the inexperience of the [ward] nurses in managing central lines, in doing CVP measurements… I've had patients where I really need to know what their central venous pressure is and at the time the [ward] nurses were measuring it and getting different values, and that doesn't look right, and I've sometimes got the outreach team up, you know, to do the measurements for me or to make sure that the [ward] Nurses are [or] to show them how it should be done.*
> [Medical Consultant]

One Pain Team Consultant described how his path might cross that of the CCOS. He suggested that, in his role, he would see post-operative patients for pain relief but, if he felt there was more going on with the patient than simply pain, he would refer them to the CCOS. Other personnel from specialist teams reported similar relationships suggesting that, although roles at times overlap, they also have very defined boundaries. One CCOS nurse, for example, stated that she would not get involved in providing care for patients who needed specialist treatment (i.e. renal care) accepting that specialist nurses from other services were more likely to know the condition better. The downside to this is that a patient may end up with half a dozen different teams dealing with them all providing very different aspects of their care.

Support provided

The majority of interviewees were very positive describing four main areas where the CCOS excelled in support for the wards: trouble-shooters for problems and issues; facilitators of access to doctors or for referrals to critical care; providers of back-up to ward nurses; and as educators. A number of other areas where the CCOS provided support were identified. These included: taking the fear out of receiving a discharged patient from the critical care or high dependency unit on to the ward; providing a timely response when called (especially when doctors were unobtainable or unresponsive); providing support and information to wards with staff shortages or where the skill mix was varied; and finally, being easier to communicate with than doctors (i.e. valuing the nurse-to-nurse interaction).

The degree to which CCOS "took over" care was an interesting issue: on the one hand, to include ward nurses in a patient's treatment, without taking over, was valued yet, conversely, many nurses also appreciated their ability to come to the ward and take over the care of a critically ill patient when they were busy (and especially if no critical care bed was available). Providing an extra pair of hands, when necessary, which was witnessed from time-to-time, was actively avoided by CCOS. CCOS nurses emphasised that this was something they would do only if they were not busy – it appeared only to be the less busy or better resourced CCOS which were able to do this.

Interviewees most frequently reported that the CCOS provided support and back-up for the nurses on the wards in the form of education: teaching new

skills (or helping to refresh old ones - especially in the use of specialist equipment), advising or reassuring.

Access to doctors
The CCOS were also described as being invaluable, when trying to contact doctors when a patient's level of care needed to escalate, as they had more authority than the average ward nurse but also because they quickly and efficiently responded to calls

> *Having that force behind you, of somebody who, yes they are a nurse but they're a specialist nurse, standing there and saying "well, what the heck do you think you're doing, get someone in here, put a line in, we need access, we need blood gases, we need this and we need this" and it just gives you that extra weight because, although you think you know what needs to be done, sometimes it's very, very difficult to push the urgency… When someone's really acutely unwell they really pitch in…*
> [E Grade Nurse, Ward]

The "extra weight" referred to above is presumably what enables the CCOS to bridge gaps between the medical staff and ward nurses. In fact, having an outsider helped to protect the working relationship between nurses and doctors on the wards:

> *I've had [CCOS] come over and tell the doctor what needs to be done and it kind of stops that break down in your relationship with your medical team. Sometimes, somebody from outside that's quite objective, them coming in and saying "well no, the nurse is right" stops you getting into a loggerhead situation which sometimes happens…They give you support and step in, and stop… your relationship with the medical doctor… starting to break down, which happens because they take it really personally if you question them.*
> [F Grade Nurse, Ward]

Several sites had formalised a "link nurse" role, where an experienced ward nurse received extra training so they were able to take extra responsibility for relaying information between the ward nurses and the CCOS. They could also monitor the numbers of sick patients, help train, and guide other staff on the ward and liaise with the CCOS. This provided a very tangible link between the ward and critical care and was often felt to be a positive development. The availability of resources on the wards, and appropriate CCOS and ward staffing levels, was still an issue this, at times, could restrict link nurses' attendance at CCOS meetings.

Professional and calm approach
Many interviewees suggested that the CCOS nurse's personal approach and professionalism was important, in particular, their ability to oversee patient care, to calm nurses down and stop them feeling stressed:

> *They're just calm. They get on with it… I think, especially for junior staff, they appreciate the professionalism…they know what they're doing, they tidy up as well, make the area, you know, from being sort of frantic, it's all calm, at the same time, talking through whatever's happening, so they really are professional…they're friendly, they're approachable and they listen to staff concerns and they act on it even if it's just reassuring them.*
> [G Grade Nurse, Ward]

A significant proportion of interviewees did not think that the CCOS could be any more supportive than they already were. Those who felt they could be suggested organisational changes, such as the provision of a 24-hour, seven days per week CCOS and increasing resources as many had "spread themselves too thinly". More consistency in staff skills and manner were also suggested (for example, not all CCOS nurses were seen as fully approachable or supportive). It was also commented that CCOS staff needed to be more assertive with ward nurses, ensuring that ward nurses were actually doing the work. On occasions, ward nurses could "disappear" into the background when CCOS staff arrived. This is illustrated in the following two quotes from non-CCOS staff:

> *[the CCOS staff] need to be more forceful with the ward staff when they're there and to say I am here to help you but it is to help you manage this patient, rather than being nice and doing it for them.*
> [Physiotherapist]

> *If you take over all the time, that nurse will never learn, will never know…some will see you are busy with the rest of the ward and they'll say "I'll do this and if I need you, you carry on what you need to do and I'll come and get you and when we've finished, I'll update you". So, what I would like to see is them come on the ward and say "OK, I'm here, what can I do to help you?", rather than take over…*
> [F Grade Nurse, Ward]

On the other hand, from a medical point of view, the CCOS can counteract a perceived lack of competence and confidence of nurses or junior doctors on the wards. For example, the following consultant did not think that nurses or junior doctors on the wards could prevent patients deteriorating, primarily due to a lack of skills, experience and knowledge. She suggested that the CCOS could act on her behalf:

> *[The CCOS] gave me a sense of security about my patients… I was always the one who was pressing the ICU outreach button… they acted in a supportive and supervisory way for me.*
> [Medical Consultant]

A similar role was envisaged by a critical care unit consultant, who described the CCOS as being the "eyes and ears" of the critical care unit. Thus, the CCOS were seen as able to supervise and oversee care across the whole hospital, able to liaise with critical care unit doctors, and support junior ward

doctors. The great benefit for many consultants, and one reason why they were predisposed to favour the CCOS, is that CCOS can usually be trusted to do all these activities without the consultant having to be called.

Negative impact of the CCOS on the wards

About a third of ward and critical care unit staff interviewed did not think there were any detrimental effects of having a CCOS (for most, it was quite the reverse). Most of the issues were reported as being possible or hypothetical problems, rather than ones that were actually occurring. Problems that were mentioned included: "taking over" (which, in turn, led to deskilling); apportioning blame; undermining junior doctors; and the question of patient ownership.

Taking over and deskilling
Interviewees from the wards voiced concerns about the CCOS nurses taking over on the ward. Some nurses felt sidelined, while others suggested they may tread on the toes of other professionals rather than working jointly with colleagues. One HCA felt ward staff may resent the CCOS nurses, more out of jealousy of their knowledge and skills, and perhaps suffer feelings of inadequacy while several interviewees felt that, if the CCOS were more interventional (seen as increased taking over), it might result in nurses feeling more demoralised.

A proportion of interviewees suggested that the CCOS deskilled staff on the wards. One CCOS matron suggested that deskilling is not just an issue for the CCOS but for all specialist services. She went on to add that, because there is a lack of faith in the ward staff, there is a danger that the CCOS will become more interventional than originally intended and will end up deskilling the ward staff even more

Ward nurses mostly reported that they wanted to be included in a patients care and listened to by the CCOS, but often felt sidelined. Even interviewees, who initially reported that there were no detrimental effects, did suggest that if the CCOS constantly took over, or came to the wards to troubleshoot rather than work with and educate ward staff, problems may occur in the longer-term. One bed manager suggested that, to avoid this, the CCOS needed to make its role clear that it was a hospital-wide service and not there to take over on one ward.

The lack of skills development for junior doctors was mentioned repeatedly.

> *I do quite strongly feel that [the CCOS] is deskilling [junior doctors]… As it is, an awful lot of these acutely ill patients are swept up by the outreach staff and [junior doctors] don't see them so much…I think it's fantastic for patient care and I think it facilitates the whole kind of transfer ICU/ward to ward/ICU but, somewhere in the back of my mind is that, junior doctors should be doing a bit more of this role and they're not.*
> [SpR, Critical care unit]

One medical consultant felt that the deskilling of junior doctors was a much wider issue:

> *There's a lot of deskilling junior doctors going on but it's not necessarily to do with [the CCOS]…Boundaries have changed all over the place. Now, a lot of nurses are doing bloods and Venflons and things like that but then they'll call the doctors for more difficult ones and maybe the doctors now don't have as much experience as they used to in doing things like that. So, there is a bit of deskilling of the doctors, partly through changes of practice and… partly through reduced working hours.*
> [Medical Consultant]

The flip-side of CCOS taking over/deskilling was the notion of a "culture of dependency", mentioned by several interviewees. This referred to the notion that ward nurses and doctors called the CCOS without considering appropriate nursing or medical interventions they could perform themselves.

> *[The] biggest change is, I think, the dependency on us. I think if the service was to stop I think the Wards would miss us quite a bit. They would cope but the patients may suffer. I think sometimes we deskill the nursing staff and definitely the doctors because, instead of doing a proper assessment of the patient, they will call us and then wait for us to do the assessment and follow that up. We feel that sometimes the doctors are getting deskilled in actually going to the bedside.*
> [G Grade Nurse, CCOS]

During informal discussions, CCOS staff stated that they were frequently called to wards where a patient only needed a simple intervention that the nurses and doctors should have initiated:

> *Sometimes, before thinking things through yourself, you can pick up the 'phone, especially the really junior doctors… If you'd actually looked…instead of panicking… and spoken to your senior, rather than calling the critical outreach team, it might have saved some time and you might have learnt something more yourself*
> [SHO]

However, dependency might be inevitable. One I Grade ward nurse went so far as to say that the "critical care without walls" objective might simply be unattainable:

> *"Critical care without walls" sounds great but to install the skills into individuals yes, you can do that, but to maintain it is very difficult and how you maintain those skills in ward nurses? I don't think it's possible at all, to make ward nurses critical care nurses… Outreach seems to be the answer to all the problems [but] I don't think it is.*
> [I Grade Nurse, Ward]

Several interviewees suggested that the culture of dependency was being reinforced as the CCOS was failing in its aim to pass on skills, educate and empower ward nurses. Many ward nurses are happy to defer problems:

> *In some instances perhaps, I feel we might have made a rod for our own back. In that, people, perhaps, become a little too reliant on us and see a problem and just call us rather than developing their own knowledge and doing something about it themselves.*
> [F Grade Nurse, CCOS]

Apportioning blame
How far should the CCOS chastise poor care on the wards? This was regarded as an important, if not political, matter which the CCOS had to deal with.

> *When it becomes a police and patrol service I guess it almost becomes unworkable.*
> [Matron, CCOS]

Some interviewees felt that ward nurses would be intimidated, that rapport with ward staff would suffer and that the CCOS would not be accepted willingly. Communication styles and personal approach were very important to ward staff. One critical care unit consultant suggested that some CCOS staff were not subtle or were too straight talking which caused some difficulties and created some personality clashes with CCOS staff and critical care unit consultants. A physiotherapist illustrates the difficulties faced by the CCOS:

> *[Some CCOS staff may think] they're superior to the nurses at ward level but sometimes, perhaps, in the communication styles - the way that they communicate with the ward staff can sometimes create barriers and that may be part of the reason why sometimes some of the ward staff move away because they feel that they will be either interrogated or maybe criticised by the outreach staff… [Outreach staff] can be quite brusque in their communication, partly because you're dealing with critically ill patients and so what you do needs to be done quite rapid and you need to be very efficient and effective in doing it, but sometimes I think that may be perceived wrong.*
> [Physiotherapist]

These points were emphasised a number of times during informal discussions with CCOS and ward nurses. All agreed that going on to the ward with a critical attitude was counter-productive in the long run as they would not be called on further to help.

Undermining junior doctors
Doctors were very concerned about the deskilling of individuals within their profession. They were also concerned about being undermined by the CCOS. This PRHO commented that it was important for the CCOS to recognise the skills and limitations of the junior doctors

> *We don't know what we're doing a lot of the time, we're still learning…You can make most of the decisions but, because it's a scary environment, you can forget things…[the CCOS] can say "what do you think about this"…*
> [PRHO]

One Consultant Anaesthetist, based on the advice he was given when establishing an Acute Pain Team, suggested that the CCOS needed to be careful…

> *… not to… take any further ownership of the patients away from the house officers because they feel quite remote to their patients already. They feel like supernumeraries already…Perhaps, there's a risk that every tricky case was immediately taken away from the house officer.*
> [Consultant Anaesthetist, Pain Team]

Another pre-registration, House Officer felt that differences of opinion could occur between the CCOS nurses and doctors where one might suggest a treatment that the other feels is inappropriate. He suggested that there might be problems as the nurses take on what was traditionally a doctor's role.

> *Without a doubt, [deskilling is] happening because, for example, nurses do cannulas, a phlebotomist does the blood. We still get asked to do them in difficult situations but we do them less… or [Arterial Blood Gases], the outreach do them. So, by the time you've got there, they've been done. So, what's the point of calling the doctor? Sometimes, outreach have been bleeped before I have and I've thought, well, I know I was busy but still…I know I'm not that experienced but I know what to do, I know how to assess a patient…*
> [PRHO]

Interviewees often perceived that the CCOS were taking on the role of a junior doctor which many felt was a necessary change due to the absence of doctors from the wards and the inability of nurses to contact them or get then to attend the ward when needed. However, doctors often felt sidelined, left out, or, at worst, undermined. Much of the negative feedback was related to the changing roles of junior doctors.

Patient ownership
At some study sites, interviewees and informal participants discussed patient ownership. It was reported that, at times, the medical or surgical team responsible for a patient's care objected to the input from the CCOS. The reason given being that they were unwilling to relinquish overall responsibility for their patients. One doctor referred to the CCOS as the "critical interference team" while another Registrar was overheard advising a junior doctor "tell them [i.e. the CCOS] to fuck off".

Finally, one comment was that there can be too many different specialist services looking after patients. These add too many different perspectives, which simply ends up being daunting for the patient

> *It is possible, sometimes, to have too many strands looking after one patient. So there'd be the nursing staff, the surgical team, the critical care outreach team, then you could involve the medical team… I think, sometimes, that can be frightening for the patient because they could have their ward nurse looking after them at the bedside as well as the senior nurse for the ward, an outreach nurse, three doctors and it's almost, you have to say "right, stop, let's - someone's got to walk away from this, someone's got to give the patient some space"*
> [F Grade Nurse, Ward]

It may indeed be that, on occasions, the CCOS is merely adding to the number of people around a patient without necessarily effecting a qualitative change in patient care.

Positive impact of the CCOS on the wards

All interviewees, from the wards and critical care unit, gave their views on whether the hospital had benefited from having a CCOS. Interviewees suggested that the biggest benefit was the support provided by the CCOS for nurses on the wards. Other positive benefits included: reassurance and empowerment; improved patient care; improved assessment and triage; and multidisciplinary working.

Reassurance and empowerment
Reassurance was a recurring theme. It was felt to be crucial to empower and enable ward nurses, make them feel less alone and increase their confidence. One CCOS nurse suggested that ward nurses had been given more confidence in dealing with critically ill patients, so were less likely to panic. Whereas, there was much discussion about deskilling, in contrast, a number of interviewees referred to the CCOS as "up-skilling" ward nurses:

> *I think I'm more skilled because I'm more educated as to what's going on. Like, the other day, they anaesthetised and intubated somebody on the ward and I was just an innocent bystander as it were … The person who'd come up with the outreach team, that evening, was explaining everything, each step of the way. I felt better for it. I felt more educated, more enlightened and I was more aware of what was going on. So, to me, it was a gain.*
> [E Grade Nurse, Ward]

When interviewees suggested that they felt supported, or there was more support as a result of the CCOS, they were most often referring to the reassurance provided in many ways. For one F Grade nurse, it was the reassurance provided for ward nurses when a patient is discharged from the critical care unit on to the ward, which helped alleviate fears. While for an H Grade ward nurse, support also meant empowerment suggesting that support increased confidence and enabled use of skills more effectively, including skills gained during formal and informal education. During the observational research, much support and reassurance was evident on the wards, for

example, where ward nurses were unsure of how to proceed with a patient's care or were unsure how to use a piece of equipment.

> *I think… knowing that there's somebody on the end of the 'phone that will come and help if you need them, knowing that person's there just makes all the difference.*
> [F Grade Nurse, Ward and CCOS]

An H Grade ward nurse suggested that this would serve to improve patient care:

> *I think it's been great for the patients. Because, as I say, we're empowering the nurses to actually do the job properly or increase their skills and knowledge to look after the sick patients and we do know that we don't have fit patients any more…So, they actually do get to practice their skills quite a bit now.*
> [H Grade Nurse, Ward]

A number of ward nurses felt that the main strength of the CCOS was just having someone there to provide advice. Especially, as many found it easier to communicate on a nurse-to-nurse level. They suggested that it was less embarrassing than talking to a doctor who made them feel silly. On the whole, the CCOS nurses were perceived as being much more approachable.

> *I've got no critical care skills. I wouldn't be ashamed (and I'm a G Grade) to say "I don't know what to do, can you come and help me please?" It's nice to have somebody you can ring and say "I don't know what to do can you give me ideas", bouncing off ideas…*
> [G Grade Nurse, Ward]

Junior doctors also reported that the CCOS provided them with support, helping them increase their knowledge and that improved multi-disciplinary working was an outcome. Ward nurses made similar comments reporting better support, especially to less experienced or skilled staff, more multi-disciplinary working and the provision of more help on the wards, when necessary.

Interviewees, especially ward nurses, felt the CCOS had impacted positively on staff morale. For example, staff were being given the opportunity to attend courses (where previously they had not) and be educated; they felt more confident. It was also suggested that morale was being boosted simply because the CCOS were now there to advise and support and that there was easier access to critical care unit nurses.

Improved patient care
It was widely believed that patient care had improved. The timeliness with which the CCOS responded to calls for help or assistance was mentioned during interviews and informal conversations. A large proportion of interviewees thought that the CCOS was quick to respond and happy to give assistance; even if, in the end, the patient did not need critical or high

dependency care. One G Grade, critical care unit nurse felt that the provision of formal and informal education had produced improvements in the appropriateness of calls to the CCOS. This was reiterated by a consultant who stated that, as a junior, he had had no idea what a seriously sick patient was like but the juniors today are much better equipped.

Interviewees (both nurses and doctors) reported distinct improvements in continuity of care. For example, ward staff were now more likely to relate information about patients back to the critical care unit as they had greater understanding of their role and function, not just in the hospital but for patients after discharge from the critical care unit.

> *I think that since the outreach and the follow-up [started], it's like a proper finish, a proper end to the care that we started on ICU really. Instead of just leaving the ward staff to deal with still poorly patients, who not only have got physical problems but they're confused and agitated,…and then the pressure was on the ward staff because they then had a confused and agitated patient falling out the bed and things. And so, at least, with outreach input there's been the support…*
> [Nurse, Critical care unit follow-up]

Several interviewees suggested that the CCOS improved patient care at night, by providing a 'point of contact' for ward nurses who could be in difficulty using a piece of equipment or just needing some general advice on patient management. CCOS could also assist by giving medication and by improving links with the doctors at a time when hospital staffing is at a minimum. It was expected that this would lead to more appropriate referrals both to the CCOS and CRITICAL CARE UNIT. At all study sites staffing levels were lower during the night, with more junior doctors being on call and less experienced nurses covering night shifts. As mentioned in section 5.3, there were differences of opinion as to whether a 24 hour CCOS was necessary, but those that had one did state that there was a benefit. For example, a CCOS matron stated that the sickest patients' location in the hospital could be more clearly identified.

One of the most important claims for CCOS was that the presence of a CCOS saves lives. While there was little robust evidence about this, one critical care manager stated categorically that there had been measurable improvements in saving patient lives, among other beneficial outcomes:

> *I think in terms of just looking at pure patients and the number of patients that have been saved as a result of outreach intervention, I think that speaks for itself. Re-admissions down into ICU has improved; I think the knowledge and skills that ward staff now have and confidence in managing much more difficult patients than previously also speaks for itself…*
> [Manager, Critical care]

The general belief was that, in the past, a lot of patients did not have the opportunity to go to the critical care unit and that they simply died on the ward; once the CCOS was established, they could at least be identified. Taking this

a step further, one CCOS nurse confidently claimed that the CCOS had contributed to a reduction in lives lost:

> *We continually, year on year, see a reduction in cardiac arrests in this hospital. And I can't claim responsibility for everything but it just seems coincidental that, with the increase in the Do Not Resuscitate Orders plus patients being able to get into intensive care earlier or being sorted out on the wards, you know, I'm sure we have an effect.*
> [F Grade Nurse, CCOS]

Later in the interview, she linked the reduction in cardiac arrests with an increased awareness on the wards. Thus, despite recent increases in the number of patients seen by the hospital:

> *The Cardiac arrest calls are still dropping… even though the population is going up and there's more and more throughput... There's [also], perhaps, a realisation on the wards to look out for the sicker patients, certainly, that there's someone that they can go to for help.*
> [F Grade Nurse, CCOS]

One speech and language therapist felt that the CCOS had not only improved patients' physical care post-critical care but also their psychological care:

> *[Interviewer: So you think patient care has been the biggest change and basic care has improved?]*
>
> *Indeed, yes. Not just in terms of clinical, medical symptoms and management but also in terms of psychological management. I think the team has really raised awareness with staff on the wards…of just how debilitating a stay on ICU/HDU can be and they need to call in specialist help and instigate appropriate treatment for psychological difficulties.*
> [Speech and Language Therapist]

One SHO described his own experiences of working on wards prior to CCOS. He acknowledged that there had been times when he had felt out of his depth with very sick patients.

> *I suppose, when I was a medical house officer and [we] didn't have an outreach team, …I got excellent experience… But, looking back now, there may have been a few patients that… would have been better managed had the outreach been around, simply because I wasn't experienced enough to necessarily flag up who was, and wasn't, in dire straits… Certainly,… a couple of times, the registrar turned up later on to review someone who I'd asked him to come and see, and have him say "let's call ICU".*
> [SHO]

He went on to say that now sick patients are identified and treated in a much more timely fashion as there is a much better link to the critical care unit.

Improved assessment and triage
Much of what CCOS do in hospitals may be seen as provision of assessment and triage. This was seen as one of the biggest benefits of having a CCOS. For many interviewees, the role of assessment or triage was the most important, and for doctors the most acceptable, CCOS role.

> *They're looking at that patient and they assess them. They assess them with you. And, then what often happens is they'll get on the 'phone to their Registrar which, of course, is not our job as nurses to do. Our doctors have to feel the element of urgency in order to contact the critical care unit Registrar themselves and say right I'm really not happy about this patient. But, the outreach nurses can do that, 'phone up the Reg, the Reg comes up and looks at the patient. So, what could take twenty-four hours potentially in a poorly handled situation, only takes four or five.*
> [E Grade Nurse, Ward]

Multidisciplinary working
AHPs, primarily, alluded to perceived improvements in multidisciplinary working brought about by the CCOS. One physiotherapist explained succinctly:

> *I think it's helped staff and patients to have a team of people from different areas who come to the same patient but from different angles.*
> [Physiotherapist]

The forming of alliances with other disciplines was discussed by a number of interviewees. A number of hospital employees - physiotherapists, dieticians, clinical educators, acute care managers and consultants - appeared to be very supportive of the CCOS:

> *All the hiccups that we've had, throughout the days, have been sorted by our very supportive ward manager. She's a modern Matron-type post who's very for the CCOS. And we've got a Chief Nurse, who's also our Directorate Manager, who's also very keen to develop the CCOS. The critical care unit consultants are sceptical of the service but, every one of them, when I have gone to them with a problem with a patient on the ward has been supportive. So, as much as they don't always agree with the principles of outreach, they've never let me down when I've needed them.*
> [I Grade Nurse, CCOS]

All grades of doctor suggested that the CCOS provided support and guidance for junior doctors and most of the junior doctors, interviewed and spoken to informally, agreed. Several interviewees, especially junior doctors, suggested that the CCOS had increased their knowledge and confidence and were invaluable when the senior doctors were hard to contact.

Lack of impact

Several areas were identified where the CCOS appeared to have made no impact where some impact might have been expected. These were considered to be ongoing issues by several interviewees. The most commonly reported problem was with how well sick patients were identified. Although some interviewees felt that there had been significant improvements since the introduction of the CCOS and TTs, the vast majority reported that identification was extremely variable from ward to ward and, at times, from nurse to nurse. Lack of impact was identified as being due to: lack of skills; poor communication; and specific issues with TTs and response algorithms or protocols.

Lack of skills
CCOS staff often reported knowing which wards were good at monitoring patients, using the TTs and calling CCOS, and which were not so good. One G Grade nurse stated that there were times where she had been called to see a patient who turned out to be fine but while she was on the ward she came across another patient who had a high TT score and was obviously very sick. Other CCOS nurses concurred, adding that they often worried about how many patients they were missing. A CCOS matron suggested that there were particular areas that were still frequently missed, for example, fluid balance charts and respiration rate. One AHP felt that calls were made late, with patients still being found in extremis, particularly on care of the elderly wards.

One physiotherapist felt that problems were missed due to the lack of skills of not only nurses but also junior doctors. Although she didn't feel there had been any significant improvements, she didn't feel it was any worse than it has always been.

Poor communication
A range of communication problems were described. Several CCOS staff said that either the ward nurses did not communicate with each other (e.g. HCA to qualified nurse) or they did not communicate problems to doctors, or doctors did not respond to their requests, or problems were not communicated to the CCOS. One nurse consultant stated that communication was related to the politics and hierarchies on the wards.

> *If you talk to the health care assistants they'll say I told the staff nurse and she didn't act. Talk to the staff nurses and they'll say the health care assistants don't talk to me… We've said to the health care assistants that they can phone us… but I've never ever taken a call from a health care assistant…I think that's the hierarchical thing… because I suppose realistically the qualified nurse is their boss, the senior, so it can be… difficult.*
> [Nurse Consultant, CCOS

A student nurse, who was on placement with one CCOS, felt it was important for the CCOS to be proactive and for them to spend time on the wards to improve communication among the staff on the ward. He witnessed occasions where CCOS staff had come across patients triggering on the ward, but the CCOS had not been alerted.

Several CCOS staff were unsure why they were unable to gain a foothold on certain wards, while being welcomed on others.

> *It's quite frustrating that I'm having to constantly, not with all wards, some wards are different but some wards, go on to the ward and the patient's been triggering for days and they didn't know anything about it. And then you look and it's quite obvious something needs doing and it's not been done… Most wards know who I am and I just think they don't think that's my role …We need to do a bit more advertising about what our role is, so that we do get contacted sooner rather than later.*
> [F Grade Nurse, CCOS]

Another theme was that of pressure on ward nurses due to low staffing levels, lack of experienced nurses, and the high level of demand placed upon them. Junior nurses appeared to routinely look after large numbers of patients while, usually unqualified, HCAs took patient observations. If a ward then has the added pressure of having a triggering patient who needs their observations checked every hour, it can be difficult to juggle all the responsibilities; workload could be doubled by having to commence hourly observations.

It was felt that the identification of deteriorating patients, or the response to a correctly identified deteriorating patient, was variable. One D grade nurse suggested that patients were not brought to the attention of the CCOS in a timely fashion, while another felt identification was good in the wards which used trigger scores. An F grade nurse felt that it was necessary for the senior nurses to be vigilant to ensure timely referral, but thought that problems occurred at house officer level, as they lacked experience and confidence about the right time to call for extra help. This was a sentiment repeated by other interviewees. One consultant stated that, despite observable improvements in the identification of sick patients, it was still difficult to know whether patients were being missed.

A critical care manager suggested it was all about the perception of the role of CCOS; ward staff should utilise the input from the CCOS as a learning opportunity and the chance to work closely on a problem in order to increase knowledge but not see it as a service that comes in and resolves their problems.

> *We wanted to empower the ward staff, the medical and nursing staff, to look after the patients without us having to intervene. Unfortunately, the way that it works, is that the ward staff, whether it's confidence or skill, isn't at a level it needs to be with these sick patients and the patients are getting sicker. So, the result is that we do end up having to intervene more. So, that's why we're having to look at expanding the service to have one that is going to be more able to support them twenty-four hours, seven days a week because otherwise they're going to suffer. So, at the moment we're doing what we actually set out to do well but what we're seeing is there's more to it…*
> [G Grade Nurse, CCOS]

From interviews and informal discussions, it was apparent that there were a number of issues at each study site and none of the hospitals visited were one hundred percent happy with the CCOS. Ward nurses often made conflicting statements, sometimes they liked the CCOS to come and take over the care of sick patients so alleviating the pressure on them while, at other times, reported that they didn't want to be judged, criticised, made to feel incompetent or pushed to one side. The impression was that the CCOS needed to be interventional (in terms of being proactive and facilitating timely treatment) without taking over and deskilling the ward staff.

TTs and response algorithms or protocols
A large proportion of interviewees reported that the identification of sick patients had significantly improved since the introduction of TTs. Any lack of impact of TTs and response algorithms or protocols was attributed to: lack of completion of TTs; inaccurate scoring of TTs; inaccurate interpretation of TTs; contacting medical staff; and over-reliance on TTs. These are addressed in Section 3 of this report.

Changing relationship between the ward and the critical care unit

Many interviewees discussed ways in which the CCOS had changed relationships between the wards and the critical care unit. In the past, it was reported that the critical care unit operated very much in isolation and had little contact with staff on the wards unless they were asked to review a patient for admission to the unit. Critical care unit nurses might provide telephone advice, or set up specialist equipment, but contact between the two groups was limited. Critical care unit nurses were stereotyped by ward nurses as aloof with ward nurses stereotyped by critical care unit nurses as incompetent. Although most critical care unit staff, especially junior nurses, had no more contact with wards than before, to a limited extent, the stereotypes were changing:

> *It does break down some of the barriers from the ward and the ICU. There's always been a perception that ICU staff think we're (ward nurses) stupid and we don't look after patients properly. The ward staff think that they (ICU nurses) don't live in the real world because they don't have ten patients per shift sort of thing. I think that's broken down a bit.*
> [F Grade Nurse, Ward]

Other interviewees reiterated that the CCOS was breaking down barriers between the wards and the critical care unit (creating "critical care without walls"). One CCOS nurse suggested this was about better communication and improvements in multidisciplinary working, especially in providing a crucial link between the ward nurses, doctors, AHPs and other specialist nursing services.

Demystifying the critical care unit

It was also claimed that the critical care unit was a less mysterious place:

> *I think the biggest change has been in demystifying ICU, as in ICU was always seen as a unit away, with closed doors, and I think we have taken that, we are taking that, perception away…by seeing somebody that is ICU trained or has critical care experience actually on the ward…*
> [H Grade Nurse, CCOS]

Ward staff were much more likely to see the barriers to the critical care unit coming down, stating that they were less afraid to 'phone the unit if they needed to. Although, there were still a significant proportion that did not feel they knew any more about the critical care unit than prior to the CCOS. Junior ward staff, for example, remained intimidated by the idea of the critical care unit. One CCOS nurse felt that the CCOS had broken down the barriers between the ward and critical care unit sufficiently to encourage ward nurses to seek jobs within the unit and see it as a viable career progression.

Enhancing critical care unit understanding of the ward
Conversely, some CCOS staff commented that their retention of links with the critical care unit had the important result of giving critical care unit staff the opportunity to see for themselves what it was like to work on the wards and how difficult it was for nursing staff "out there". Some nurses stated that it had opened their eyes to conditions on the wards and made them appreciate how lucky they were to work in the critical care unit.

Results – the impact of CCOS on the critical care unit

The CCOS was perceived to affected referral patterns. This included, in some cases, an alleged increase in appropriate referrals although, on the whole, most comments reflected the view that the CCOS was: changing admission patterns; improving post-critical care unit care; and influencing critical care unit practices and morale. In addition, the view that communication and information transfer between the critical care unit and the wards had improved was expressed by critical care unit staff as well as ward staff.

Changing admission patterns
It was suggested that there was a noticeable change in critical care unit use:

> *The ICU is actually pushing through more patients…whether that's got anything to do with us stopping other patients coming in, blocking those beds, I don't know but I think that's part of it.*
> [F Grade Nurse, CCOS]

Interviewees commonly reported changes in admission patterns as having a big impact on the critical care unit. Some suggested that admissions were more timely since the CCOS began. This was attributed to CCOS nurses seeing the patient quickly, in the first instance (formerly, junior doctors had often simply had too many patients to deal with), and then being able to communicate directly with the critical care unit doctors.

> *Ward nurses will bleep outreach if they are worried about a patient… The outreach sister will go and see a patient very promptly and then, if they are worried, they will get an intensivist …and I think that's invaluable…we seem to get fewer patients who are absolutely in extremis…*
> [G Grade Nurse, Critical care unit]

An accelerated admissions process was also attributed to CCOS nurses having greater influence on ward doctors.

A large proportion of interviewees felt that admissions to the critical care unit were being averted. Providing timely nursing interventions on the ward was, according to many interviewees, the most important way of averting critical care unit admissions, especially if the CCOS were able to support them in initiating treatment sooner.

In general, at most of the study sites, the requests received from the CCOS were viewed as appropriate and a great deal of trust was instilled in their judgement

> *Consultants are getting more and more amenable…because they now know that, if they get a referral from the outreach team, it's going to be something very sensible so they will go up…If the CCOS nurse wants a bed on HDU, the nurses there will make a bed for her. Because, they again, once …the outreach team feel that a patient needs to come down, they will make a bed available.*
> [Manager, Critical care unit]

It was commented that CCOS nurses made good use of high dependency areas, for example, admitting patients to HDU for a short period rather than transferring them to the critical care unit.

Several interviewees suggested that inappropriate, critical care unit admissions were reduced due to the CCOS input into DNAR discussions. This was mentioned by a number of ward and critical care unit nurses and doctors. One critical care unit doctor felt that critical care unit admissions were thought about more carefully since the CCOS had been established (although, she was unsure whether this had translated into a reduced number of admissions).

While acknowledging that discussions about the appropriateness of resuscitation or the limitations of critical care are difficult, averting inappropriate admissions was regarded as a very important area of work for CCOS.

> *I think this is one of [the CCOS'] strengths. I think it's hard to sort out patients that are deemed not appropriate to admit [to the critical care unit], you know, patients that are end-stage, lung disease or renal disease, and I think they often … try and get the teams to decide what*

> *they want for that patient and what is most appropriate and best for the patient…Making a decision about not resuscitating or making a decision about limits of critical care.*
> [G Grade Nurse, Critical care unit]

So, in some instances, the role of CCOS could be conceived as educating patients, relatives and staff about the limitations of critical care – and that this may not always be in the patient's best interests.

Not all critical care unit staff felt that there was a reduction in referrals. Some were sceptical simply for the lack of recorded evidence; one consultant felt admissions had increased as the CCOS were now identifying patients on the ward who previously may have died on the wards:

> *I think, because there's a lot of patients who would otherwise languish on a ward and possibly succumb on a ward who have now been identified and admitted to ICU… It's just that, before, we never knew about it and now we do…*
> [Consultant, Trauma]

In this case, the increase in referrals is deemed appropriate. In contrast, some doctors felt that there had been an unwarranted increase in critical care since the inception of the CCOS. For example, one critical care unit consultant felt that there had been an increase in inappropriate critical care unit admissions and that the CCOS had created unnecessary work. It was also commented that patients were arriving on HDU without really needing to be there simply because the CCOS nurses wanted them to be there.

Some critical care unit doctors disliked the change in referral patterns (from consultant-consultant referral to CCOS nurse-consultant referral). It was apparent that some felt that it should be the job of the junior doctor to care for sick patients on the wards as a member of the medical team; the direct clinical, or organisational, intervention of the CCOS was seen as a problem:

> *In the past, where we would get the call ourselves, directly from the medical consultant or surgical consultant, we now get calls from outreach or even, sometimes, from the trainees themselves on the wards. Now, I would prefer the referral to have been from consultant to consultant, like in the past… Now it tends to be trainees calling, very junior trainees calling, the outreach team, outreach getting involved and they call us without the consultant knowing about the case … I don't think that's how it should be.*
> [Consultant Anaesthetist, Critical care unit]

Improving post-critical care unit care

The general opinion was that post-critical care unit care had significantly improved and it was now safe to discharge some patients sooner than previously. This was illustrated by considering the care of patients with a tracheostomy:

> *I think there's such a lot of pressure on ICU beds that patients may be discharged to a level of care that probably isn't experienced enough to deal with them, particularly when there's a tracheostomy in place…Our ward nurses are not used to tracheostomies and are very frightened of them, so trache- care is very important post-ICU discharge.*
> [Medical Consultant]

Several stated that improvements were to be expected because there had not been any post-critical care unit care prior to the CCOS. Several interviewees suggested that improvements were simply due to having someone come and keep an eye on ex-critical care unit patients for however long they needed to be seen. Study sites had varying time spans for which they would follow-up patients, for some this was 24 hours while others continued until the patient was discharged from hospital. Generally, it was felt that continuity of care had improved.

Several participants claimed to have evidence that they were saving lives, for example, a decrease in post-critical care unit mortality. This had an additional benefit of raising the critical care unit's profile in the hospital.

> *With the ICU discharges, we've nearly halved post-ICU mortality from twelve to seven percent… The effects it had were it raised the profile of intensive care around the hospital and came to be seen as much more user-friendly, helpful organisation than it had been before…its now a very popular place to work.*
> [Consultant, Critical care unit]

It was suggested that critical care unit discharge procedures had been changed since the inception of the CCOS. In one case, a hospital stopped non-emergency, evening discharges from the critical care unit after a CCOS audit found that patients discharged during the evening or night time were more likely to encounter problems (partly because staff were unable to support them on the wards). Another nurse described the impact on discharges:

> *It has definitely had an impact in that… we've improved our rehabilitation. We've started using tracheostomies slightly differently, so that has definitely made an impact.*
> [G Grade Nurse, CCOS]

The CCOS also provided, for critical care unit staff, an indirect reassurance about post-critical care unit care. The support provided by the CCOS to ward staff and also felt, to some extent, by patients and their relatives, in turn meant

that critical care unit staff were reassured and could reassure patients and relatives before they moved from the critical care unit to the ward:

> *I think, for patients … they're used to such high one-to-one nursing care, where everything is done and it's like they cough and someone gets them a tissue or something is done for all the time, I think that when they go, even to the high dependency unit, there's less nursing staff, there's less medical staff around and, I think, there is just a link back to sort of say, [you're] not on [your] own… I've had patients that are afraid to sleep because they're worried what's going to happen and I think we can actually reassure them just to say you've still got the ICU link coming to see you, you're getting better, and give that reassurance.*
> [H Grade Nurse, CCOS]

The provision of a link back to the critical care unit for patients and relatives was clearly valued, as was the support given by the CCOS which enabled patients to occasionally be discharged from the critical care unit early (for example, when there were pressures on unit beds). Improving ward staff's understanding of the type of care, treatments and procedures patients have undergone in the critical care unit was also regarded by critical care unit staff as a positive outcome from CCOS.

Several interviewees felt that a big impact of the CCOS was that there was a better transfer of information back to the critical care unit. This improvement in information was seen, not only in potential admissions, but also in former critical care unit patients. Several critical care unit nurses commented that formerly, once a patient had left the unit, there would be no news about them. However, since CCOS had been established the nurses had been more able to retain contact once they had recovered and were returning to "normal life".

> *[Critical care unit nurses] love the follow-up, they're always asking us who's doing what, how's the patient getting on. If they can, they come out with us and see how they are, so the follow-up aspect of it's really good*
> [G Grade Nurse, CCOS]

This is understandably a very personally, rewarding outcome from CCOS for critical care unit nurses.

Influencing critical care unit practices and morale

Interviewees and informal participants suggested that the CCOS often took some of the pressure off the critical care unit by providing advice and assistance to the wards. Critical care unit nurses and doctors stated that, prior to the CCOS, they were often telephoned or called out to wards to provide advice, see patients, or help set up equipment. A number reported that this no longer happened thus, allowing critical care unit staff to get on with looking after the patients on the unit.

Morale in the critical care unit was improved, with one critical care unit manager suggesting that the CCOS had provided an additional career

pathway to follow which helped in retention of senior critical care unit staff. Simply joining the CCOS had enabled them to stay within the hospital, use their critical care skills, but be doing something different.

More negatively, some interviewees argued that critical care unit nurses were under more strain, especially where they were expected to rotate on to the CCOS. Some felt that the workload of critical care unit doctors had increased, as more patients were being seen by the CCOS and, consequently, there were more requests for the doctors to provide patient reviews. These comments were primarily made by doctors who felt that their personal workload had increased, although they often conceded that the requests to see patients were generally appropriate.

The integration of the CCOS into the critical care unit was seen as important by some interviewees. One SpR suggested that it was a lack of this integration which had meant that CCOS had not fulfilled expectations:

> *[The CCOS] it came in with great excitement. It was going to make a big difference… but, subsequently, been disappointed that they haven't. There's no real evidence that it's making a huge difference. I don't think the integration into the intensive care is as good as it could be because I think a lot of intensive care consultants, rightly or wrongly, probably wrongly, feel relatively unsupported by the CCOS and so it's stopped it progressing.*
> [SpR, Critical care unit]

Results - the impact of CCOS on patients and their family

The impact of the CCOS from the perspective of patients and their families, including care received while an inpatient, provision of follow-up care post-discharge and the CCOS' interaction with patients' families is examined. Interviewees discussed: memories of; identification of; reassurance from; knowledge and information of CCOS.

Memories

Many of the patients and family interviewed had no memory of the CCOS. Family, in particular, were less likely to have been present when the CCOS were conducting ward rounds so, unless patients informed family about the CCOS, it was unlikely that patients' family would know anything about the CCOS, let alone meet them. When they did meet, the encounter was often fleeting:

> *My initial response, when we got onto HDU, was to concentrate on the nurse who was going to be looking after him…and I then remember that the Sister came and checked on him, he'd been down there about an hour or half an hour. She only introduced herself very, very quickly but I think she probably was from the outreach because she said I follow-up people who have been on ICU. And I haven't seen her again, so I imagine she was working for outreach.*
> [Family member]

Patients, even where CCOS nurses reported having a lot of contact with them, did not necessarily remember the CCOS. Some patients were still under sedation or were quite ill when they returned to the ward and so were unaware of what was going on around them. Some stated that they were visited by so many different people that it was difficult to work out who was who:

> *I can remember [the CCOS] coming to see me [but], if you try to tie me down to dates then I wouldn't have a clue. I think they might have come to see me on a couple of occasions [but] there was so many people coming to see me like the physios and, obviously, the doctors making their rounds*
> [Patient]

Not knowing who the health care workers around their bed were could make patients feel quite vulnerable.

Identification

Patients mentioned that it was important that CCOS nurses introduce themselves. Some interviewees felt that the CCOS nurses should have clear identification of who they were, as the following patient and his wife suggested:

> *Patient: There was no badge or no identification on them which would help.*
> *Family member: I think that you need to have your identity clear because certainly I've been on the scene pretty consistently and I hadn't been aware of who they were, but it's a very good idea*.

From the patient's perspective, there was considerable importance in knowing who the health care workers, who gather at the end of the bed, were. Being seriously ill in hospital can be very disempowering; not knowing who people were and not being introduced, only adds to the feelings of being out of control. Many of the patients and relatives interviewed thought that CCOS' visible identification could be improved.

Reassurance

For a great deal of patients and their families, the reassurance provided by the CCOS was the most important part of their job. Reassurance included both physical and psychological support. Several patients mentioned being scared or concerned about returning to the ward and they hoped that the CCOS could alleviate this distress. It is clear that leaving the critical care unit, and leaving one-to-one nursing care, can be very stressful. Patients suggested that they felt relieved knowing that the CCOS would be following them up although, on occasion, they would have liked earlier CCOS support:

> *I was used to one-to-one nursing and quite terrified of coming up to the ward and they told me that the outreach nurses would come and see me and I felt a lot better about that… The first day they said you'll*

> *probably be going up to a ward tomorrow. I never slept that night…I was terrified. They kept saying you'll be alright, you'll be alright, it's a lovely ward, the nurses are lovely and, you know, you have an outreach nurse…I was still frightened and I wished that the outreach nurse had actually come up with me for a little while just to settle me in.*
> [Patient and Family member]

Reassurance for patients and their family was provided in several kinds of ways, particularly psychological reassurance:

> *I think the [CCOS] nurse, yesterday, picked up some of [my husband's] problems, particularly the stress levels that he was suffering. And she tried to keep explaining to him that it was perfectly normal to feel how he does, he's lost time, how ill he really was and what happened…, it's not that you're going mad, it's just how the drugs you've been given in ICU affect you. How you feel about yourself and your memory… she was very effective and certainly she reminded me not to get stressed…*
> [Family member]

Reassurance was provided, not only for patients post-critical care unit, but also for those seen by the CCOS without being admitted to the critical care unit, as illustrated by the following patient and her husband:

> *Patient: I wanted to go to intensive care but I think this was better because they brought it to me. You know, I didn't have to move around so much, they just kept coming to me and monitoring me and they would then do the service that they had to do without having the palaver of all the equipment and moving around.*
>
> *Family member: I had mixed feelings about it. In one sense it was explained that if she'd gone to intensive care then they would have had all the equipment there if something had gone wrong and it was all precautionary so that was reassuring… Fortunately, as it happened, there weren't any complications, we didn't need any extra help in our situation, probably better to be here and have the care coming to us.*

As has already been touched on, patients' mental health and psychological well-being were well supported by CCOS, even if just cheering up patients:

> *They're really friendly, courteous. They're nice nurses, they're not serious like most nurses are, you know, ooh, you know, you're ill, so you must be down in the dumps but these outreach nurses they have a laugh*
> [Patient and Family member]

A large proportion of patients and relatives stated that they found the nurses relaxed and easy-going, making jokes and keeping patients spirits up. Patients also felt that the CCOS nurses had time for them; they explained things well and were knowledgeable and informative.

Knowledge and information

One patient, who was not admitted to the critical care unit but treated on the ward, suggested that it was CCOS nurses' specialist knowledge which enabled them to remain calm.

> *Family member: I think there's two aspects that I found useful, having somebody coming round like that. First of all, there's the reassuring bit, that's a lot I think towards the recovery.*
>
> *Patient: It's also the knowledge that she could bring…*
>
> *Family member: Well, that's right. I mean she had the knowledge, she knew the case. She knew exactly what was going on because she had the technical knowledge, the nursing knowledge. Also, if we were concerned about something, she could go and see the nursing staff. She had the clout to get something done…It's the reassurance backed up by the knowledge that she was able to explain all the technicalities exactly what was going on which we appreciated more.*

Talking and providing information about what is going to happen, and why things have happened, provided patients with an enormous amount of reassurance:

> *… when I actually came up (to the ward), I was on my own and didn't know anybody, didn't know any nurses. It wasn't too long before somebody came up, one of the outreach…she was very nice and wanted to take my trachy out and I was absolutely terrified. But, she sat with me and said just ten minutes and we'll put it back in if you're not happy or uncomfortable, it'll go straight back in, and she sat with me the whole time, which was nice. And then, the next day, she came, she took it out. She said I'm only going to be at the desk. If you feel any discomfort, I will stay here until you're sure that you can breathe OK on your own, which was really, really good… Knowing that she was on hand there… She sat there writing her notes and she kept looking up at me…[The CCOS] really are a good help because they know everything about the patient and you know, it settles them in* [Patient and Family member]

CCOS nurses were commended for being explain things well,

> *Patient: [An Outreach Nurse] explained about the morphine and explained about the PCA's, the button you can shoot yourself with the morphine as you needed it because at first they just gave me a lot of morphine…and then afterwards she explained that I could just inject myself or just self administer the morphine.* [Patient and relative]

Patients and relatives also referred to the CCOS nurses as being informative; this could be either while they were in hospital or as they were being discharged home:

> *And they gave us a kind of pack after she left hospital about how you'd feel after being in intensive care, or how you could feel…You know, your appetite and things like that…and about mobility as well*.
> [Patient and Family member]

Several interviewees mentioned that the CCOS helped with their mood and provided psychological support by providing clear information to help them understand why they were experiencing symptoms, such as, nightmares.

Importance of contact with patients and family members
Responses from hospital staff concurred with patients and family, in that, interviewees generally felt that there had been little or no increased contact with patient's families (either pre-admission or post-discharge). Similarly, ward and critical care unit nurses had usually not witnessed the CCOS interacting with family. CCOS nurses stated that they did not always meet family on the ward, either due to limited visiting hours or because the times they carried out their observations differed from visiting hours or just that they were very busy. Some CCOS nurses did not see talking with families part of their remit, although this was definitely a minority view.

CCOS nurses had more contact with family if the patient had been in the critical care unit for a long time. Where CCOS nurses worked closely with the critical care unit, contact with family was also more likely, as they may have met on the unit (while working as a critical care unit nurse) and again on the ward (as a CCOS nurse). There were several comments as to why it was felt that the CCOS improved contact for family and why it was also important to provide family with support:

> *[In a study], we showed that patients relatives were equally, or if not more, anxious than the patients after a few months post-ICU. We can offer them our phone number and they can contact us if they're worried. And they do occasionally contact us but if we've got a concern about them we [refer to] the GP.*
> [G Grade Nurse, CCOS]

> *I think we have learned, through the years, that the relatives are a vital aspect to the care, especially when you've got a patient that's been in quite a long time. [The Occupational Therapist], especially, has done some counselling or anxiety management with the family, rather than the patient, because they're suffering in some ways just as much…*
> [Physiotherapist]

> *The relatives of survivors, in general, have much less communication with ICU staff because there are often lots of discussions revolving around the death of a patient, where the relatives get involved in withdrawal of treatment … in family conferences… Whereas survivors, because they're sort of getting better, nobody really bothers. They say, oh yeah, everything's OK, they don't really get any depth of conversation and information that the dying people get, so they're often*

> *left quite short changed…*
> [Consultant, CCOS]

Some families were explicitly told about the CCOS, their provision of follow-up on the wards and the type of care they would provide for their relative in order to alleviate their anxieties.

A number of interviewees stated that they felt the provision of support for relatives – discussing issues and care with them and providing reassurance – were all explicit parts of the job of the CCOS. Some CCOS nurses suggested that, because they were perceived as being very senior, this helped reassure relatives. Others felt that they improved communication between staff and families, telling them what is going on, if their relative is very sick.

Interviewees also commented on the improvements in communication for patients and their families, going on to suggest that the CCOS facilitated the passing of information to patient's families and the CCOS has provided relatives with an additional person with whom they can discuss their concerns:

> *It's got to benefit the patient because there is somebody there, giving more support to the treatment of the patient…I think, in the past, when people became ill, the nurses on the ward wanted them down in intensive care and flew out the door as quick as they could. Whereas, now I think, it's obviously better for the patients, because there's more verbal explanation for them, as well as reassurance. And maybe not having to go to intensive care, but even if they do, I think there's more explanation and reassurance as to what's happening to them …And, I think (when they are discharged back to the ward), they're also more likely to say to the outreach nurse if they're not alright because you've made contact with them. Whereas, they would perhaps be a little hesitant to complain to the ward nurse because, they've just arrived in this environment and it's new and they don't know them.*
> [Bed manager]

Results - the impact on sharing skills

Comprehensive Critical Care identified education and skills sharing as one of the key roles of CCOS but the type of education and skill sharing, formal or informal, were not specified. The balance between formal and informal education, the perceptions of education from both the CCOS and ward staff and the limitations of education were explored.

Balance between formal and informal education

Numerous instances of CCOS nurses actively training ward staff were observed. One example was where a patient on a ward required CPAP and the ward nurse was not familiar with how to set it up. The CCOS nurse talked the ward nurse and a colleague through setting up the equipment, all the time telling them about the machine, what it did, showing them how to use it and how to monitor the patient with it. On other occasions, CCOS staff working

with nurses and junior doctors teaching them about all kinds of equipment, passing on clinical skills, such as interpretation of blood gas results, CVP monitoring and setting up specialist equipment was observed.

A substantial proportion of interviewees reported that the CCOS at their hospital conducted both formal and informal training. However, it was noticeable, in observation, that CCOS who provided a great deal of formal training engaged in less *ad hoc* training on the wards and these CCOS were more likely to voice frustrations with ward nurses who did not appear to know what they were doing or who were not recording observations or trigger scores. Their views were that they had provided extensive training; so they could not understand why ward nurses were not using that knowledge. CCOS, with little in the way of formal training, appeared to conduct much more *ad hoc*, ward-based training, working more closely with the ward nurses, insisting the ward nurses be involved in the patient's care.

On the other hand, CCOS nurses were frequently observed taking over the care of patients, with limited interaction with the nurses on the ward. At times, CCOS nurses exhibited overt exasperation with situations they discovered on the wards and found it incredibly difficult to hide their frustrations from the ward staff. There were also times when ward nurses simply disappeared when the CCOS nurse arrived.

Some CCOS reported experiencing difficulties implementing TTs. One CCOS decided to implement a TT on a ward-by-ward basis; ensuring all staff on a ward (or group of wards) had been trained and knew how to use it appropriately before moving onto the next ward(s). Hospitals that did not take this approach reported having more difficulty getting staff to use TTs consistently and subsequently found that they had to do spend time consolidating the initial training with subsequent ad hoc training on the wards.

Perceptions on education from the CCOS

CCOS staff suggested that training was not always doing what they had hoped but were not always sure why. Several interviewees felt apathy, or lack of motivation, from ward staff played a part and there was (anecdotal) criticism of ward nurses. For example, one CCOS nurse described a situation where she had taught a ward nurse how to use the TT and when she returned to the ward two days later they had not been done at all. When asked why, the ward nurse stated that she could not find the documentation although it was right in the front of the folder.

Staff turnover on wards was identified as another problem. It seemed to some CCOS nurses that trained ward staff moved on quickly, being replaced by new staff that needed training, in a seemingly endless cycle.

One nurse consultant felt that recording observations was not the problem, but interpretation and appropriate communication of that information was still lacking. She went on to suggest that training could only work if the ward staff were able to use and practice their new skills, otherwise confidence to use them routinely was not gained.

> *…I've arrived at bedsides, I've seen people going right, ABC and doing it as they would have been taught on the [training course]. So yes, [training is working] in some respects. What stops it is confidence and I think we need to improve confidence and I don't know how we do that very easily. But that's what stops some of the care. And, if you ask people here would you have known what to do they'll say yes, but we just didn't do it for whatever reason.*
> [G Grade Nurse, CCOS]

CCOS perception was that much training worked, in theory and in practice, but trained staff were hampered by practical, organisational or communication issues. In the lengthy quotation below, for example, are described several issues which can be summed up as poor communication within and between medical teams.

> *I think the system, in terms of using simple physiological parameters to identify patients at risk of being critically ill, that works, definitely. You can almost consistently look back to somebody who's been admitted to ICU or somebody whose cardiac arrest you've had the misfortune of attending and you can see that they've been triggering an early warning score, you can see that the system works in principle. It's just what's done about it beyond a certain level. I think the person taking the score will usually speak to somebody else to let them know but what happens after that…It goes up through the chain of command, within the medical team that's responsible for patient care, but we find that it gets blocked at a fairly low, junior level and often decisions are delayed because of that… Some junior doctors are afraid to call a consultant, or the consultant's away, and cross cover consultant responsibility falls apart. So, often patients go four or five days without being seen by a consultant and, even if they are becoming obviously very ill, nobody wants to call another consultant to review them. I think there's discontinuity of care amongst consultants…*
> [Consultant, CCOS]

The strong words of this consultant were not restricted to junior or senior medical staff. The critical care unit response was also described as inconsistent. Of course, it would be wrong to make too much of one consultant's criticisms but there was, undoubtedly, frustration on the part of many CCOS that well-trained staff were being hampered by continuing systemic or organisational problems.

Perceptions on education from ward staff

Ward nurses' perceptions of the impact of training differed, to some extent, from those of CCOS. The sharing of clinical skills, in particular informal, *ad hoc* or impromptu training was appreciated by many ward staff. Many felt encouraged when the CCOS were keen to teach them:

> *They're always very keen, if you're asking questions and if you want to learn things, always to go through your stuff with you, teach you*.

[E Grade Nurse, Ward]

It was suggested that, the main strength of the CCOS was improving specialist care on the wards, especially education about tracheostomy management (for AHPs, as well as ward nurses). The majority of ward staff felt that training was extremely beneficial especially in terms of empowering ward nurses and improving basic treatment:

> *[Training] made me look and realise that I could do this and I got all me trigger scores and it taught me how to do fluid balance charts correctly and how to work out a positive and negative balance, which…I didn't have a clue how to do before I did that. All I knew was how to chart something and anything else I left to the nurses.*
> [Health Care Assistant, Ward]

This was reiterated by another nurse who felt that it was just as important to teach HCAs as qualified nurses, since HCAs were those who usually completed the observations charts. Rather than simply recording scores without knowing the meaning, the nurse commented that it was important that they were also able to interpret the scores so as to know when to pass things on to qualified nurses.

There was, though, some trepidation in relating to the CCOS. Many nurses perceived that too many questions or requests for developing skills might be wasting the CCOS' time. Although the CCOS stated that they were very willing to answer questions and provide training, in practice this was not always the case. CCOS staff were observed complaining about being asked inappropriate questions and being called inappropriately on several occasions.

Limitations of education

There was scepticism expressed about training. For example, one nurse suggested that teaching ward nurses HDU or Critical Care skills was unachievable:

> *I'm not sure I honestly believe that you can give ward nurses HDU skills in one study day. I have got questions about that goal as whether really it is achievable* [H Grade Nurse, CCOS]

Other interviewees felt that staff turnover prevented the success of training initiatives:

> *I think there's a limit to education and training benefits within a big City hospital, simply because of the staff turnover and the ability of staff to retain information from all different training courses that they go on… I wonder if people need to be more realistic about the aims of training and what can actually be achieved* [Speech and Language Therapist]

Staff shortages and the loss of senior experienced staff to specialist posts were also mentioned in this vein. Indeed, staffing issues within the CCOS itself could also affect their ability to provide training.

Few study sites provided training for doctors so consequently they were less likely to have experienced any training by the CCOS. One consultant from a study site that did provide training for doctors suggested the House Officers were the ones who benefited most and because of the training they had a much better understanding of the trigger scores.

6. Discussion

Discussion - TTs

Principal findings

There was a reported increase in the proportion of hospitals using some form of TT, to almost 100%, when compared with the Modernisation Agency survey in 2002[26] and the NCEPOD survey conducted in 2003[27]. The proportion of wards, within hospitals, reporting using a TT had also increased, with many hospitals reporting incorporating them into routine observations. Aggregate scoring systems, rather than single parameter systems, continued to be the most popular with the majority of hospitals reporting using the EWS or some modification or adaptation of it.

The proportion of hospitals reporting using a specified response algorithm in association with their TT had also increased. Most hospitals reported that more than one member of staff was notified in the response algorithm, presumably graded by risk. Response within thirty minutes was reported as the agreed response time; a balance between the ideal (immediate) and the pragmatic (achievable).

There was a variety of published TTs in use with little rigorous evidence for their validity, reliability and utility. Given that clinical decision rules should be developed using a combination of clinical judgement and statistical analysis[28], there was only one published study which derived a TT using recognised statistical techniques[29]. At present, no TT meets the requirements for a Level 1 clinical decision rule.

Many more unpublished TTs being used in a variety of hospitals, as demonstrated by the evaluation of available data. Using a composite outcome measure for established critical illness (defined as the composite of CPR, DNAR placed, admission to critical care and death), this evaluation found that sensitivities (proportion of patients with established critical illness who triggered) and positive predictive values (proportion of triggered patients with established critical illness) were low and specificities (proportion of patients without established critical illness who did not trigger) and negative predictive values (proportion of non-triggered patients without established critical illness) were generally acceptable. Sensitivity and specificity did not appear to be dependent on age, ward or speciality.

Low sensitivities may have been due, in part, either to rapidly deteriorating patients or to patients where no physiological warning of impending catastrophe, by virtue of the disease process, was likely. Low sensitivities may also have been due to infrequent and non-standardised measurement of the physiological parameters.

Low positive predictive values may have been due to legitimate triggering for potential (not included as part of the composite outcome measure in this evaluation), rather than established, critical illness i.e. the trigger and response may have alerted staff, as intended, and averted further clinical deterioration thus preventing established critical illness.

The summary ROC curve indicated that the differences between TTs may have largely reflected differing trigger thresholds. In addition, anecdotal evidence suggested that trigger thresholds were placed artificially high to manage workload. Therefore, it may be possible to increase the sensitivity, at the cost of increased workload, by reducing trigger thresholds.

Due to the wide variations in: the characteristics of patients; data collection; and response algorithms; direct comparisons between the different TTs, either to establish the best existing TT or to develop a new, high-quality TT for timely recognition of established critically illness, was not possible.

In terms of reproducibility, there was only fair to moderate agreement for measurement of the physiological parameters used to generate scores and only fair agreement for the scores. Reassuringly, there was better agreement on the decision as to whether a patient had triggered or not. As one would expect, reproducibility was partially a function of simplicity - MET achieved higher percentage agreement than ASSIST, and ASSIST higher than MEWS. [The TTs selected represented three levels of complexity - MET is very simple but does not allow monitoring of clinical progress; MEWS is a more complex assessment that takes into account urine output and relative changes in blood pressure; ASSIST is a simplified version of MEWS with only four parameters and an age-constant; both ASSIST and MEWS allow monitoring of clinical progress - and were representative of the wide range of TTs in use.]

Intra-rater reliability was better than inter-rater reliability. Using corrected calculation of scores improved the level of inter-rater but not intra-rater agreement, suggesting that, if scoring systems were misapplied, each rater was doing so in a consistent manner.

Many interviewees suggested that TTs were helping inexperienced staff (HCAs, nurses, junior doctors) identify sick and deteriorating patients, giving them “objective evidence”. TTs were seen to increase staff knowledge and understanding but this had to be finely balanced against over-reliance.

Local issues were identified that might affect the accuracy of TTs. These ranged from lack of, or poor, use in some hospital areas, variation in use among staff and issues of completion and interpretation. Some felt the latter was because TTs were completed by HCAs, although in observations a lot of enthusiastic and motivated HCAs were seen to adhere firmly to protocols (and many qualified nurses were seen not to). Training, particularly informal training, was seen to be extremely important. A number of local issues were raised about response algorithms for TTs predominantly around communication, delay, resistance, authority and documentation.

Overall, this research indicated how TTs and response algorithms needed to be clear, well publicised in their introduction and implementation, accompanied by training, enforced and monitored. Within this context, staff also required enough flexibility to allow them to use their own initiative.

Limitations

Survey

The high response rate to the survey (80%) suggests that the findings were a representative picture across England in the early part of 2005. A comparison, however, of the characteristics of responding to non-responding hospitals was not possible to ascertain if any biases existed that would have affected the results relating to TTs.

Systematic review

This was the first systematic review of the literature on TTs. This review confirmed that most published work regarding TTs has been associated with either MET in Australia or CCOS in the UK, with only a small body of work identified from North America. However, similar teams/services are now rapidly emerging in a number of countries across Europe including Sweden[30,31], the Netherlands[32], Portugal[33] and Italy[34]. As these teams/services become more widespread around the world, it will be essential to consider new evidence, regarding development and validation of TTs, as it emerges.

Quantitative evaluation

The ideal outcome measure for evaluation of TTs would be some measure including both potential and established critical illness i.e. some measure of alerting staff and yielding the appropriate response by either averting clinical deterioration or identifying the potential to benefit from some kind of intervention above what is usually available on the ward. Outcomes for potential critical illness are hard to define and measure and, as such, were not available within any of the available TT datasets.

Therefore, the limitation of the composite outcome measure used in this evaluation must be acknowledged. CCOS do many important activities not reflected in any of the outcomes in the composite outcome measure used. Many appropriate referrals to CCOS might not have resulted in our composite outcome measure. When multiple visits from the CCOS were included in the composite outcome measure, the results suggested that, for some CCOS, if the score was high on a visit, then another visit would be scheduled and if the score was low on a visit, then the patient would be discharged from the care of the CCOS. In this situation, decisions (and outcomes) were made based on the score; the score was not predicting the outcome but determining it.

Though, all acute NHS hospitals in England were invited to contribute data for the evaluation, data were received from only 31 of 92 that indicated they collected any data; this may have limited the generalisability of the results. In addition, as this evaluation was based on existing TT datasets, there was no direct control over the population for whom data were collected, the actual data collected, the timing or frequency of the data collected or the data quality. Only the latter could be addressed by us through establishing a system of quality criteria and excluding datasets that did not meet certain important criteria. In addition, not all outcomes within the composite outcome measure used were recorded in every dataset, which may also have introduced some bias.

All, except hospitals G and M, collected data for CCOS referrals and follow-up. The latter are select populations and the data collected in these datasets were either those most recently recorded prior to arrival or those recorded on arrival. Only hospitals G and M included routine recording for all patients on the Medical Admissions Unit and were closest to a true evaluation of a TT.

The nature of the response, the response time (the time from the trigger to the response, for example, arrival of the CCOS) and lead time (the time from the response to when treatment would otherwise have occurred) are also important factors in how well a TT performs but data were unavailable to evaluate these.

The potential benefits of using any TT can only be realised if physiological parameters are accurately measured and recorded. No assumptions about the quality of routine observations or chart design, or the effect of introducing a TT on these, can be made on the basis of this study. In addition, this study was not designed to directly assess the impact of introducing a TT on patient outcomes; TTs are usually introduced in combination with a CCOS or similar.

Reproducibility study

There were a number of potential weaknesses in this study. Given that the vast majority of observations in many wards are carried out by HCAs, the fact that the raters did not include an HCA (only a student nurse/nursing auxiliary who had previously worked as an HCA) may limit generalisability to this important group. Repeated measurements were taken within an hour but it was very possible that patients would have deteriorated or improved during this time period. Whether there was a systematic drift of figures between measurements was not assessed.

A small number of patients were not able, or were unwilling, to give consent. In particular, patients with reduced neurological function (approximately 5%) could not be included and these were generally likely to be the sicker patients. Inclusion might have led to different results with regards to reproducibility of the trigger. However, abnormal neurological scores have been found to be rare in previous studies[35,36].

The aim was to assess the reliability of the TTs in routine clinical practice. Reproducibility depends partially on the reliability of the electronic measurement devices, for example, those used for blood pressure and temperature. This could not be assessed directly as repeated measurement was unacceptable to the patients. Our results therefore represent the human element of reproducibility only.

Kappa is a chance-corrected measure of agreement, expressed as a fraction of the maximum difference between observed and expected agreements. Negative values indicate that observed agreement was lower than expected by chance. As trigger events with MET were very rare, expected agreement was extremely high. Kappa is largely meaningless for events this rare, and the

chance-independent measure phi can only assess agreement between two raters.

Conclusions

The low sensitivity of existing TTs means that a high number of patients with established critical illness requiring intervention were likely to be missed if ward staff relied solely on these for identifying deteriorating patients. It may be possible to increase the sensitivity, at the cost of increased workload, by reducing trigger thresholds. However, TTs will never provide 100% identification of critically ill patients (nor potentially critically ill patients) and should therefore always be used as an adjunct to clinical judgment and experience. Give the physiological parameters routinely made on the ward and therefore available to a TT, what is actually possible from a TT needs to be borne in mind.

Our results suggested that accurate use of a TT and response algorithm may improve the pathway of care for the recognition and management of the acutely ill patient on the ward, both prior to and post-admission to a critical care unit.

Discussion – CCOS

Principal findings

Despite evidence for benefit, CCOS have evolved quickly; the UK is not unique in this. In 2005, the Institute for Healthcare Improvement (IHI) in the USA made hospital implementation of rapid response teams one of six platforms for nationwide roll-out as part of their saving "100,000 lives campaign". Similarly, in Australia, the Quality Council has replicated the IHI initiative for their "safer systems saving lives campaign". The first Consensus Conference on Medical Emergency Teams (MET), held in the USA in 2005, concluded that hospitals should implement MET[37].

The overwhelming picture was one of diversity of service provision. Few clear patterns emerged in terms of service models. CCOS were, and are, being delivered in many different ways across the country. Variation existed in: the composition of CCOS; the availability; the proportion of wards covered; the nature of the activities undertaken; and the balance between provision of direct care or acting in an advisory role. Some hospitals have established a service model which placed a particular focus on one or more of the three primary objectives outlined in Comprehensive Critical Care[38], whilst others showed no such emphasis.

However, despite widespread promotion and endorsement of CCOS by the Audit Commission[39] The Department of Health[38], The Intensive Care Society (ICS)[40] and The Royal College of Physicians[41], there was still a considerable gap between the current level of service provision and the recommendation made by NCEPOD in 2005[27] and echoed by The Critical Care Stakeholder Forum in 2005[42]; that every hospital should have formal CCOS 24 hours a day/7 days per week. Our findings suggested that many hospitals were not currently able to satisfy the recommendations on minimum staffing levels for CCOS made by the ICS[40].

There was insufficient robust, rigorous research to assess the impact of CCOS on patient or service outcomes in a UK context. Most studies were uncontrolled before and after studies and many were of poor methodological quality. Only one study[43], provided Level 1 evidence for the UK, this demonstrated that CCOS significantly reduced hospital mortality. In addition, two observational studies, which scored higher in terms of study quality, also demonstrated significant reductions in hospital mortality[44,45]. However, the multi-centre, cluster RCT conducted by the MERIT team in Australia found no significant differences in any of the outcomes measured. The authors listed MET being ineffective as only one of a list of possible interpretations: poor implementation of MET; too short timeframe for the study; contamination between groups; insufficient statistical power; lack of blinding; overall system-wide improvement; and cardiac arrest teams in control hospitals functioning as a MET.

No clear typology of CCOS emerged from this review. Across all studies, there was wide variation in terms of: CCOS aims; composition; availability; and activities; in addition to the timing of the evaluation of the CCOS. The

variation in this complex intervention, in addition to variation in hospitals and patients contributed to the considerable heterogeneity of the included studies.

Presence of a formal CCOS was associated with a significant decrease in: CPR rates during the 24 hours prior to admission; out-of-hours (22:00–06:59) admissions to the critical care unit; and acute severity of illness of admissions (ICNARC physiology score); for admissions from the ward. There was no evidence for an association between the presence of a formal CCOS with the other outcomes investigated in this study. In particular, no sustained effect was seen on mortality or readmission rates for patients discharged alive from the critical care unit. Causality cannot be attributed to the observed associations.

The finding of decreased CPR rates was consistent with some previous non-randomised before/after comparisons [45-48]. However, other studies, including the MERIT cluster-randomised trial, have reported no significant effects on CPR rates [36,49,50]. CPR rates in patients admitted to critical care units may be reduced because arrest rates were reduced. Cardio-pulmonary arrest is a clinically important adverse event that carries a high mortality. Such an event is often preceded by signs of physiological deterioration [51,52]. The findings in this study suggest that the use of TTs may be an important part of CCOS activity and their use may lead to earlier intervention. But there are also other plausible explanations. It may be that the arrest rate remained the same but CPR was attempted less frequently through more appropriate use of DNAR decisions. Alternatively, it may be that the same number of arrests and CPR attempts were occurring but that fewer of these patients were being admitted to critical care units as the CCOS determined admission to be futile. It is most likely that some combination of all these effects was taking place.

Reductions in out-of-hours admissions to the critical care unit may result from a number of different processes. It may be that patients requiring critical care were being identified earlier and admitted appropriately during working hours. Alternatively, it was possible that, in hospitals with a CCOS that did not operate 24-hours per day, at-risk patients identified overnight were being left until the CCOS started work in the morning rather than referring them directly to the unit.

Acute severity of illness may be decreased by at least three processes with respect to the CCOS aims of averting or ensuring timely admission. Averting admissions would either remove some of the least sick patients because they could be managed safely on the ward (with assistance from the CCOS) and/or remove some of the sickest patients because admission was deemed futile (with advice from the CCOS). Ensuring timely admissions would enable patients to be admitted at an earlier stage in their critical illness, with lower, acute severity of illness. Alternatively, lower, acute severity of illness may reflect lead-time bias—a reduction in the apparent severity of illness due to stabilisation prior to admission, rather than a true reduction severity of illness [53].

Other anticipated changes as a result of CCOS were not evident. This may be due to the variation in the way CCOS were designed, implemented or funded leading to similar variation on impact. Overall, this study showed a very mixed picture and there did not appear to be any clear characteristics for an optimal CCOS.

Of 71,660 visits, patients received a mean of three CCOS visits. Approximately, 45% of patients, who were visited at least once by the CCOS, were admitted to a critical care unit (ICU or HDU) at some time during their hospital stay.

Patients with CCOS visit(s) pre-critical care unit admission, when matched by individual patient characteristics or by propensity score to either historic (pre-CCOS) controls in the same unit or concurrent admissions to a different unit (in a hospital with no formal CCOS), were associated (including results from sensitivity analyses) with decreased acute severity of illness (historic match only) – primary outcome - and increased pre- (critical care unit) hospital length of stay, decreased CPR rates during the 24 hours prior to admission and increased critical care unit length of stay – secondary outcomes.

Patients with CCOS visit(s) post-discharge from the critical care unit, when matched by patient characteristics or propensity score to either historic (pre-CCOS) controls in the same unit or concurrent admissions to a different unit (in a hospital with no formal CCOS), were associated (including results from sensitivity analyses) with decreased hospital mortality – primary outcome – and decreased readmissions within 48 hours and post- (critical care unit) hospital length of stay – secondary outcomes.

Using costs based on WTE staff and restricting the economic analysis solely to patients receiving CCOS visit(s) post-discharge from the critical care unit, the mean cost per patient visit was £115. The mean number of days in critical care after original discharge from the critical care unit was higher but the mean number of days in hospital was lower for cases compared with controls.

Taking account of the mean visits from the CCOS, the mean number of days in the critical care unit (following original discharge) and the mean number of days in hospital, the difference in mean total cost per patient between cases (patients receiving CCOS visit(s)) and controls, matched as per the matched cohort analysis above, ranged from -£289 to -£34. Though these differences were not statistically significant, both matches showed a high probability that CCOS visits following discharge from critical care were cost effective, regardless of willingness to pay.

Using relatively broad criteria, no other, relevant, published economic evaluations or studies considering the costs or cost effectiveness of CCOS were found for comparison.

Comprehensive Critical Care (ref) outlined three main objectives for CCOS; averting admissions, enabling discharge and education/sharing skills. The majority of CCOS visited had attempted to achieve these objectives. CCOS

studied had different methods of operation and priorities, for example, some saw themselves as primarily concerned with patient follow-up, improving long-term survival and quality of life post-discharge, while others saw themselves more akin to a MET. It was difficult, therefore, to identify themes common to all eight interview sites and interviewees except for the education role. Almost universally, CCOS nurses saw themselves as having an educational and training role; this despite the fact that half of our sample of sites rated education a low priority.

The individuals responsible for initial development of CCOS can be regarded as organisational entrepreneurs, extremely committed to ensuring that the CCOS was implemented and was a success; sometimes in the face of opposition. It was apparent from the data that their role in marketing the service within the hospital was crucial to its success. Given these kinds of personal investments and the likely personal characteristics of those involved, it was perhaps unsurprising that the majority of interviewees wanted to see their CCOS grow; taking on more staff and expanding their clinical remit.

Many CCOS had established formalised objectives but had taken on other local roles; sometimes at the insistence of hospital management and sometimes because they were best placed to do so (for example, tracheostomy care on the wards). For most CCOS, the original objectives had remained the same although local activities had changed. This was not necessarily a problem, of course, except where the parameters for audit/evaluation of a service are founded on stated objectives. It seemed that, with COOS, local solutions were often found to local problems/issues and this seemed entirely laudable.

The reassurance given to ward staff was the most important, quoted impact. Sometimes, this was linked to a feeling of empowerment arising out of educational activity; many ward nurses and HCAs interviewed stated that they had benefited enormously from participating in education and training.

Several respondents identified a problem with education. It was felt that CCOS were meeting their educational objectives but several factors hampered retention of new skills on the wards (for example, staff shortages and staff turnover). However, there was a natural conundrum in the educational objectives for CCOS. The logic of education and training (that skill levels can be increased on the ward and relieve pressure on critical care units and that CCOS can be reduced as ward staff begin to undertake critical care-like procedures) is persuasive. But, it needs to be recognised that the expert skill of CCOS staff is founded on, and enhanced by, daily, practical experience of critically ill patients. It is unreasonable to expect ward nurses to attain and retain the same level of expertise when they will not see critically ill patients with such frequency. For this reason, it could be argued that the full transfer of critical care skills to the wards is not achievable. A modified educational objective, perhaps focused on improving knowledge about critical illness and its detection, rather than skills, would be more achievable.

The development of CCOS appears to have contributed to a rapprochement between wards and critical care units. This has worked in both directions - from the perspective of the wards, the critical care unit is no longer a mysterious black box, whereas from the perspective of the critical care unit, there is enhanced understanding of the pressures on ward staff. The original meaning of "critical care without walls" was related to clinical objectives which have been only partially achieved. Yet, the aspiration of "critical care without walls" also has a valid organisational and social meaning about which there is considerable evidence of achievement.

Limitations

Survey

The high response rate to the survey (80%) suggested that the findings were a representative picture across England in the early part of 2005. A comparison, however, of the characteristics of responding to non-responding hospitals was not possible to ascertain if any biases existed that would have affected the results relating to CCOS. Although the proportion of responding hospitals with a CCOS appeared unchanged since the Modernisation Agency survey of 2002[26], it should be noted that the sampling frames differed. It should also be noted that, if non-responders were largely from hospitals which had not yet established a CCOS, the true proportion of hospitals with CCOS may be slightly lower. In addition, as for all surveys, the collection of retrospective data relied on respondents' recall.

Systematic review

This was the first systematic review of the literature on CCOS. This review confirmed that there was insufficient robust, rigorous research to assess the impact of CCOS on patient or service outcomes and that most published work regarding CCOS has been associated with either MET in Australia or CCOS in the UK. However, similar teams/services are now rapidly emerging in a number of countries across Europe including Sweden[30,31], the Netherlands[32], Portugal[33] and Italy[34] and rapid response teams in North America. As these teams/services become more widespread around the world, it will be essential to consider new evidence, regarding the impact of CCOS, as it emerges.

Interrupted time series

Three major strengths of the study: size (approximately half of all adult general critical care units in England); high quality data (CMPD has been independently evaluated according to criteria for a high quality database and scored highly [14]); and rigorous methodology (the interrupted time series approach has advantages over a simple before/after comparison as it controls for long-term trends and seasonality in the data) must be balanced by a number of limitations.

First, the way in which CCOS were implemented decreased our ability to analyse and understand their impact. As CCOS are widespread in England[54], an RCT of their effectiveness was not feasible. Well-controlled, multi-centre observational studies were therefore likely to be the best way to gain additional insight. Second, the interrupted time series approach may be influenced by other events occurring around the same time as the event of

interest (historical bias) [55,56]. However, the introduction of CCOS at different times in different locations produced a natural experiment by which the effects of historical bias could be reduced; the population-averaged panel-data models estimated the consistent (average) effect of CCOS across hospitals - this effect estimate is of most relevance for policy decisions – and all major, potential, confounding factors were identified and included. Third, associations were observed with the introduction of CCOS for which causality was difficult to attribute (for example, whether the decrease in CPR rates was due to earlier referral preventing arrests or an increase in treatment limitation decisions). Fourth, although the population-averaged effect is the most relevant for policy decisions, the expected benefit for an individual patient was not measurable; as the population included individuals with no potential to gain from the presence of CCOS. For this reason, analyses were concentrated on sub-populations with the most potential to benefit. Finally, length of stay in critical care and in hospital may be important performance indicators and are strongly associated with costs but these were not investigated as they are highly skewed variables making it difficult to identify significant population-averaged effects.

Matched cohort analysis
As for the interrupted time series, the way CCOS were implemented decreased our ability to analyse and understand their impact. As CCOS were widespread in England[54], an RCT of their effectiveness was not feasible.

The matching, both in terms of identifying the control pools and the specific factors used for matching, may have limitations. There are potential biases, for example, historical and selection biases, to all control pools used. Using more than one control pool, and the broadly consistent results from the historic and the no CCOS matches, helped interpretation, however, it was impossible to totally eliminate bias from such comparisons. [The results from the contemporary match - to an admission to the same critical care unit during the study period but not seen by the CCOS – was subject to severe selection bias and results were included in Appendix 5 for completeness and comparison only].

As the analyses for CCOS visits prior to admission were limited by the availability of data solely for those admitted to a critical care unit, the primary outcome measure used was also limited. While we were able to investigate any impact of CCOS visits prior to admission on the acute severity of critical care unit admissions (ICNARC physiology score), we were unable to investigate the impact of CCOS visits prior to admission on admission rate.

The propensity models helped to determine the appropriateness of the factors used to match cases to controls. For patients with CCOS visits prior to admission to the critical care unit, the propensity model indicated acceptable discrimination of cases. However, for patients with CCOS visits following discharge from the critical care unit, the propensity model indicated discrimination of cases that was little better than by chance. This suggested the propensity model did not explain the decision to follow-up certain patients and that matching on propensity (or the individual matching on these factors)

was doing a poor job of controlling for selection bias. Factors measured at the point of discharge from the unit (not available within our data) may have improved the matching.

Economic evaluation
The outcome measure used in the analysis was not ideal. No estimate was made of the incremental (discounted) life years gained. The impact on health related quality of life was unknown and it was unclear whether extrapolation beyond hospital survival would have altered the conclusions of the analysis.

This economic evaluation was based on observational, patient-level data. It only considered CCOS visits following discharge from the critical care unit, and for only those patients admitted to the critical care unit, over a comparatively short time horizon. Despite being secondary outcomes and therefore requiring cautious interpretation, CCOS visits prior to admission indicated possible increases for pre-(critical care unit) hospital length of stay and critical care unit length of stay suggesting CCOS visits may not be cost effective prior to admission to the critical care unit.

Ideally, an economic evaluation would have also incorporated the effectiveness of the TT and appropriate response (i.e. usual care versus TT with ward response versus TT with CCOS response) to estimate incremental costs per quality-adjusted life year gained. However, the data to inform such a model were predominantly absent.

Conclusions
CCOS form a spectrum of different service models across the NHS and are, therefore, complex interventions making evaluation difficult. CCOS appear to fill gaps according to local need and “one size may not fit all”. Perhaps pragmatically, “best fit” for local needs has predominated.

Despite precise service models varying, the underlying principles are the same. The objectives of CCOS are to improve the quality of acute patient care and experience. Despite the introduction of CCOS into the NHS without any provision for a concurrent evaluation (and thereby preventing robust evaluation within an RCT), our more limited, yet rigorous, non-randomised evaluation suggested, both quantitatively and qualitatively, some positive effects. However, no clear characteristics of what should form the optimal CCOS could be identified.

Though not an original aim for CCOS, they facilitate connectivity, reduce communication difficulties and enhance the delivery of care across organisational, professional and speciality boundaries and may, in this way, create an important culture change leading to improved quality of care, that is, improved recognition of acute deterioration, initial management and escalation of treatment. CCOS also appear to have made a siginificant impact on morale , career development, ward staff clinical skills, confidence levels, education and training. However, ultimate management of the critically ill should be the responsibility of those who have the appropriate knowledge and experience.

CCOS activities and workload depend on the CCOS being alerted at the right time to the right patient. Therefore, research on CCOS should focus, first, on improved TTs.

7. Implications for practice and policy

Implications for practice and policy - TTs

Despite the lack of rigorous testing of TTs in the literature and the low sensitivity for established critical illness in our evaluation of available data, this work does not constitute sufficient evidence for the use of TTs to be discontinued.

Therefore, we recommend:

Use of TTs with a response algorithm
TTs and response algorithms promote good practice by:

- reinforcing the need for periodic, appropriate physiological observations;
- educating the significance and interpretation of abnormal physiological observations;

and, when combined with a response algorithm,

- reinforcing the need, once triggered, for a non-negotiable obligation from more senior, experienced staff to attend the patient's bedside to determine an appropriate management plan to include location and level of care.

TTs
TTs must be explicit both to the physiological observations required (heart rate, respiratory rate, systolic blood pressure and level of consciousness are common to all TTs) and the frequency of the physiological observations.

Response algorithm
TTs must be accompanied by a clear, explicit and non-negotiable response algorithm. Response algorithms which allow for a graded response (for example, incorporating different responses at different thresholds) may be the best for balancing optimum trigger threshold for sensitivity/specificity relative to workload.

TTs and response algorithm
TTs with a response algorithm should be seen as an aid to, and not a failsafe for, clinical judgement. Embedding the TT and response algorithm into routine, daily practice may improve its application. Communication with all critical care and ward based staff, at every level, may enhance introduction, implementation and application.

For TTs to work in practice, they depend on complete and regular recording of observations, accurate calculation of scores (where relevant) and, if triggered, a non-negotiable obligation for senior staff to attend. Junior staff must be empowered and have authority, along with a non-negotiable obligation from more senior, experienced staff, to initiate and expect adherence to the response algorithm.

In this way, use of TTs with a response algorithm should aid timely recognition of patients with potential or established critical illness, timely attendance and initial management from appropriately skilled staff and timely determination of

an appropriate management plan including appropriate escalation of treatment, tailored to the patient's needs, in an equitable manner across all acute hospital settings.

Training and competency to use TTs and response algorithm
Staff using TTs must have the necessary training, both informal and formal, and competencies to recognise potential or established critical illness (including measurement and interpretation of physiological observations).

Auditing of TTs and response algorithm
Health care professionals must be prepared to audit the performance of their chosen TTs and response algorithm in all settings. Auditing should include, not only completeness and frequency of observations, accuracy of calculation of scores, sensitivity and specificity, reproducibility (inter- and intra-rater) and ease of use in practice (time to complete and acceptability to staff and patients) but also adherence to the response algorithm (nature, timing and appropriateness of the response). An obligation should exist to share audit data nationally to increase knowledge across a wider setting.

In addition, local root cause analysis investigations into adverse incidents that involve deteriorating patients may yield local, contributory and causal factors.

Selection of a TT and response algorithm
Selection of a TT and response algorithm should be based on the most up-to-date evidence. This evidence is continuing to emerge.

In the absence of evidence for a Level 1 clinical decision rule, hospitals with a poorly performing TT or those considering introduction of a TT may do well to seek a system that is best suited to their local needs. Hospitals seeking a system suited to their local needs should consider not only accuracy but feasibility and utility.

Different TTs might perform better in different scenarios. Those including only basic information might be appropriate for screening a large population. Those including both more complex information (for example, relative changes in blood pressure) and calculation of scores might be better suited as a monitoring tool for pre-selected patients known to be at high risk of deterioration.

NICE Guidelines
On release of the NICE guidelines on the recognition of, and response to, acute illness in adults in hospital, all local, relevant policies, systems and procedures should be reviewed.

Implications for practice and policy - CCOS

When policy calls for the introduction of an intervention in the absence of convincing evidence for its effectiveness, and when the intervention is defined purely in terms of its objectives and not in terms of how it is implemented, then variation is bound to occur due to local interpretation.

This work does not provide the basis for suggesting that CCOS should be discontinued or developments of CCOS halted. However, in the absence of evidence as to which model of service delivery works best to achieve the objectives for CCOS, and in which circumstances, it is impossible to recommend any specific model.

Given that future policy indicates that the acutely ill patient will be the core business for acute NHS hospitals, we recommend:

A response strategy or model for care being delivered to patients identified as having potential or established critical illness on the ward
To be triggered either by a TT or by clinical concern. Response should include: initiation of the appropriate intervention; assessment of response; and formulation of a management plan.

Continuation of CCOS activities with the best model for local needs
For all adult patients in all adult, acute hospital settings.

CCOS activities should be based on local need but should include: use of a TT with a graded, response algorithm; provision of training and competencies to staff on the ward in monitoring, measuring, interpreting and recognising potential and established critical illness, as well as, an appreciation of the physical, psychological and emotional needs of patients and family.

To include ongoing audit of the results from CCOS activities and submit relevant CCOS data where specified as part of practically collected critical care data.

Note: No specific service model can be recommended as a preferred strategy for patients identified as having potential or established critical illness.

Shared responsibility for care of patients with potential or established critical illness from those who have the appropriate knowledge and experience
For all adult patients in all adult, acute hospital settings.

To include all appropriate observations recorded and acted upon.

To include continuity of care to an agreed management plan that includes level and location of care and ensuring that the management plan can be delivered in the patient's location.

Admission to the critical care unit should continue to be a consultant to consultant decision.

A review of future resource allocation for the critically ill
Resource allocation for critical care may act as a dis-incentive for CCOS activities.

The implementation of PbR for critical care will impact on resource allocation for critical care. The Critical Care Minimum Data Set (CCMDS) will inform Healthcare Resource Groups which, in turn, will impact on each hospital's critical care resource allocation. Patients have to be in "critical care areas" for data collection for CCMDS. There will be no incentive to keep sick patients on the ward with CCOS support. CCOS may become regarded as a model of service delivery that reduces demand for critical care and threatens income.

NICE Guidelines
On release of the NICE guidelines on the recognition of, and response to, acute illness in adults in hospital, all local, relevant policies, systems and procedures should be reviewed.

8. Implications for future research

Implications for future research - TTs

Development of appropriate outcomes
TTs were developed to alert staff to potential and established critical illness. Appropriate outcomes, both for potential critical illness and appropriate responses, require development and validation.

Primary research to evaluate TTs
TTs should be evaluated for their original intent i.e. early identification of acute deterioration. Once appropriate outcomes have been identified and developed (from above), primary research is needed.

Data should be collected on all ward patients from several hospitals; preferably where no TT has previously been used to avoid any bias. Patients would receive normal clinical care from ward staff and referrals to critical care would happen in the usual way. All physiological parameters used in existing TTs would be measured at an agreed frequency and recorded together with the time the measurements were taken. The outcomes under normal care would form the composite outcome measure and the time at which any outcome occurred would be recorded to estimate lead time. Sensitivity, specificity and lead time would be calculated for each TT system, enabling fair comparisons between the existing systems. In addition, a new TT could be derived from the physiological data, with the ability to balance sensitivity, specificity and lead time in seeking a system with high sensitivity, acceptable specificity and sufficient lead time to enable a real difference in outcomes to be made; if such a target is achievable.
hievable.

Validation of TTs
Either the existing TTs of the “best” TT (from above) would require rigorous validation in different patient populations and settings.

New technology
With the advent of new technology, intelligent systems or surveillance and hand-held, electronic devices, acceptability, utility and reproducibility studies will be required.

Implications for future research - CCOS

CCOS activities and workload depend on the CCOS being alerted at the right time to the right patient. Therefore, research on CCOS should focus, first, on improved TTs (see: Future research – TTs).

Failure of CCOS
Beyond those related to accuracy and implementation of TTs and response algorithms, research efforts could be addressed at better understanding how the impact of CCOS could be increased. Perhaps, this might be best achieved by a systematic study of where CCOS activities fail and why.

CCOS tools
Should the bundle methodology prove effective, perhaps a similar approach of simple, ward based bundles could be developed to aid CCOS.

CCOS model(s) of service delivery
If one model of service delivery is seen as desired, then further research comparing different models, preferably within the context of an RCT, should be considered alongside a full economic evaluation. However, the design of such a study would be complex and the costs high.

CCOS' roles
The role of CCOS could be extended or merged with the role of other similar, new or existing, services within the hospital.

For example, within an RCT, CCOS' membership/role could be extended to deliver the early goal directed therapy in the emergency department that has shown such significant survival benefits in a single hospital in the USA. A multicentre RCT is underway in the USA and funding is being sought for similar in Australia.

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Acknowledgements

This study was supported by the NIHR Service Delivery and Organisation (SDO) Programme. The authors would like to thank unit, hospital and critical care outreach patients and staff for participating in this study. We would also like to acknowledge the contributions made by Roy Brown, Tracey Moore, Gareth Parry, Catherine Waskett and the three anonymous reviewers of this report. We are indebted to Richard Grieve for his advice on (and patience with) our economic evaluation. Last but not least, work at ICNARC is a team effort, and we are very grateful for the support of our colleagues James Folan, Lucy Lloyd-Scott, Keryn Vella and Emma Wood.

Appendix 1

Descriptive national survey of CCOS

Publication:

McDonnell A, Esmonde L, Morgan R, Brown R, Bray K, Parry G, Adam S, Sinclair R, Harvey S, Mays N, Rowan K. The provision of Critical Care Outreach Services in England: findings from a national survey. Journal of Critical Care. In press.

Background

In 2001, the NHS Modernisation Agency piloted a national survey of CCOS which was sent to clinical directors of critical care services in all acute units in England. This was revised and followed, in 2002, by The National Critical Care Outreach survey, supported by the Critical Care Modernisation Agency[26]. These two surveys achieved response rates of 60% and 70%, respectively, and established that there was considerable variation in CCOS across acute hospitals in NHS Trusts in England. It was also clear that, despite endorsement of CCOS from a variety of professional bodies, some NHS Trusts had yet to establish CCOS.

Given the ongoing development of CCOS, and in order to understand current provision, we undertook a further survey of service development in 2004.

Aim

To describe current service provision of CCOS in acute NHS hospitals in England.

The survey had the following objectives:

to update the picture of service provision supplied by previous Modernisation Agency surveys;

to characterise models of service provision of CCOS in terms of operation, function, coverage, staffing, and availability;

to provide data to inform the sampling frame for the qualitative evaluation of CCOS;

to determine important timings for the introduction and implementation of CCOS and to collect information about important confounders to inform the interrupted time series analysis of the impact of CCOS;

to distinguish between acute NHS hospitals that have, and have not, introduced CCOS and, for acute NHS hospitals with no CCOS, to elicit any plans for their introduction.

Methods

Pilot survey

Prior to finalising the survey questionnaire, user consultation was undertaken to explore the feasibility of collecting the data required from a postal questionnaire to be sent to CCOS leads. A series of group discussions were held with 92 delegates from 56 hospitals attending a National Outreach Forum (NOrF) one-day conference on CCOS in London in September 2004. Draft questions, some of which were based on earlier Modernisation Agency surveys of CCOS, were discussed and delegates were also asked to anticipate potential problems which might affect questionnaire completion, for

example, including the availability of retrospective, as well as current information.

Developing the sampling frame
The sampling frame for the survey needed to take into account the ways in which CCOS are configured within acute NHS Trusts. To inform the analysis of the interrupted time series, survey data were required at the individual hospital level, however, some CCOS covered a single hospital while others covered a number of hospitals within a multi-site acute NHS Trust.

There was no definitive list with contact details for CCOS at individual acute hospitals. To further complicate matters, as the Audit Commission had pointed out, there was no precise definition for what constituted an acute hospital and there was no definitive list of acute hospitals in existence.

However, a database of all acute hospitals in England that routinely provide care for Level 1 patients was kept by ICNARC. This database excluded paediatric services, psychiatric services, day case units with no in-patient beds and birthing units with no surgical facilities. The database included the details of a named individual who was either the clinical lead for CCOS or who could complete a questionnaire on the level of CCOS activity within the hospital. This was an existing database, which was kept up-to-date and its accuracy was confirmed using a number of methods, including cross-checking with other databases, for example, the ICNARC database of critical care units and The Directory of Emergency and Critical Care Units, and by regular contact with hospitals. A copy of this database was supplied to the University of Sheffield and this formed the sampling frame for the survey, which was conducted by the University of Sheffield.

For the purposes of piloting, a random sample of ten hospitals was selected from the database of acute hospitals. In addition, the ten Steering Group members who were also in clinical posts were also selected, making a pilot sample of 20 responses.

Ethical approval
The advice of an NHS OREC Manager was sought over whether the survey required the approval of an NHS Ethics Committee. Since the sampling frame for identifying contacts was being supplied to the University of Sheffield by ICNARC – an external organisation – rather than the NHS, the advice given was that the study did not fall within the Ethics Committee remit.

Instrumentation
The questionnaire built on the two previous Modernisation Agency surveys[26]. The questionnaire comprised a series of mainly closed questions with some open questions and space to add additional comments at the end. The Modernisation Agency gave permission for the use of their logo both in the footer for letters relating to the survey and on the front of the questionnaire.

Respondents were asked to indicate how long it took them to complete the questionnaire and were invited to comment on any questions which were either difficult to interpret or to answer.

Data collection
Evidence-based, data collection strategies were used throughout, in order to maximise the response rate[57]. For the ten acute hospitals selected from the database for the pilot, one copy of the questionnaire was sent, on white paper, with a personalised covering letter on headed paper, including the University of Sheffield logo. The latter asked respondents to complete the questionnaire for their acute hospital, even if there was no formally funded CCOS. A stamped addressed, manila envelope was included for replies. For the ten Steering Group members, the questionnaire was sent by email. A gift of a small box of chocolates was sent to all respondents, as a token of appreciation for completing the pilot questionnaire, enclosing a request that they also completed the final questionnaire, at a later date.

Follow-up of non-responders
In order to increase the response rate[57], after two weeks, postal reminders were sent to all non-respondents enclosing a further copy of the questionnaire and a stamped addressed envelope with a request to return completed questionnaires as soon as possible. After a further two weeks, telephone follow-up with non-responders was attempted. Once it had been established that the questionnaire had been received, a request was made that it was completed and returned, as soon as possible. For Steering Group members, follow-up was done by email.

Data analysis
Responses to closed questions were pre-coded for computation and questionnaire responses were entered into an SPSS Data Entry database (SPSS Data Entry Builder Release 3.0). This allowed data entry to be undertaken by checking boxes/entering data in a form that is displayed on screen. The software also allowed validation rules to be set. This speeded up the process of data entry and minimised coding errors.

Data were then moved across to SPSS (SPSS Windows version 11) where further validation checks were performed to expose possible errors in data entry or coding. Further analysis highlighted any questions which had posed problems for respondents and explored the time taken to complete the questionnaire.

Findings from the pilot survey
The final response rate was: 6 out of 10 database contacts = 60% (telephone follow-up revealed that three non-respondents were no longer in post and, presumably, never received a copy of the questionnaire. The corrected final response rate for database contacts was 6 out of 7 = 86%); and 7 out of 10 Steering Group members = 70%. This made an overall response rate of 65%

A number of modifications were made to the questionnaire to clarify areas of ambiguity and highlight instructions to respondents. A number of questions

were omitted since responses indicated that the information which had been requested was not readily available to respondents. This was most noticeable when retrospective information was requested. The final version of the questionnaire is available on request from the authors.

Main survey

Data collection
In order to maximise response rate, a pre-survey letter was sent out to all contacts on the ICNARC acute hospital database approximately two weeks prior to the main survey, alerting respondents that the questionnaire was on its way and requesting their help by completing it[57].

For all hospitals listed on the database, one copy of the questionnaire was sent, on cream paper, enclosing a stamped addressed envelope for replies. A covering letter, on headed paper, which accompanied all questionnaires, gave an estimate (based on pilot data) of how long the questionnaire should take to complete and enclosed a tea bag. The letter thanked participants, in advance, for their help and invited them to enjoy a cup of tea as they completed the questionnaire.

Where the same contact was listed for more than one hospital within a multi-site Trust (presumably reflecting a CCOS which was multi-site), customised letters were sent requesting a completed questionnaire from each named hospital within the Trust. In total, 247 questionnaires were sent out.

Follow-up of non-responders
Written follow-up of non-responders was conducted as outlined in the pilot survey. Follow-up letters for multi-site Trusts were customised to indicate which hospitals had not responded. Telephone follow-up of non-responders was conducted as outlined in the pilot survey. In some cases, this was done as late as 28 days after the questionnaire was sent, due to annual leave of non-responders. Where necessary, further copies of the questionnaire were mailed out and, in two cases, an electronic copy was sent.

Data analysis
Questionnaire responses were entered onto an SPSS Data Entry database as outlined in the pilot survey before being exported to SPSS (SPSS Windows version 11).

A random sample, of 10% of the questionnaires entered by each of the four members of staff who performed data entry, were double entered to expose systematic errors in coding. Further data checks were then performed to expose random errors in data entry and data were updated accordingly.

Data were analysed descriptively in SPSS. Responses to open questions were content analysed for themes.

In order to describe the variation in models of CCOS, two different matrices were created to reflect variation in staffing/availability and variation in service aims.

Matrix 1: Variation in staffing/availability
This matrix was created by analysis of data for the year 2004 from Section D (Staffing and Hospital Coverage) and Section F (Availability) of the questionnaire.

Staffing was represented by a variable with four categories:

- no medical staff, 4 or less whole-time equivalent (WTE) nurses;
- some medical staff, 4 or less WTE nurses;
- no medical staff, greater than 4 WTE nurses;
- some medical staff, greater than 4 WTE nurses.

Hospital coverage was represented by a variable with two categories:

- less than 100% ward coverage;
- 100% ward coverage.

Availability was represented by a variable with five categories:

- 7 days per week, 24 hours per day;
- 7 days per week, 12-23 hours per day;
- 7 days per week, up to 11 hours per day;
- selected days 12-23 hours per day;
- selected days, up to 11 hours per day.

Matrix 2: Variation in service aims
This matrix was created by analysis of data for the year 2004 from Section C, Question 4 (aims of the CCOS when first established). Ranking was standardised, for example, from 1,1,2,3,4, 5,6 to 1,1,3,4,5,6,7, prior to analysis.

Depending on the ranking of listed pre-admission, post-critical care or education activities, models of CCOS were categorised.

A preference for a pre-admission model was represented by a variable with two categories:

- strong (pre-admission activities ranked one);
- not strong.

A preference for a post-critical care model was represented by a variable with two categories:

- strong (post-critical care activities ranked one);
- not strong.

A preference for an education model was represented by a variable with three categories:

- strong (educational activities ranked one);
- medium (educational activities ranked two, three or four);
- no preference (educational activities ranked five or six).

Results

Response rate

A total of 191 completed questionnaires were returned = 77.3%. However, feedback from hospitals indicated that one hospital was not an acute hospital and three hospitals had, despite instructions to the contrary, given a joint response for their hospital and an additional acute hospital within their Trust. There were also four duplicates in the original database. The corrected response rate, excluding these eight hospitals, was 191 out of 239 = 79.9%.

The cumulative corrected response rate, following each stage, is shown in Table A1.1:

Table A1.1: Response rates to main survey

	No of respondents	Response rate (%)	Cumulative response rate (%)
First mail out	120	50.2	50.2
Written follow-up	25	10.5	60.7
Telephone follow-up	46	19.2	79.9

Of the non-responders, feedback on telephone follow-up indicated that four had no CCOS and one had only just started a service. For the remaining 45 non-responders, the CCOS status in these acute hospitals was unknown.

Characteristics of hospitals

Around half the responding hospitals (51.1%, n = 97) were teaching hospitals and, of these, 40.2% (n = 37) had attained teaching status in 1996, or later.

Only 13.2% (n = 25) of responding hospitals were part of an NHS Trust with Foundation status. However, 38.2% (n = 71) were tertiary referral centres. Table A1.2 indicates the variety of referral specialities among responding hospitals, some of which were referral centres for more than one speciality.

Table A1.2: Referral specialities of responding hospitals

Speciality	Number
Cardiac	25
Neurosurgery/medicine	21
Renal	15
Trauma	12
Vascular	12
Burns	11
Liver/hepatobiliary	8
Oncology	7
Orthopaedics	7
Cancer	6
ENT	6
GIT	5
Spinal surgery/injuries	5
Head and neck surgery	3
Infectious diseases	3
Gynaecology	2
Thoracic surgery	2
Urology	2
ED	1
Respiratory medicine	1

ENT ear nose & throat, GIT gastro intestinal tract, ED emergency department

The mean (SD) number of adult surgical and medical wards in responding hospitals was 16.7 (8.8), ranging from 2 to 53. This can be seen as a proxy for hospital size and was another indicator of the variation in responding hospitals.

The number of responding hospitals with general critical care units is shown in Table A1.3.

Table A1.3: Number of hospitals with critical care units

Type of critical care unit	n (%)
General critical care unit (ICU)	83 (43.5)
General critical care unit (combined ICU/HDU)	117 (61.3)
General HDU	69 (36.1)

ICU intensive care unit, HDU high dependency unit

However, some hospitals had more than one type of critical care unit and some hospitals (n = 5) had no general, critical care unit. Figure A1.1 indicates the combination of units in the responding hospitals.

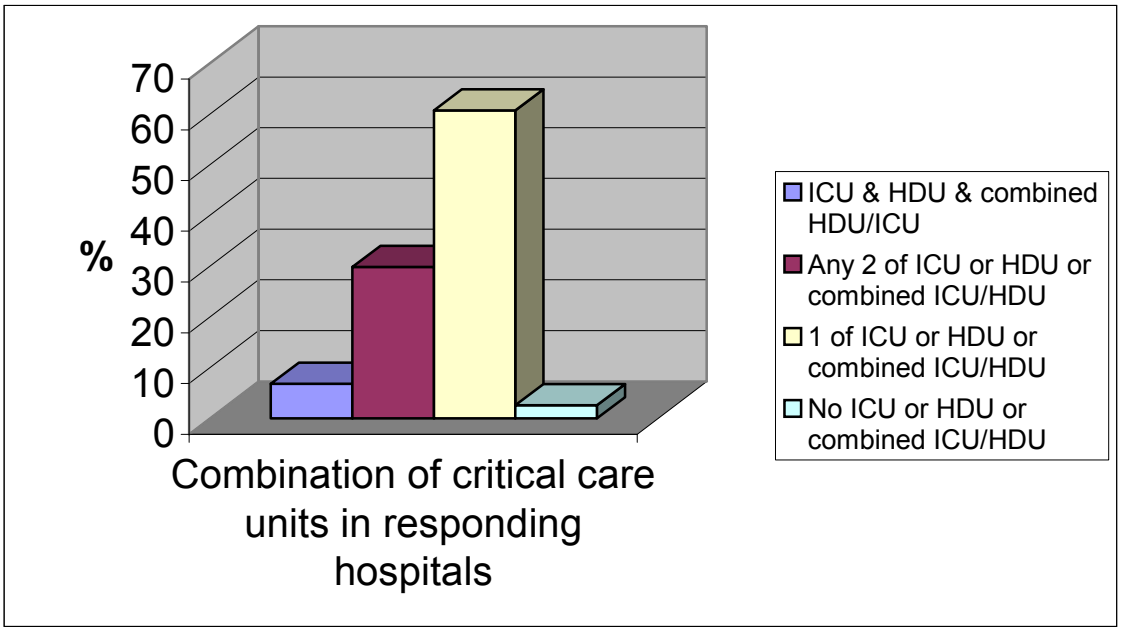
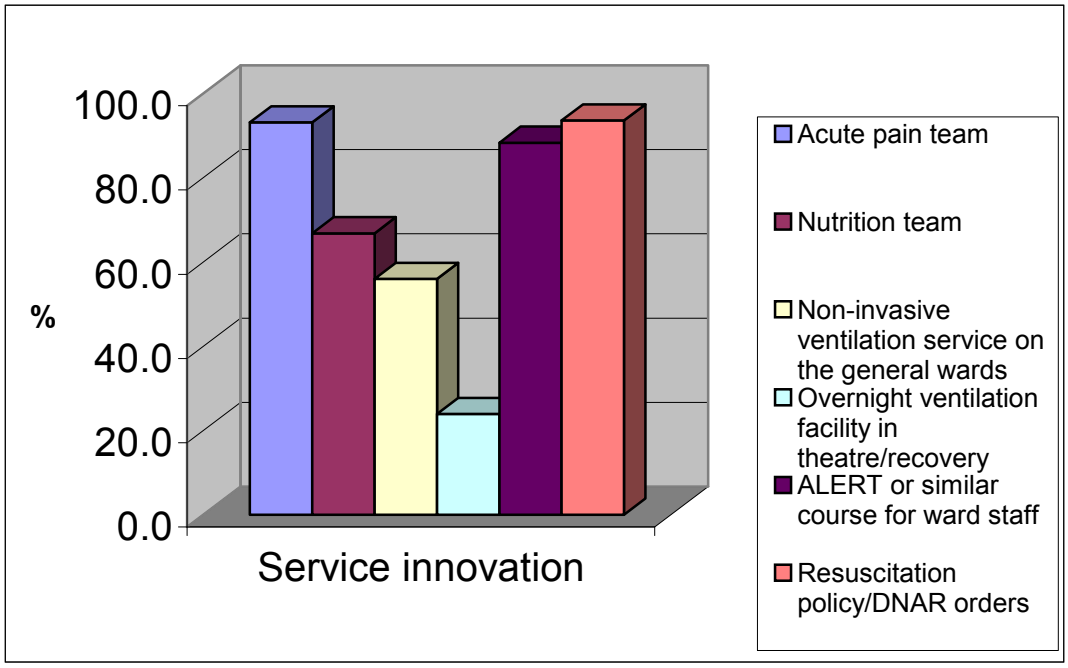


Figure A1.3: Combination of general critical care units in responding hospitals

ICU intensive care unit, HDU high dependency unit

A number of responding hospitals had introduced service innovations which might be expected to have an impact on the same patient outcomes as the CCOS. The proportion of respondents providing some of these services is summarised in Figure A1.4.

Figure A1.4: Selected service innovations provided



ALERT acute life threatening events – recognition and treatment course, DNAR do not attempt resuscitation

In addition to service innovations in care delivery, there were reported significant changes to the number of critical care beds over time.

Table A1.4 presents the reported increases in the number of all types of critical care beds in responding hospitals since 1996. Table A1.5 presents the reported total increase in critical care beds.

Table A1.4: Reported changes in numbers of critical care beds since 1996

The number of non-flexible, general, level 3 beds									
	1996	1997	1998	1999	2000	2001	2002	2003	2004
Mean (SD)	1.6 (3.0)	1.6 (2.9)	1.6 (3.1)	1.8 (3.7)	1.9 (3.9)	2.0 (4.0)	2.2 (4.1)	2.1 (4.1)	2.1 (4.1)
Range	0-14	0-14	0-15	0-30	0-30	0-30	0-30	0-30	0-30
Median (IQR)	0 (0-3)	0 (0-4)	0 (0-4)	0 (0-4)	0 (0-4)	0 (0-4)	0 (0-4)	0 (0-4)	0 (0-4)
Total number of beds	291	290	301	322	352	374	405	386	387
Number of hospitals	183	183	183	183	183	183	183	183	183
The number of non-flexible, general, level 2 beds									
	1996	1997	1998	1999	2000	2001	2002	2003	2004
Mean (SD)	0.3 (1.1)	0.4 (1.3)	0.5 (1.6)	0.7 (2.0)	1.1 (2.4)	1.5 (2.5)	1.6 (2.7)	1.6 (2.8)	1.7 (3.1)
Range	0-6	0-6	0-10	0-12	0-12	0-12	0-12	0-12	0-22
Median (IQR)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-3)	0 (0-4)	0 (0-4)	0 (0-4)
Total number of beds	55	72	96	134	203	268	299	300	315
Number of hospitals	183	183	183	183	183	181	183	183	183
The number of flexible (level 3 or 2), general, critical care beds									
	1996	1997	1998	1999	2000	2001	2002	2003	2004
Mean (SD)	3.6 (4.2)	3.8 (4.4)	4.1 (4.4)	4.3 (4.5)	5.0 (4.9)	5.7 (5.3)	6.0 (5.5)	6.3 (5.7)	6.6 (5.7)
Range	0-25	0-25	0-25	0-25	0-25	0-25	0-25	0-29	0-29
Median (IQR)	4 (0-6)	4 (0-6)	4 (0-6)	4 (0-6.8)	5 (0-8)	6 (0-9)	6 (0-9)	6 (0-10)	7 (0-10)
Total number of beds	661	707	749	784	914	1,044	1,112	1,164	1,210
Number of hospitals	184	184	184	184	184	184	184	184	184

The number of non-flexible, specialised, level 3 beds									
	1996	1997	1998	1999	2000	2001	2002	2003	2004
Mean (SD)	0.9 (3.1)	1.0 (3.4)	1.1 (3.4)	1.1 (3.5)	1.1 (3.5)	1.1 (3.5)	0.9 (3.3)	1.0 (3.5)	1.1 (3.8)
Range	0-20	0-20	0-20	0-21	0-21	0-21	0-21	0-21	0-23
Median (IQR)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Total number of beds	169	189	197	202	204	198	171	184	205
Number of hospitals	183	183	183	183	183	183	183	183	183
The number of non-flexible, specialised, level 2 beds									
	1996	1997	1998	1999	2000	2001	2002	2003	2004
Mean (SD)	1.1 (3.2)	1.1 (3.2)	1.1 (3.6)	1.1 (3.6)	1.5 (4.1)	1.5 (4.1)	1.6 (4.3)	1.8 (4.6)	2.0 (5.0)
Range	0-20	0-20	0-22	0-22	0-22	0-22	0-24	0-25	0-25
Median (IQR)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Total number of beds	198	198	222	240	274	279	299	320	362
Number of hospitals	182	182	182	182	182	182	182	182	182
The number of flexible (level 3 or 2), specialised critical care beds									
	1996	1997	1998	1999	2000	2001	2002	2003	2004
Mean (SD)	1.2 (4.4)	1.2 (4.4)	1.3 (4.5)	1.5 (4.8)	1.6 (4.9)	1.8 (5.3)	2.0 (5.6)	2.0 (5.6)	2.0 (5.8)
Range	0-38	0-38	0-38	0-38	0-38	0-38	0-38	0-40	0-40
Median (IQR)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Total number of beds	214	222	230	274	297	338	362	365	372
Number of hospitals	184	184	184	184	184	184	184	184	183

SD standard deviation, IQR interquartile range

Table A1.5: Changes in the total number of critical care beds over time

The total number of critical care beds									
	1996	1997	1998	1999	2000	2001	2002	2003	2004
Mean (SD)	8.6 (10.4)	9.1 (10.6)	10.6 (11.7)	9.8 (11.0)	12.2 (12.1)	13.6 (12.2)	14.4 (12.7)	14.8 (13.1)	15.5 (14.0)
Range	0-76	0-76	0-76	0-76	0-76	0-76	0-76	0-80	0-80
Median (IQR)	6 (4-11)	6 (4-11)	7 (5-12)	6 (4-12)	8 (5-15)	10 (7-16)	11 (7-16)	11 (7.8-18)	11 (8 -17.5)
Total number of beds	1,572	1,662	1,933	1,779	2,216	2,452	2,620	2,691	2,803
Number of hospitals	182	182	182	182	182	180	182	182	181

SD standard deviation, IQR interquartile range

CCOS activity

Previous surveys by the Modernisation Agency[26] had reported CCOS activity fell into a number of categories. Figure A1.3 to Figure A1.10 illustrate how each of these broad elements of activity had evolved over time in responding hospitals.

Figure A1.5: Hospitals reporting performing follow up of patients discharged from level 2/3 facilities to adult (level 1) wards

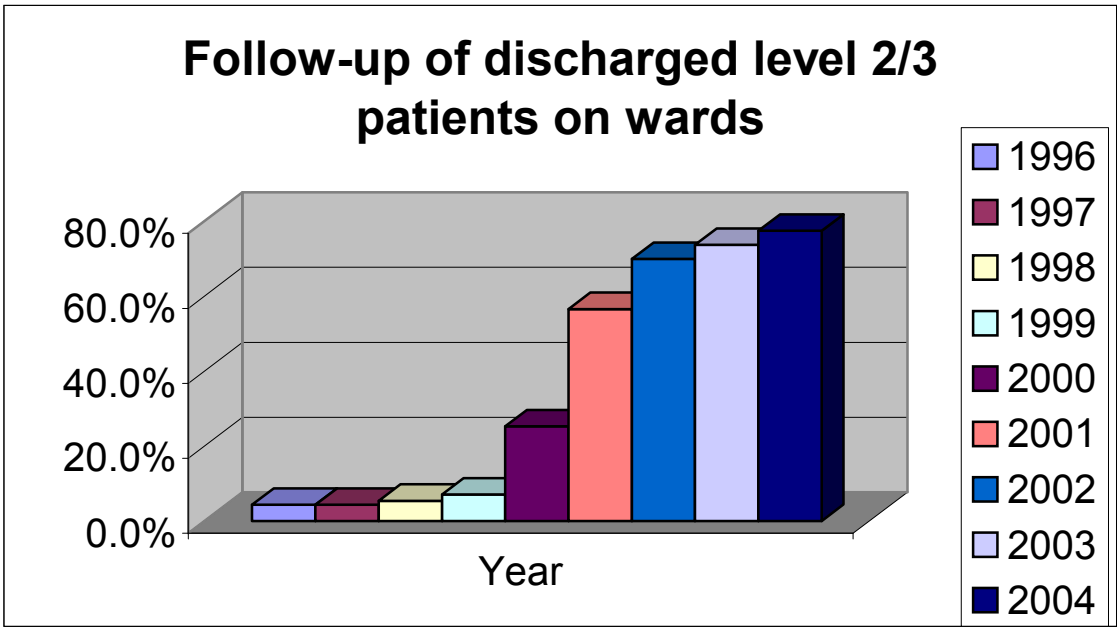


Figure A1.6: Hospitals reporting performing post-critical care discharge follow-up by critical care staff in dedicated out-patient clinics

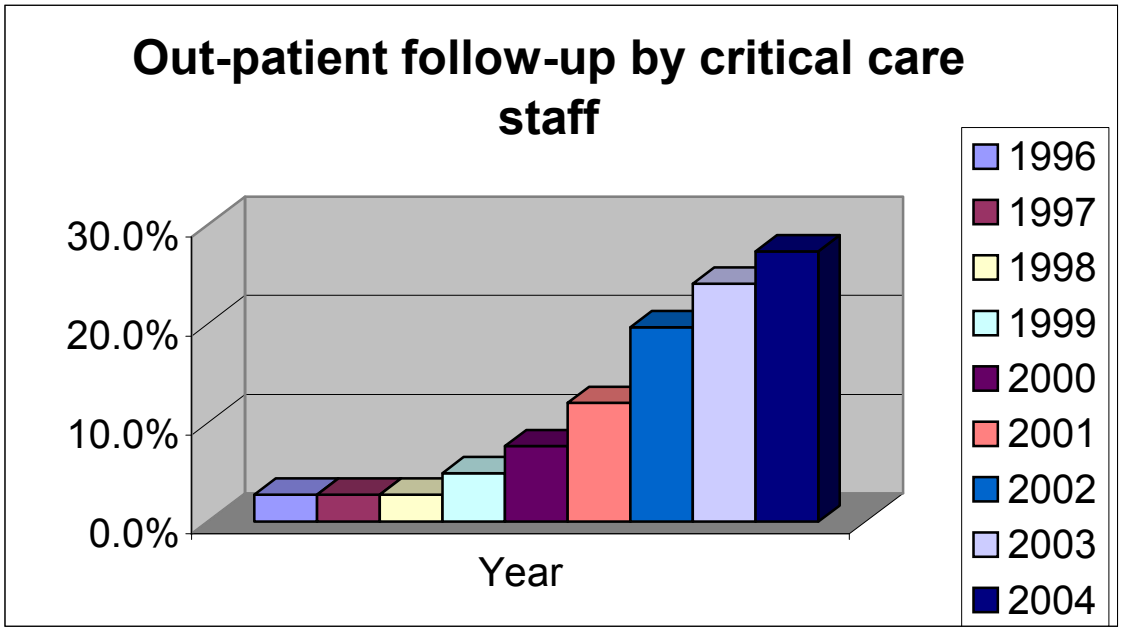


Figure A1.7: Hospitals reporting offering telephone hotline advice from critical care staff for adult wards

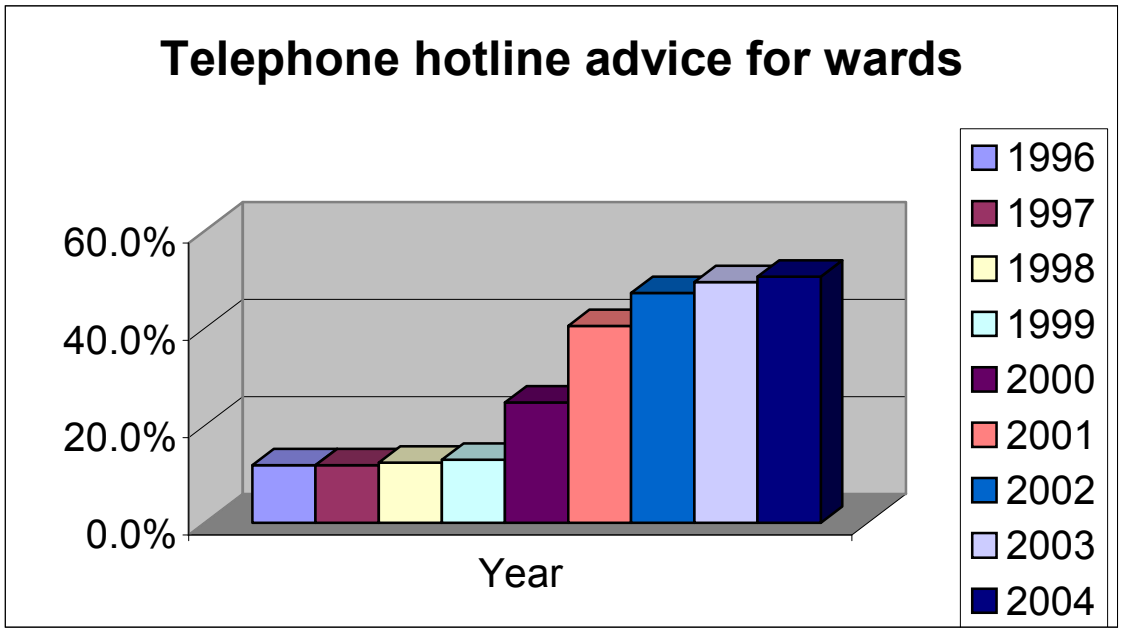


Figure A1.8: Hospitals reporting providing direct bedside clinical support from critical care staff on adult wards

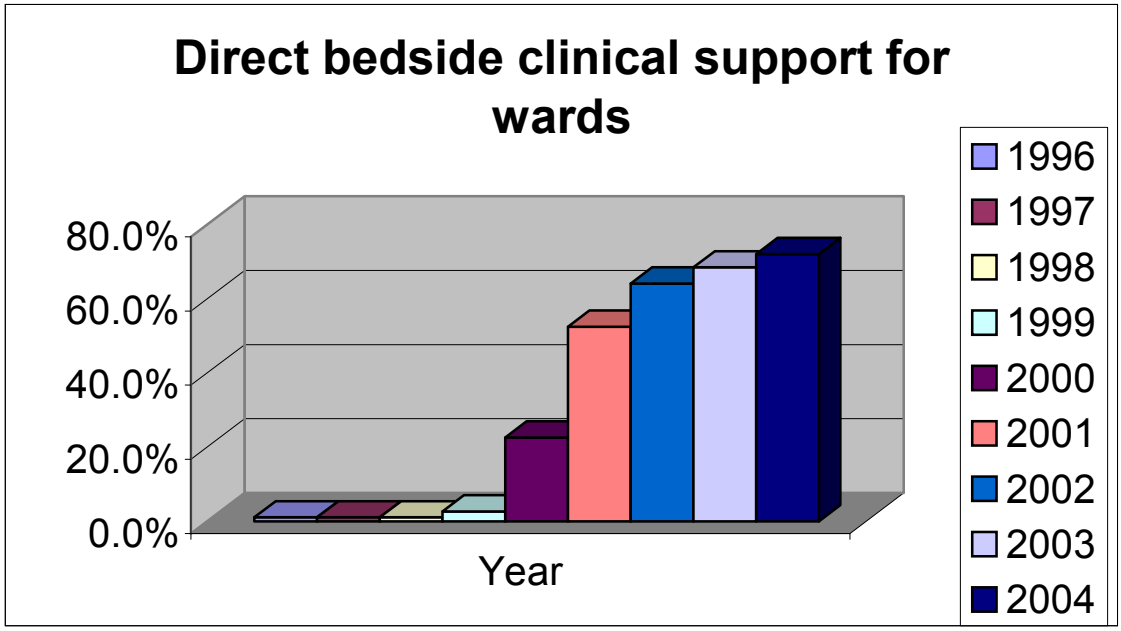


Figure A1.9: Hospitals reporting informal bedside teaching by critical care staff outside critical care area

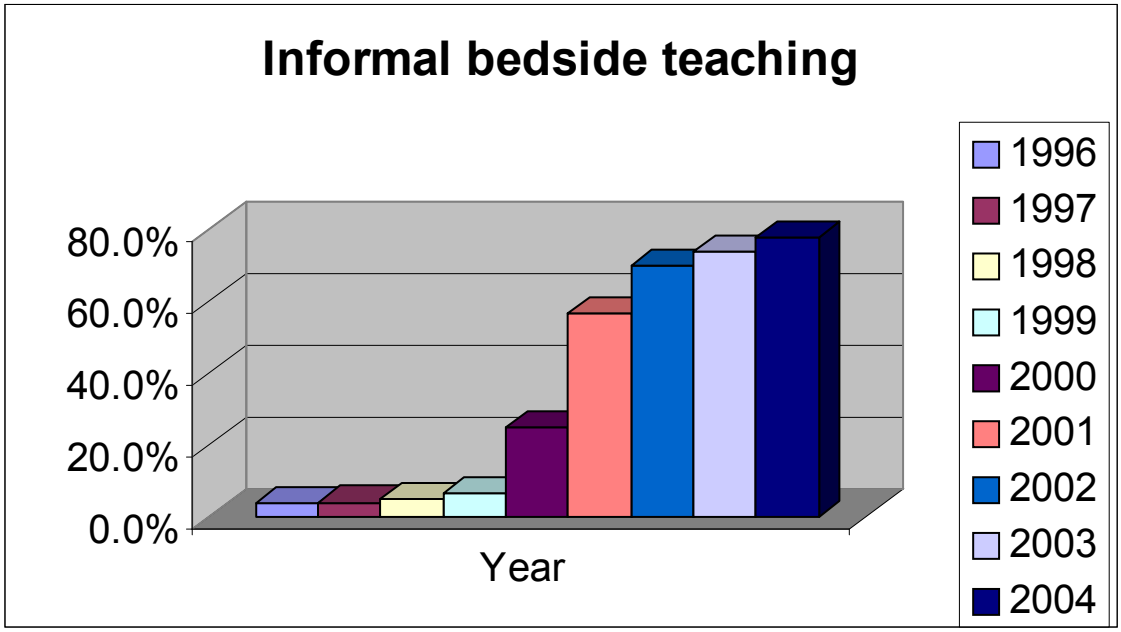


Figure A1.10: Hospitals reporting formal educational courses delivered by critical care staff

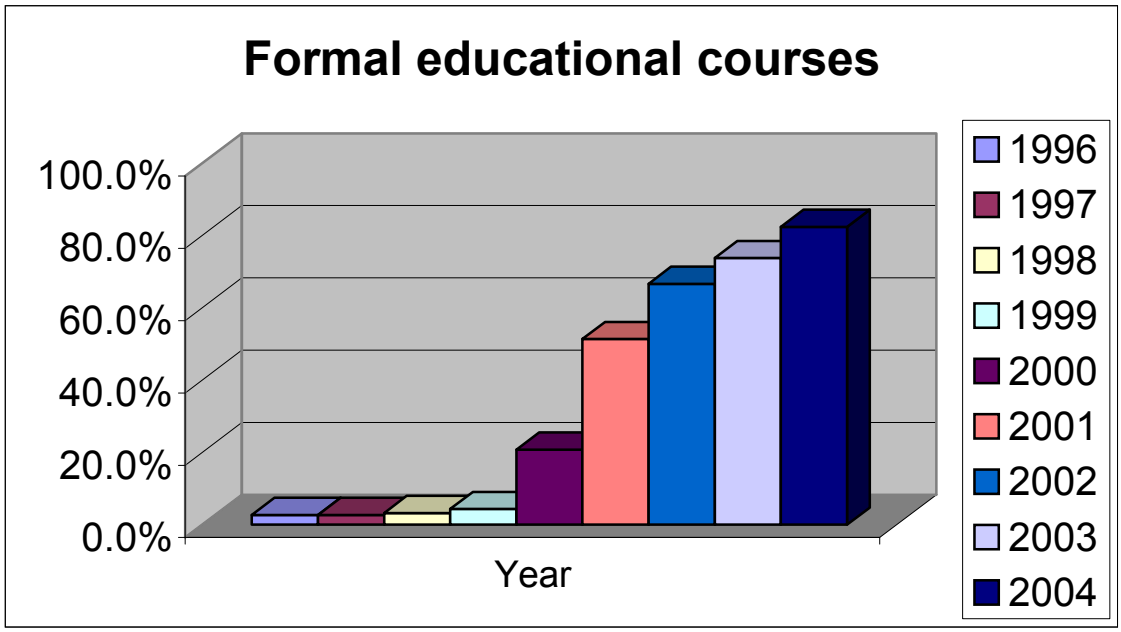
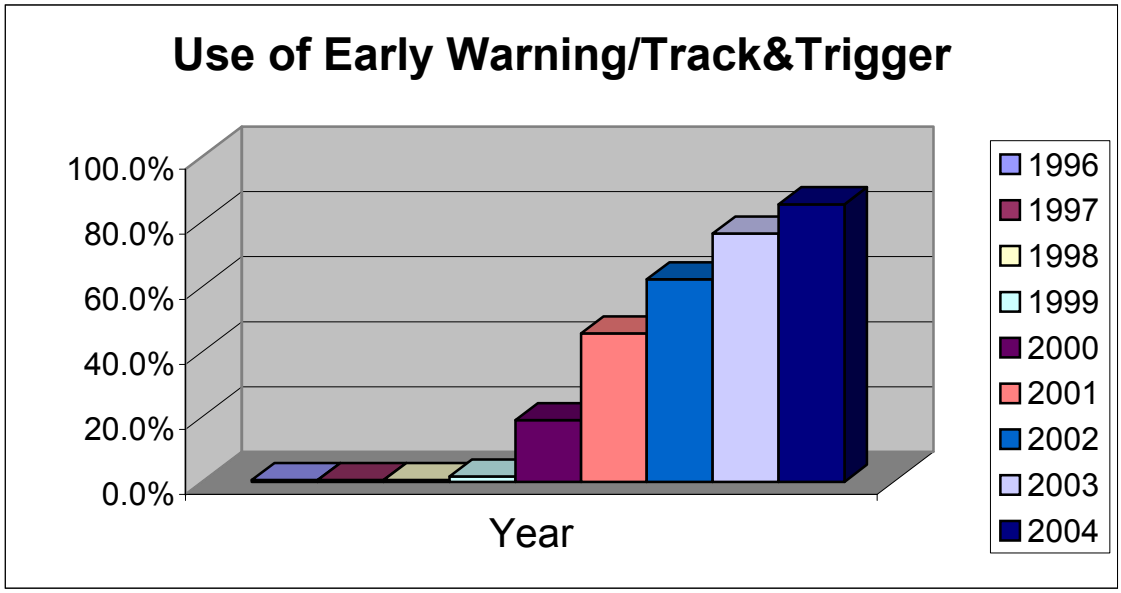
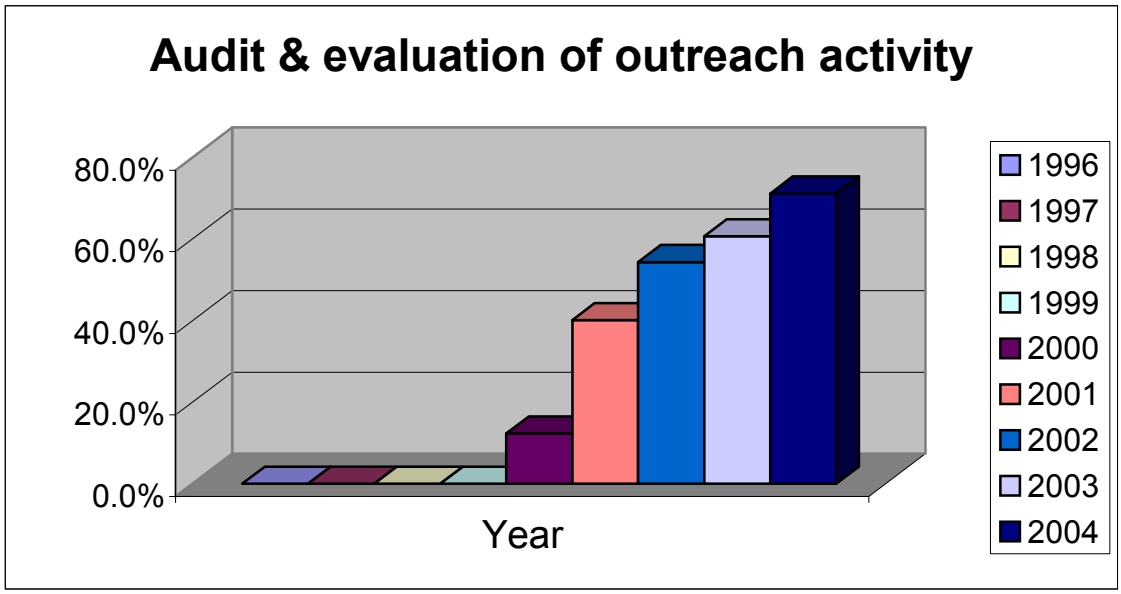


Figure A1.11: Hospitals reporting formal use of TTs



TT physiological track & trigger warning system(s)

Figure A1.12: Hospitals reporting performing audit and evaluation of CCOS activity



CCOS critical care outreach service(s)

For each of these elements of CCOS activity, there were sharp increases from 2000 onwards, following the release of the influential Department of Health Report "Comprehensive Critical Care"[38]. Nonetheless, there was some CCOS activity which preceded 2000 notably, provision of telephone hotline advice from critical care staff to adult wards.

Further evidence that the provision of CCOS activity can occur, even in the absence of a formal CCOS, is shown in Table A1.6. This details the amount of CCOS-like activity in hospitals which do not currently have a formal CCOS in their hospital i.e. no designated staff with defined and protected time to perform CCOS activities away from the critical care unit.

Table A1.6: Reported CCOS-like activities over time in hospitals with no formal CCOS

CCOS-like activities n (%)	1996	1997	1998	1999	2000	2001	2002	2003	2004
Follow-up of patients discharged to wards	2 (4.2)	2 (4.2)	2 (4.2)	2 (4.2)	4 (8.3)	10 (20.8)	13 (27.1)	13 (27.7)	13 (27.1)
Post discharge follow-up in outpatient clinics	1 (2.1)	1 (2.1)	1 (2.1)	1 (2.1)	3 (6.3)	6 (12.5)	8 (16.7)	7 (14.6)	7 (14.6)
Telephone hotline advice for wards	7 (14.6)	7 (14.6)	7 (14.6)	7 (14.6)	9 (18.8)	12 (25)	14 (29.2)	13 (27.1)	13 (27.1)
Direct bedside clinical support on wards	1 (2.0)	1 (2.0)	1 (2.0)	1 (2.0)	1 (2.0)	4 (8.3)	9 (18.4)	9 (18.8)	6 (12.2)
Informal bedside teaching	4 (8.0)	4 (8.2)	5 (10)	5 (10.2)	6 (12)	11 (22)	17 (34)	17 (34)	14 (28)
Formal educational courses	2 (4.2)	2 (4.2)	2 (4.2)	3 (6.3)	9 (19.1)	15 (31.9)	19 (40.4)	23 (48.9)	28 (59.6)
Use of TTs	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.0)	4 (8.0)	11 (22.0)	19 (38.0)	27 (54.0)	31 (64.6)
Audit and evaluation of CCOS-like activity	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (4.0)	4 (8.0)	10 (20.4)	11 (22)	11 (22)

CCOS critical care outreach service(s), TT physiological track & trigger warning system(s)

Current provision of CCOS

Respondents were asked to indicate whether there was currently a CCOS which covered their hospital. This was defined as the provision of designated staff with defined and protected time to perform CCOS activities away from the critical care unit. The majority (72.8%, n = 139) of respondents reported that they did have cover by a CCOS. This proportion was unchanged since the Modernisation Agency survey of 2002, which found that 72% (n = 121) of respondents reported having a CCOS.

One third of the CCOS (32.8%, n = 45) reported covering additional hospitals within their Trust. In hospitals with no CCOS, 13.7% (n = 7) had had a CCOS in the past. Reported reasons for discontinuation of CCOS were mainly lack of resource in terms of funding for staff (n = 6). In one hospital, the CCOS had been discontinued after a one-year pilot.

Respondents were asked to rank, in order of importance, the aims of their CCOS when it was first established. Table A1.7 presents the number of respondents who ranked each of the listed aims as one of the three most important.

Although the most commonly ranked aims were timely identification of patients with impending critical illness and averting/ensuring timely admissions to critical care, there was considerable variation among respondents. This variation is further illustrated by the fact that 29.4% (n =37) of respondents also cited aims which were not listed in Table A1.7. These are summarised in Table A1.8.

Table A1.7: Ranking of CCOS aims on establishment of service (includes three top ranked aims only)

Aim of CCOS	n (%)
Timely identification of patients with impending critical illness	109 (85.8)
To avert/ensure timely admissions to critical care	102 (80.3)
To avoid readmissions to critical care	56 (43.8)
To share critical care skills with staff on the wards/in the community	51 (40.5)
To enable discharges from critical care	41 (32)
To support ward-based care through education at the bedside	40 (31.5)
To support ward based staff through formal teaching	25 (19.4)

CCOS critical care outreach service(s)

Table A1.8: Additionally ranked aims of CCOS on establishment of service

Aim of CCOS	N
Improve communication/raise profile	5
Improve teamwork/improve relationships	5
Decrease cardiac arrest rate	4
Follow-up clinic	4
Specific care i.e. tracheostomies	3
Improve ability of ward staff to recognise and treat deteriorating patients	2
Audit level of care on wards	2
Implementation of scoring system	2
Demonstrate effectiveness	1
Observe recovery	1
Make service more accessible	1
Nursing leadership	1
Educational programme	1
Set patient group directives	1
Reduce hospital mortality in patients discharged from critical care	1
Support step down	1
Support families	1
Improve training	1

CCOS critical care outreach service(s)

Changes to the CCOS over time

Respondents were asked for information on how the staffing of their CCOS had changed over time. They were asked only to include posts which were

funded and staffed and to indicate the total amount of time (on average) available to the CCOS for each year i.e. irrrespective of how much time staff actually gave to the service, only the contracted commitment was requested. Analysis of these data revealed some ambiguities in responses which were treated as missing data. The values given should therefore be treated as broad estimates only rather than precise values. Table A1.9 presents the reported medical input to CCOS over time.

Table A1.9: Reported medical input to CCOS (sessions per week) over time

Number of consultant sessions per week									
	1996	1997	1998	1999	2000	2001	2002	2003	2004
Mean (SD)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0.2 (1.0)	0.4 (1.4)	0.6 (1.5)	0.6 (1.7)	0.7 (1.8)
Range	0-0	0-0	0-0	0-0	0-7	0-10	0-10	0-10	0-10
Median (IQR)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-.5)	0 (0-1)
Total number	0	0	0	0	29	58	72	83	94
Number of hospitals	130	130	130	130	130	130	130	129	128
Number of non-consultant, career Grade sessions per week									
	1996	1997	1998	1999	2000	2001	2002	2003	2004
Mean (SD)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0.1 (0.5)	0.1 (0.6)
Range	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-6	0-6
Median (IQR)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Total number	0	0	0	0	0	0	0	7	11
Number of hospitals	131	131	131	131	131	131	130	129	129
Number of junior doctors sessions per week									
	1996	1997	1998	1999	2000	2001	2002	2003	2004
Mean (SD)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.2)	0.1 (0.5)	0.2 (1.9)	0.3 (2.1)	0.4 (2.2)
Range	0-0	0-0	0-0	0-0	0-2	0-5	0-21	0-21	0-21
Median (IQR)	0 (0-0)	0 (0-0)	0 (0-0)	0 0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Total number	0	0	0	0	4	9	30	40	53
Number of hospitals	130	130	130	130	130	130	130	130	130

Total medical staff sessions per week									
	1996	1997	1998	1999	2000	2001	2002	2003	2004
Mean (SD)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0.3 (1.0)	0.5 (1.5)	0.8 (2.7)	1.0 (3.2)	1.2 (3.5)
Range	0-0	0-0	0-0	0-0	0-7	0-10	0-26	0-26	0-26
Median (IQR)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-1)	0 (0-1)
Total number	0	0	0	0	33	67	102	130	157
Number of hospitals	129	129	129	129	129	129	128	127	126

CCOS critical care outreach service(s), SD standard deviation, IQR interquartile range

71.1% (n = 91) of respondents had no consultant input to their CCOS in 2004.

Table A1.10 presents the reported nursing input to CCOS over time.

Table A1.10: Reported nursing input to CCOS (WTEs)

Number of Nurse consultants									
	1996	1997	1998	1999	2000	2001	2002	2003	2004
Mean (SD)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0.1 (0.2)	0.2 (0.4)	0.3 (0.4)	0.3 (0.4)	0.3 (0.4)
Range	0-0	0-0	0-0	0-0	0-1	0-1	0-1	0-1	0-1
Median (IQR)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0.3)	0 (0-1)	0 (0-1)	0 (0-1)
Total number	0.0	0.0	0.0	0.0	7.0	31.0	35.8	37.0	39.6
Number of hospitals	133	133	133	133	133	132	131	129	129
Number of I Grade nurses									
	1996	1997	1998	1999	2000	2001	2002	2003	2004
Mean (SD)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.1)	0 (0.1)	0 (0.1)	0 (0.1)	0 0.1)
Range	0-0	0-0	0-0	0-0	0-1	0-1	0-1	0-1	0-1
Median (IQR)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Total number	0.0	0.0	0.0	0.0	1.0	1.0	1.0	2.0	2.8
Number of hospitals	135	135	135	135	135	134	134	134	134

Number of H Grade nurses									
	1996	1997	1998	1999	2000	2001	2002	2003	2004
Mean (SD)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.2)	0.1 (0.3)	0.1 (0.3)	0.2 (0.4)	0.3 (0.5)
Range	0-0	0-0	0-0	0-0	0-1.4	0-1.4	0-1	0-1.6	0-3
Median (IQR)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0 -0.3)
Total number	0.0	0.0	0.0	0.0	5.2	12.5	11.9	22.5	35.1
Number of hospitals	135	135	135	135	135	135	134	134	134
Number of G Grade nurses									
	1996	1997	1998	1999	2000	2001	2002	2003	2004
Mean (SD)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.2)	0.3 (0.9)	0.8 (1.2)	1.0 (1.2)	1.2 (1.4)	1.5 (1.7)
Std Deviation	0.0	0.0	0.0	0.2	0.9	1.2	1.2	1.4	1.7
Range	0-0	0-0	0-0	0-2	0-6	0-6	0-6	0-62	0-12.8
Median (IQR)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0.4 (0-1)	1 (0-1.7)	1 (0-1.9)	1 (0.2-2)
Total number	0.0	0.0	0.0	3.0	44.7	112.7	134.9	161.8	205.4
Number of hospitals	135	135	135	135	135	134	133	133	134
Number of F Grade nurses									
	1996	1997	1998	1999	2000	2001	2002	2003	2004
Mean (SD)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.2)	0.3 (0.9)	0.6 (1.2)	0.7 (1.2)	0.7 (1.2)	0.9 (1.6)
Range	0-0	0-0	0-0	0-2	0-6.5	0-6.5	0-6.5	0-5.7	0-10
Median (IQR)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-1)	0 (0-1)	0 (0-1)	0 (0-1)
Total number	0.0	0.0	0.0	3.5	35.7	81.0	87.0	86.7	123.0
Number of hospitals	132	132	132	132	132	132	132	130	130

Number of E Grade nurses									
	1996	1997	1998	1999	2000	2001	2002	2003	2004
Mean (SD)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.4)	0.1 (0.4)	0.1 (0.6)	0.1 (0.5)	0.1 (0.5)
Range	0-0	0-0	0-0	0-0	0-4	0-4	0-4	0-4	0-3
Median (IQR)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Total number	0.0	0.0	0.0	0.0	5.0	10.3	13.5	17.5	17.5
Number of hospitals	134	134	134	134	134	134	133	133	133
Number of D Grade nurses									
	1996	1997	1998	1999	2000	2001	2002	2003	2004
Mean (SD)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.1)	0 (0.1)	0 (0.1)
Range	0-0	0-0	0-0	0-0	0-0	0-0	0-1	0-1	0-1
Median (IQR)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Total number	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0
Number of hospitals	134	134	134	134	134	134	134	134	134
Total Number nurses									
	1996	1997	1998	199	2000	2001	2002	2003	2004
Mean (SD)	0 (0.0)	0 (0.0)	0 (0.0)	0.1 (0.4)	0.8 (1.5)	1.9 (1.8)	2.1 (1.8)	2.5 (1.8)	3.3 (2.3)
Range	0-0	0-0	0-0	0-4	0-7.4	0-7.5	0-7.5	0-8.1	0-15.6
Median (IQR)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-1)	1 (0-3)	2 (1-3)	2 (1-3.6)	2.9 (1.7-4.2)
Total number	0.0	0.0	0.0	6.5	98.7	242.1	269.9	310.6	407.2
Number of hospitals	130	130	130	130	130	128	126	124	125

CCOS critical care outreach service(s), WTE whole-time equivalent, SD standard deviation, IQR interquartile range

65.1% (n = 84) of respondents reported no nurse consultant input to their CCOS in 2004. 41% (n = 57) of CCOS reported no input from either a nurse consultant, an I Grade or an H Grade nurse in 2004.

A number of respondents reported that Allied Health Professionals had input to their CCOS. This information is summarised in Table A1.11 and Table A1.12.

Table A1.11: Reported Allied Health Professionals/other staff input to CCOS over time (WTEs)

Number of Allied Health Professionals									
	1996	1997	1998	1999	2000	2001	2002	2003	2004
Mean (SD)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.1)	0 (0.2)	0.1 (0.3)	0.1 (0.4)	0.1 (0.4)
Range	0-0	0-0	0-0	0-0.1	0-1	0-1.5	0-1.5	0-2	0-2
Median (IQR)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Total number	0.0	0.0	0.0	0.1	1.2	5.5	10.1	16.0	18.3
Number of hospitals	130	130	130	130	128	128	128	128	128
Number of other staff									
	1996	1997	1998	1999	2000	2001	2002	2003	2004
Mean SD)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.1)	0.1 (0.2)	0.1 (0.2)	0.1 (0.2)	0.1 (0.3)
Range	0-0	0-0	0-0	0-0	0-1	0-1	0-1	0-1	0-1.6
Median (IQR)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Total number	0.0	0.0	0.0	0.0	2.3	7.4	10.6	11.4	16.7
Number of hospitals	125	125	125	125	125	125	125	124	124

CCOS critical care outreach service(s), WTE whole-time equivalent, SD standard deviation, IQR interquartile range

Table A1.12: Reported type of other staff with input to CCOS

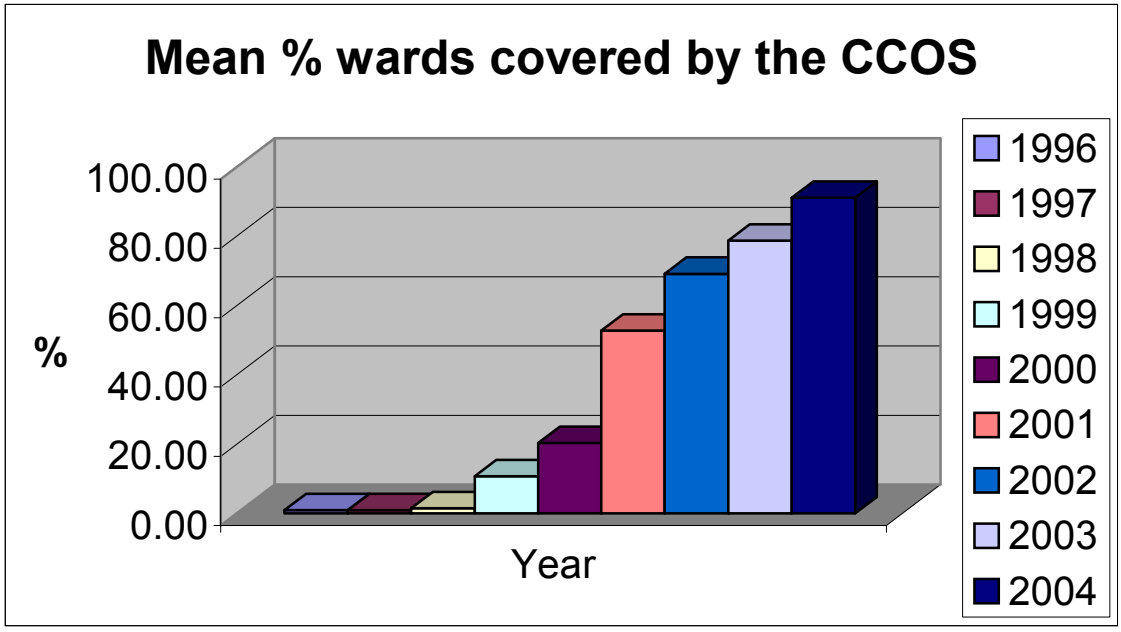
Staff member	Number
Data input/audit clerk	8
Ward clerk	3
Secretary	2
Administrative assistant	1
Information officer	1

CCOS critical care outreach service(s)

Hospital coverage

Figure A1.13 illustrates how the reported proportion of adult wards in responding hospitals which were covered by the CCOS has increased over time. Again, a marked increase is noticeable after 2000 but, importantly, this increase is still continuing.

Figure A1.13: Reported percentage of adult wards covered by the CCOS



CCOS critical care outreach service(s)

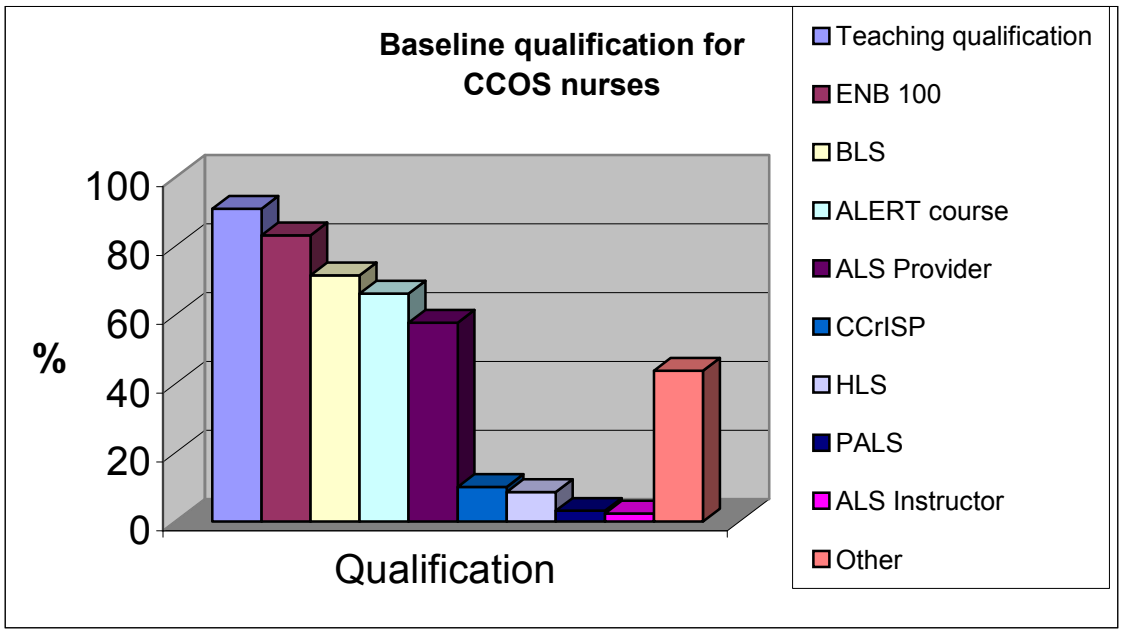
Skills/competencies of CCOS staff

Respondents were asked about the particular skills and competencies required for nursing staff working in the CCOS in their hospital. Skills and competencies for nurses had been identified in the majority (89.2%, n = 116) of hospitals. This percentage represented a marked increase since the Modernisation Agency survey of 2002[26] when the corresponding figure was only 45% (n = 54).

Over half the hospitals (58.5%, n = 76) had an in-house training programme to develop staff working in the CCOS. Again, this figure had increased since 2002 from 31% (n = 37)1.

The majority of hospitals (91.5%, n = 118) reported that they expected CCOS nurses to have critical care experience and all hospitals with a CCOS (n = 130) required some baseline qualifications for CCOS nurses. The nature of the qualifications required is presented in Figure A1.14. “Other” qualifications, reported by respondents, are described in Table A1.13

Figure A1.14: Reported baseline qualifications for CCOS nurses



CCOS critical care outreach service(s), ENB English National Board, BLS basic life support, ALERT acute life threatening events – recognition and treatment course, ALS advanced life support, CCrISP care of the critically ill surgical patient, HLS hospital life support, PALS paediatric advanced life support

Table A1.13: Other baseline qualifications reported for CCOS nurses

Qualification	Number
Other critical care course	16
Other clinical assessment skills course	16
History/physical assessment/examination course	8
BSc / Diploma	6
Venepuncture and cannulation	3
ILS/ALS	3
Advanced practice	1
NIV competence	1

CCOS critical care outreach service(s), BSc bachelor of science, ILS immediate life support, ALS advance life support, NIV non-invasive ventilation

83.3% (n = 95) of hospitals reported expecting CCOS medical staff to have critical care experience but, in contrast to nursing staff, only 23% (n = 23) of hospitals reported requiring any baseline qualifications for medical staff. The nature of these baseline qualifications is summarised in Table A1.14.

Table A1.14: Reported baseline qualifications required for CCOS medical staff

Qualification	Number
Advanced course e.g. ALS/CCrISP/ AIM / ALERT Provider	7
Consultant Anaesthetist/Intensivist	5
Anaesthetist	8
FRCS	2
Anaesthetist/Intensivist	1
Senior grade (not specified)	1
Trainee Anaesthetists	1

CCOS critical care outreach service(s), ALS advanced life support, CCrISP care of the critically ill surgical patient, AIM acute illness management, ALERT acute life threatening events – recognition and treatment course, FRCS fellow of the royal college of surgeons

Availability of CCOS

Respondents were asked for details of the availability of their CCOS to deliver clinical support to adult wards. Table A1.15 presents availability in days per week. Table A1.16 availability in hours per day.

Table A1.15: Reported availability of CCOS for clinical support (days)

Service n (%)	7 days per week	Selected days	Not provided	Total
Follow-up of discharged level 3/2 patients on adult wards	69 (50.4)	67 (48.9)	1 (0.7)	137 (100)
Telephone hotline advice for adult wards	69 (50.7)	30 (22.1)	37 (27.2)	136 (100)
Direct bedside clinical support for adult wards	72 (52.2)	63 (45.7)	3 (2.2)	138 (100)

CCOS critical care outreach service(s)

Table A1.16: Reported availability of CCOS for clinical support (hours)

Service n (%)	24 hours per day	12-23 hours	Less than 12 hours	Not provided	Total
Follow-up of discharged level 3/2 patients on adult wards	17 (12.2)	22 (15.8)	99 (71.2)	1 (0.7)	139 (100)
Telephone hotline advice for adult wards	45 (33.8)	13 (9.8)	37 (27.8)	38 (28.6)	133 (100)
Direct bedside clinical support for adult wards	20 (14.5)	23 (16.7)	92 (66.7)	3 (2.2)	138 (100)

CCOS critical care outreach service(s)

Figure A1.15 to Figure A1.15 illustrate the reported variation in availability for each clinical support activity. Over half the hospitals reported providing each type of clinical support seven days per week. While 65.2% (n = 45) of hospitals reported providing telephone follow-up 24 hours a day for 7 days per week, less than 28% of hospitals reported offering follow-up or direct bedside clinical support on the same basis. Although the availability of 24 hour/7-day cover has not increased since 2002[26], clearly CCOS reported extending beyond a weekday service in many more hospitals.

Figure A1.15: Reported availability of follow-up for discharged level 3/2 patients on adult wards

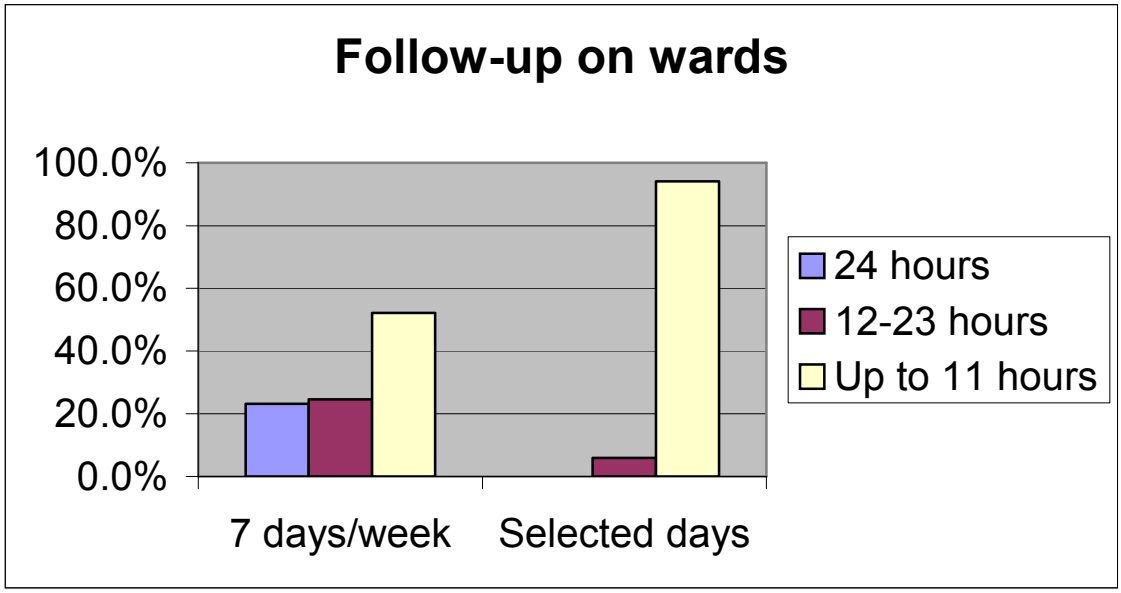


Figure A1.16: Reported availability of telephone hotline advice for adult wards

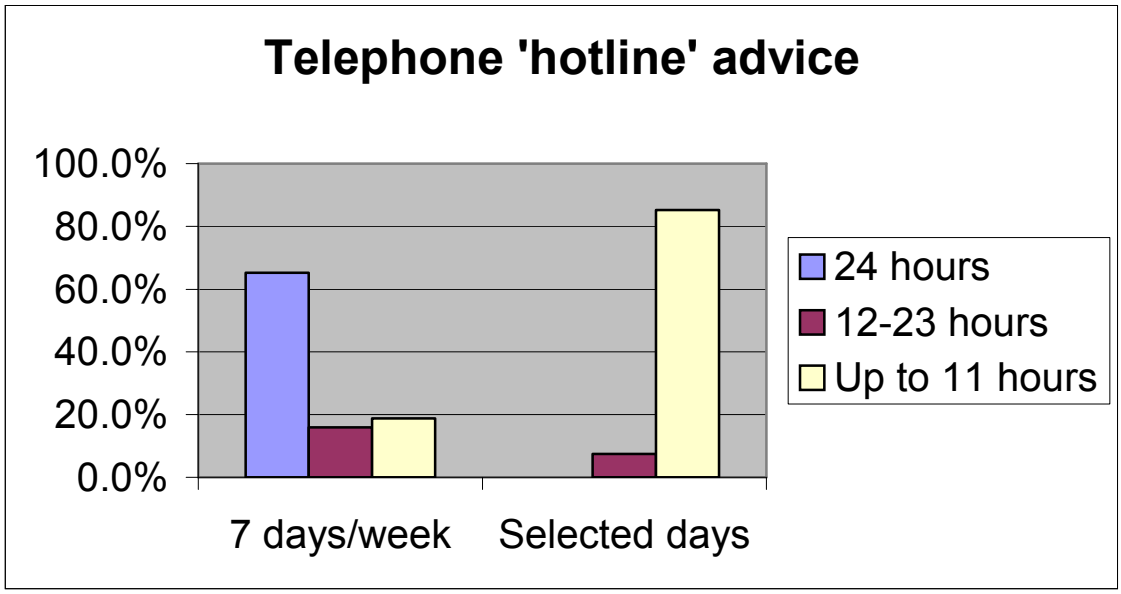
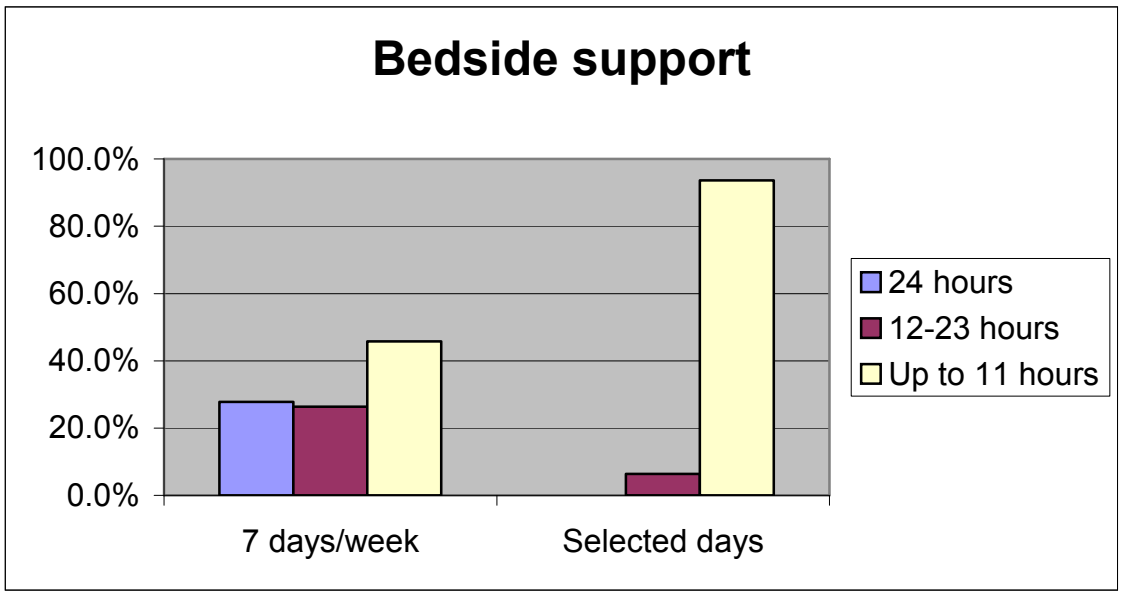


Figure A1.17: Reported availability of direct bedside clinical support for adult wards



Post-critical care discharge follow-up on adult wards
Almost all hospitals reported providing follow-up i.e. a visit from a member of the CCOS for level 2 (95%, n = 132) and level 3 (97%, n = 133) patients discharged from critical care to adult ward areas. This represented a slight increase since 2002, when 89% (n = 106) of hospitals included post-discharge follow-up within the CCOS[26].

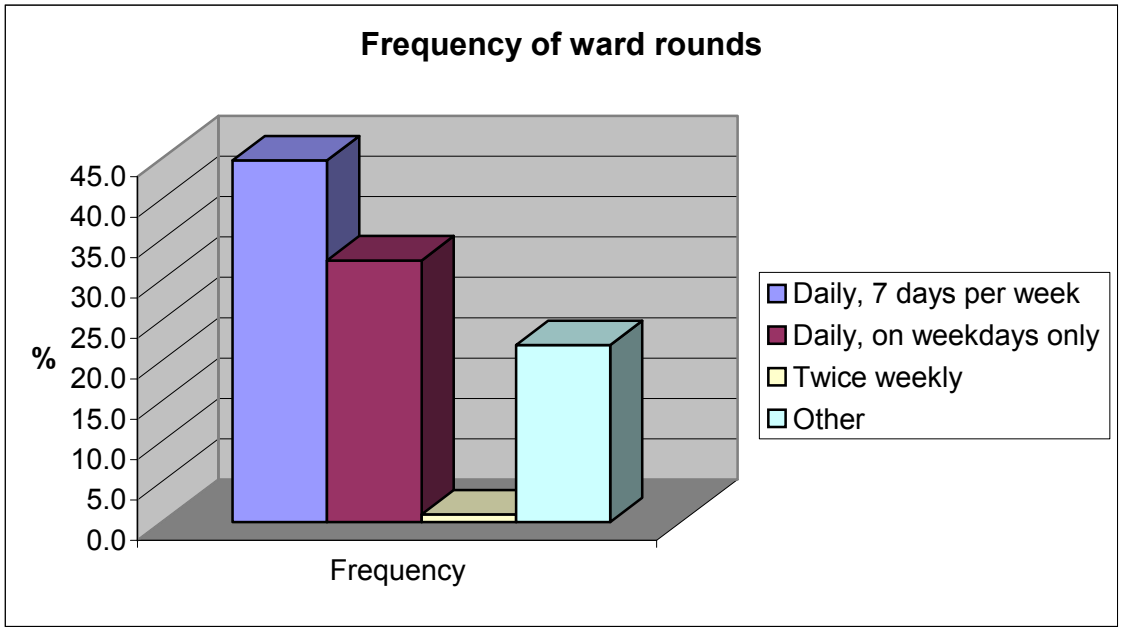
The category of patients followed up is detailed in Table A.17.

Table A.17: Reported categories of patients followed up on adult wards post-discharge from critical care

Category of patient	Level 2, n (%)	Level 3, n (%)
All	105 (80.2)	117 (88.6)
Minimum stay of 2-3 nights	7 (5.3)	3 (2.3)
Minimum stay of 4 nights or more	0 (0)	1 (0.8)
Other	19 (14.5)	11 (8.3)
Total	131 (100)	132 (100)

The majority (75.5%, n = 105) of CCOS reported completing post-discharge follow-up by means of a regular ward round. This number had increased substantially since 2002, when the figure was 20% (n = 24). Figure A1.18 presents the reported frequency of these ward rounds. The most common frequency was a daily/7days per week ward round, again indicating that CCOS are no longer predominantly a weekday service.

Figure A1.18: Reported frequency of CCOS follow-up ward rounds

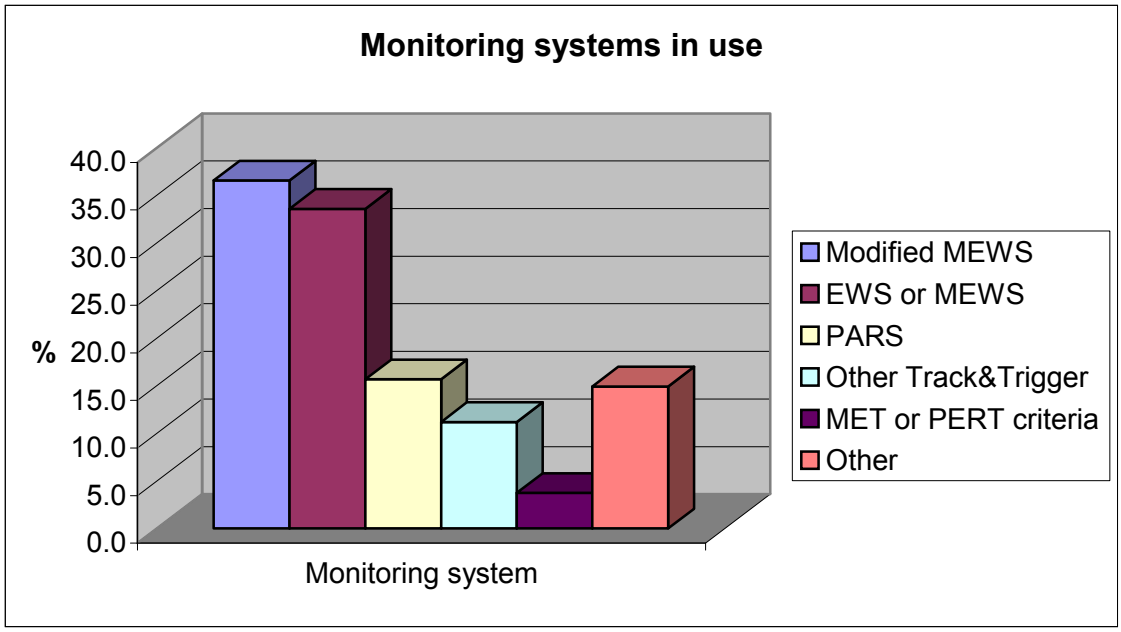


CCOS critical care outreach service(s)

Activation of the CCOS

Almost all (96.4%, n = 134) hospitals with a CCOS reported using a TT to identify patients on adult wards with established or impending critical illness. The equivalent figure for 2002 was 81.5% (n = 97). Figure A1.17 illustrates the variety of systems in use. Over 70% of hospitals reported currently using EWS or a modification based on EWS. The popularity of aggregate scoring systems over single parameter systems was also noted in the 2002 Modernisation Agency survey[26].

Figure A1.19: Reported TTs in use to monitor patients on adult wards with established or impending critical illness



TT physiological track & trigger warning system(s), MEWS modified early warning score, EWS early warning score, PARS patient at risk score, MET medical emergency team, PERT patient emergency response team

Most hospitals reported only use one TT (Table A1.18).

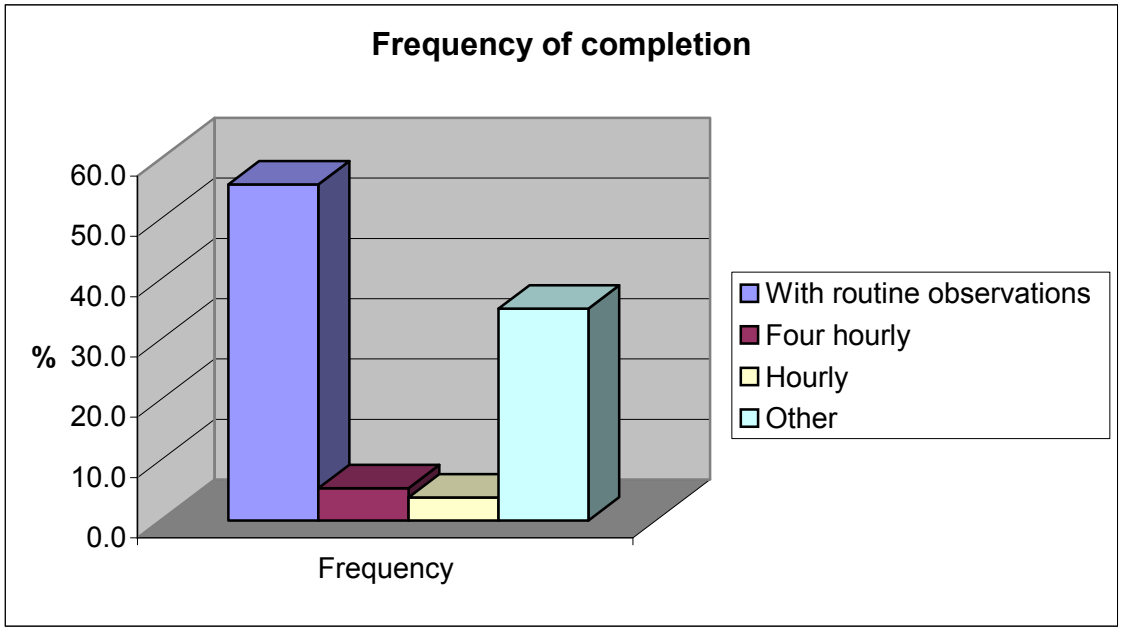
Table A1.18: Number of TTs reported in place in each hospital

Number of TTs in place	n (%)
1	115 (85.8)
2	17 (12.7)
3	2 (1.5)
Total	134 (100)

TT physiological track & trigger warning system(s)

Figure A1.20 presents the physiological parameters included in the TTs.

Figure A1.20: Reported physiological parameters included in TTs in use



TT physiological track & trigger warning system(s)

Other parameters are presented in Table A1.19.

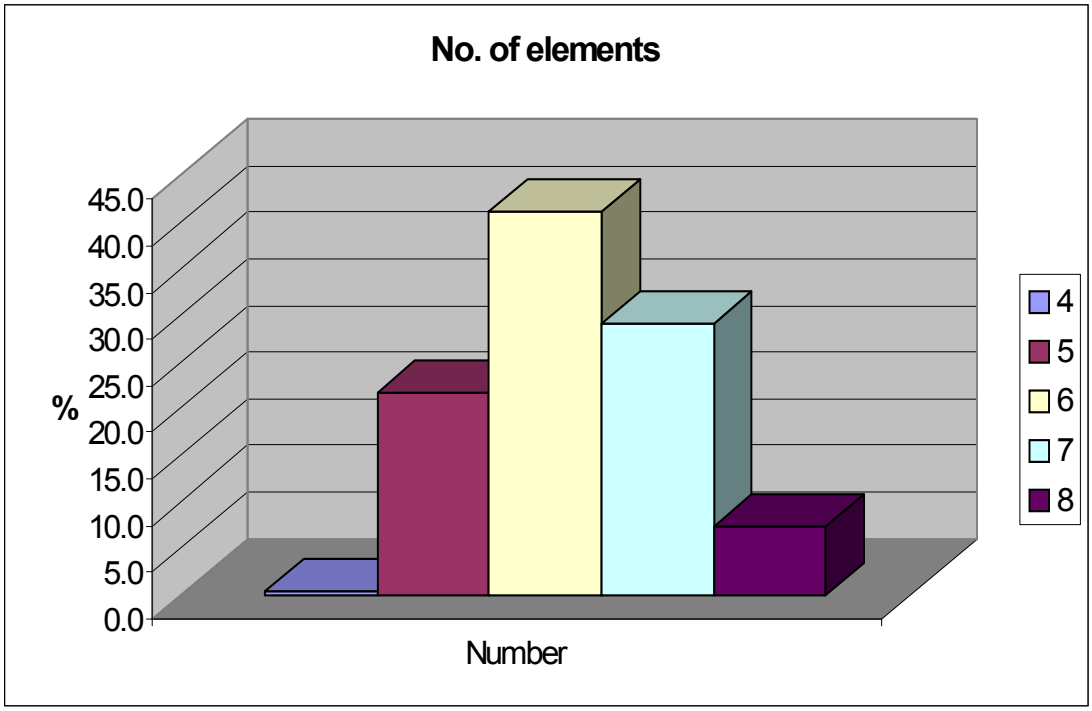
Table A1.19: Reported other parameters included in TTs in use

Parameter	Number
Level of O_2 therapy	10
Cause for concern	8
Pain	5
Blood sugar	4
NIV/CPAP	4
ABGs	1
Tracheostomy	1
Encephalopathy grading	1
Total	31

TT physiological track & trigger warning system(s), NIV non-invasive ventilation, CPAP continuous positive airway pressure, ABG arterial blood gas

Almost all hospitals reported that their TTs included more than four physiological parameters, with the majority including six (Figure A1.19).

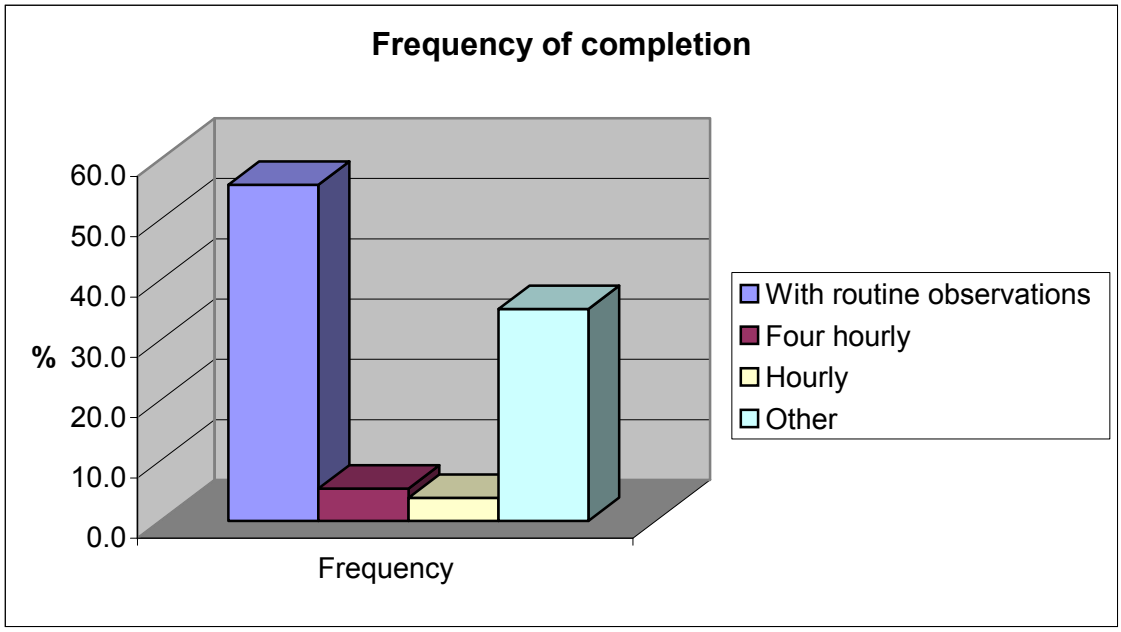
Figure A1.21: Reported total number of physiological parameters included in TTs in use



TT physiological track & trigger warning system(s)

In 69.6% (n = 94) of hospitals, a TT was reported as in use on all adult wards. In the wards where the TT was in use, most hospitals (72.7%, n = 96) reported using the system for all patients. The equivalent figure for 2002 was 46% (n = 49). Over half the hospitals reported completing the TT with routine observations while the remainder of hospitals reported a variety of systems (Figure A1.20 and Table A1.20)

Figure A1.22: Reported frequency of completion of TT



TT physiological track & trigger warning system(s)

Table A1.20: Reported other frequencies for completion of TT

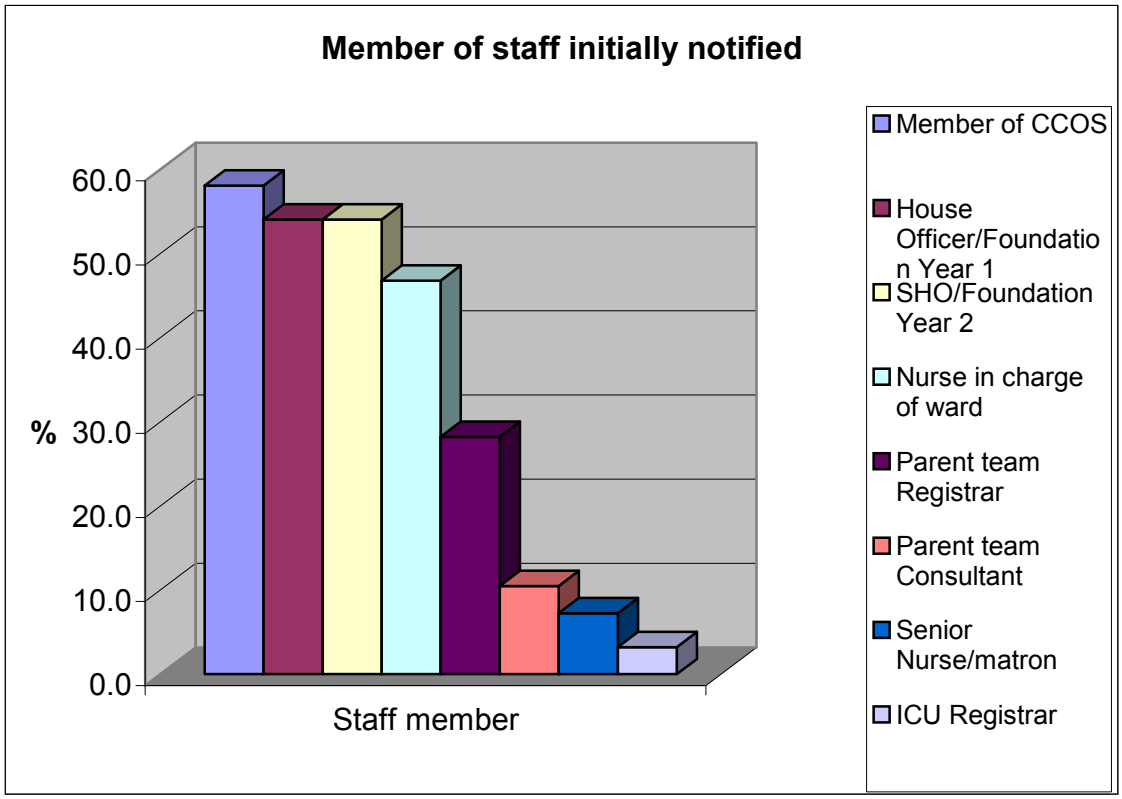
Frequency	Number
According to concerns of staff	14
According to score/scoring/trigger	12
According to individual need	9
Ad hoc	6
According to ward standards/protocols	3
At request of CCOS	1
On referral to CCOS	1
Total	46

TT physiological track & trigger warning system(s), CCOS critical care outreach service(s)

Response algorithms/protocols

The majority (88.4%, n = 122) of hospitals with a CCOS reported having a specified, initial response pattern or response algorithm for patients identified as being 'at risk' on the basis of the TT in use. The equivalent figure for 2002 was 74%[26]. For most hospitals (76.4%, n = 90), the response algorithm identified more than one member of staff who should be notified, presumably depending on the level of risk. As in 2002, it was noticeable that many primary respondents to a TT trigger were junior medical staff from the parent ward team or ward nursing staff. Figure A1.23 presents the reported details of staff members who might initially be called.

Figure A1.23: Reported member of staff who might be notified on trigger



CCOS critical care outreach service(s), SHO senior house officer, ICU intensive care unit

Some respondents (n = 61) reported figures for the number of patients on adult wards who were identified as "at risk" each month on the basis of the TT used. The median (IQR) number of patients was 50 (25 – 84.5). Of these, the median (IQR) reported number seen by the CCOS was 45 (19 – 82). The median (IQR) difference between the number of patients identified and the number seen by CCOS was 0 (0 – 0) indicating that, in most of the hospitals who were able to provide this information, the CCOS saw all "at risk" patients. Most (67.2%, n = 86) hospitals reported their agreed target response time for "at risk" patients. The mean (SD) time was 28.8 (13.1) minutes. This reflected the picture in 2002, when the majority of respondents had an agreed target response time of 30 minutes.

Independent delivery of care by CCOS staff
While almost all hospitals reported that their CCOS provided clinical assessment, liaison with critical care and advice and intervention in support of the parent team, substantially less reported intervening independent of the parent team (Table A1.21).

Table A1.21: Reported care delivered by CCOS

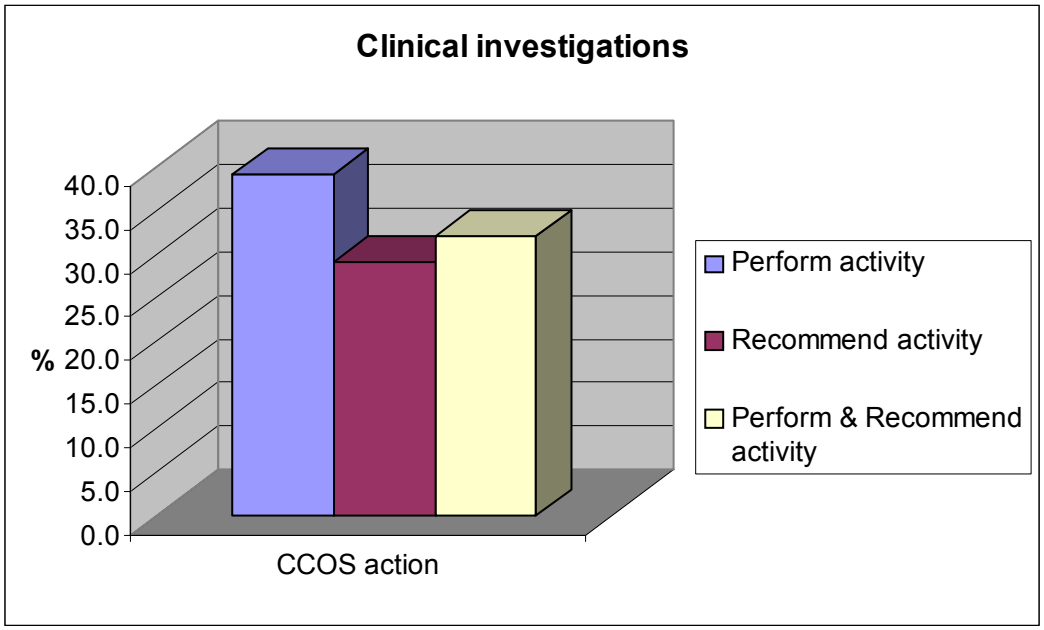
Care delivered	n (%)
Clinical assessment	132 (97.8)
Clinical advice and recommendations to the parent team	132 (97.8)
Liaison with critical care medical team for advice, support and possible transfer to critical care	130 (96.3)
Direct clinical intervention in support of the parent team	119 (88.1)
Direct clinical intervention independent of the parent team	84 (62.2)

CCOS critical care outreach service(s)

The reported distribution of care delivery activities was very similar to the picture in 2002, but the reported proportion of CCOS involved in each of the listed activities had increased slightly since 2002[26].

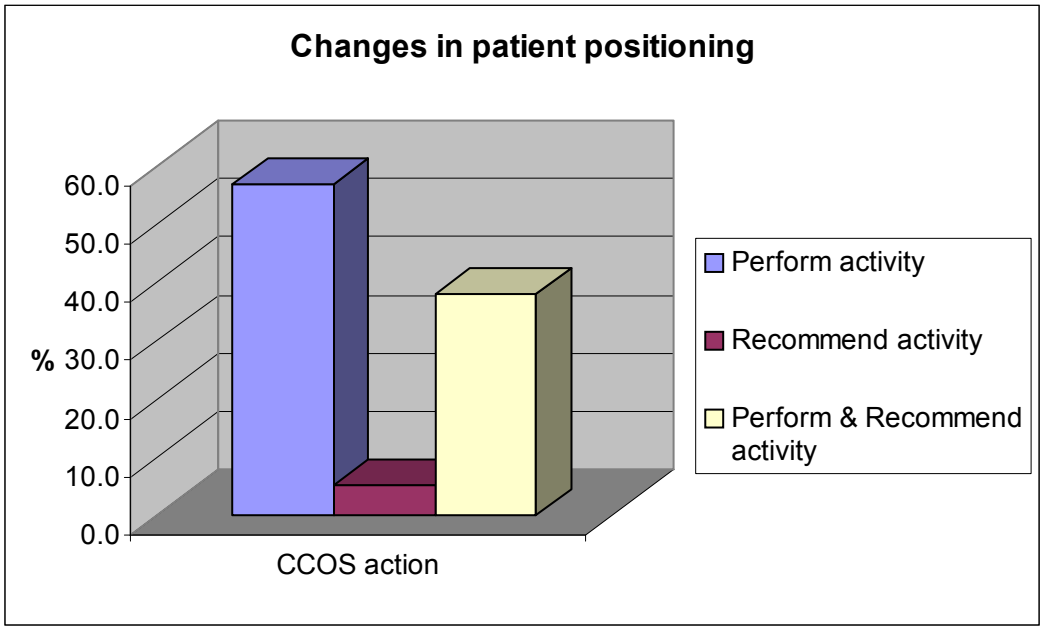
This distinction, between direct intervention and making recommendations about patient treatment, is illustrated in Figure A1.24 to Figure A1.32. These present the extent to which CCOS were reported as being involved in a number of clinical activities. The pattern of interventions is not uniform. The mean (SD) number of the eleven listed activities which were reported as commended by CCOS staff was 8.1 (2.6). The mean (SD) number of the eleven listed activities which were reported as performed by CCOS staff was 4.9 (2.5).

Figure A1.24: Reported involvement of CCOS staff in investigations, for example, venupuncture, blood gas sampling, chest x-ray etc



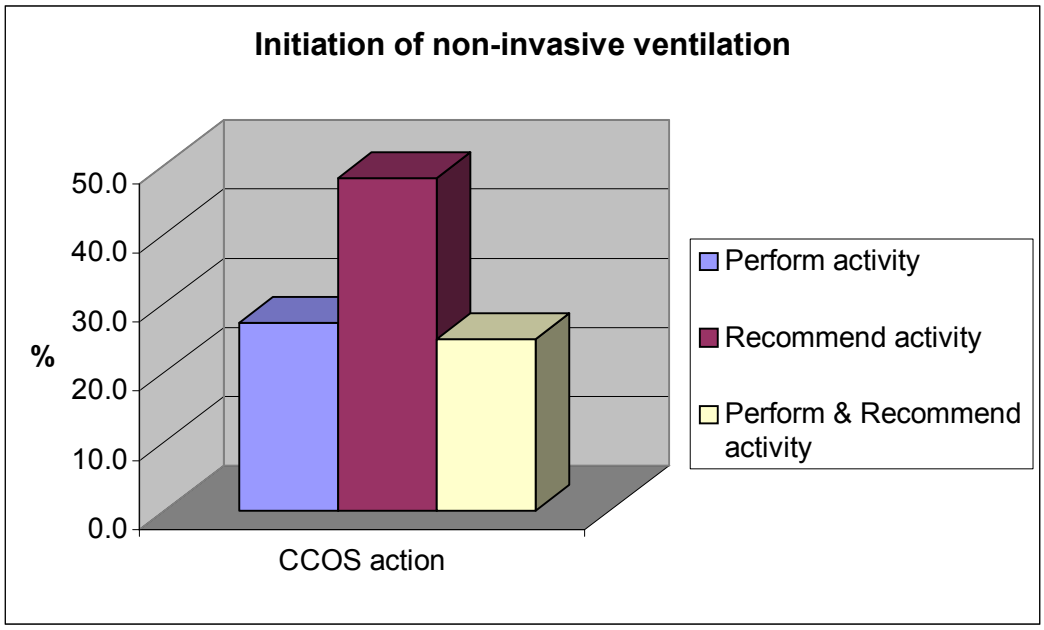
CCOS critical care outreach service(s)

Figure A1.25: Reported involvement of CCOS staff in changing patient positioning



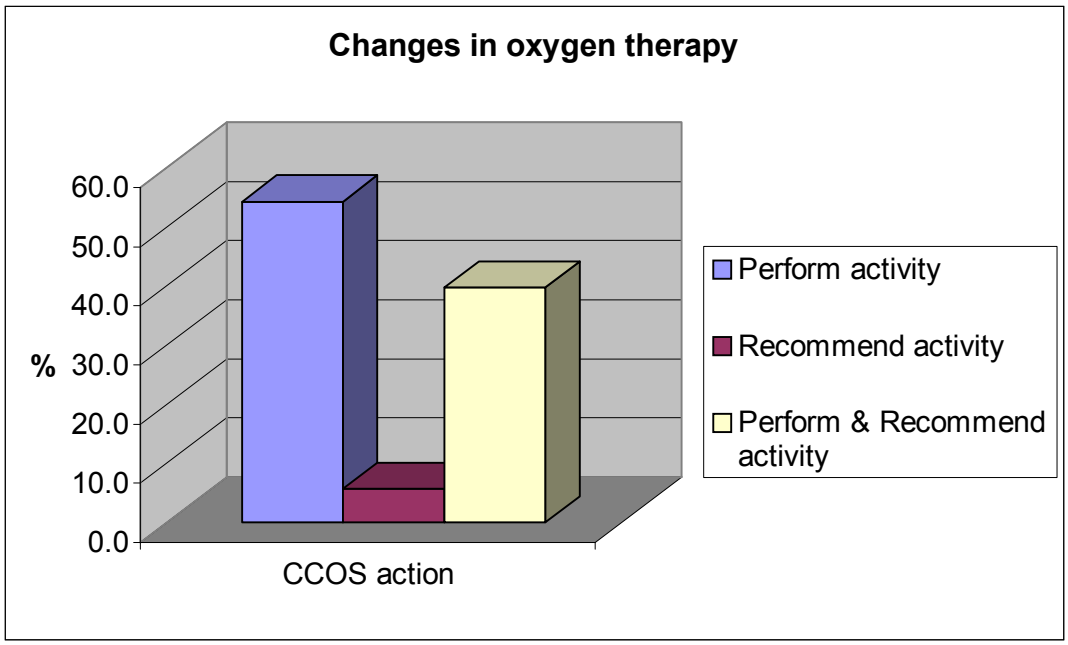
CCOS critical care outreach service(s)

Figure A1.26: Reported involvement of CCOS staff in changing oxygen therapy



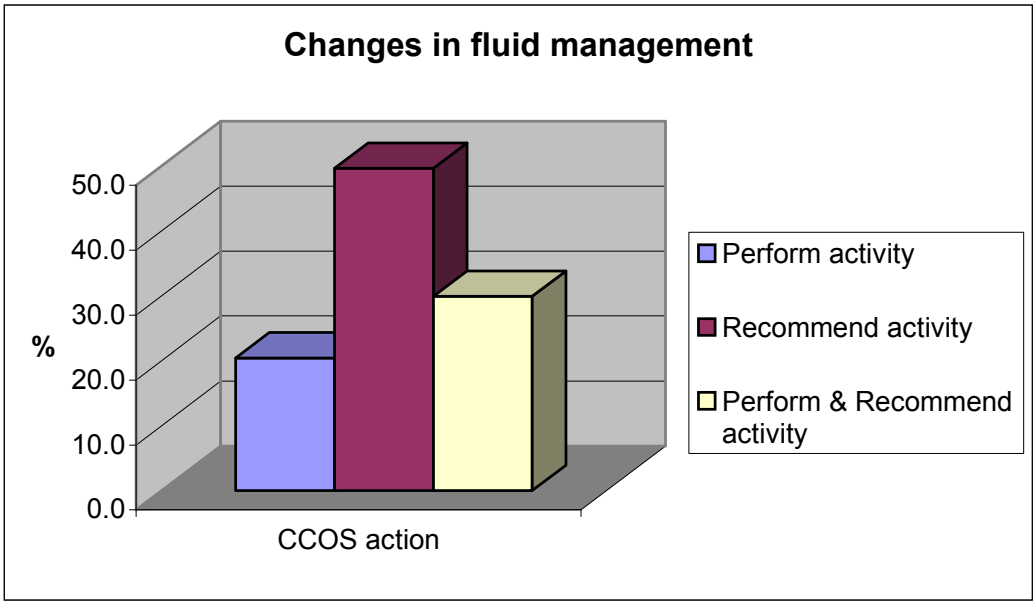
CCOS critical care outreach service(s)

Figure A1.27: Reported involvement of CCOS staff in initiation of non-invasive ventilation



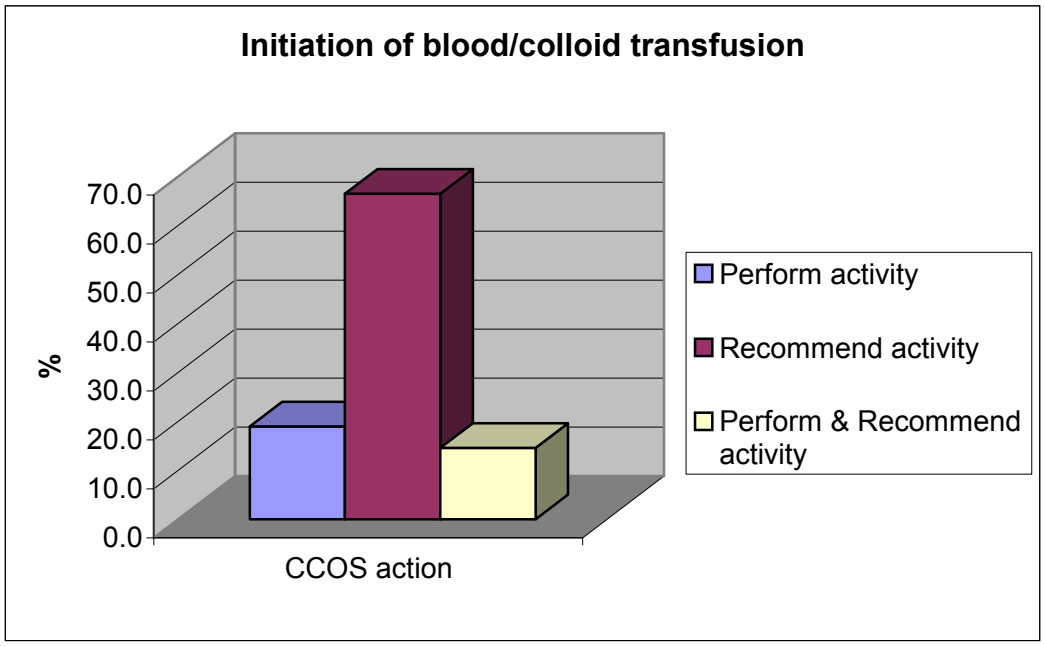
CCOS critical care outreach service(s)

Figure A1.28: Reported involvement of CCOS staff in changes in fluid management



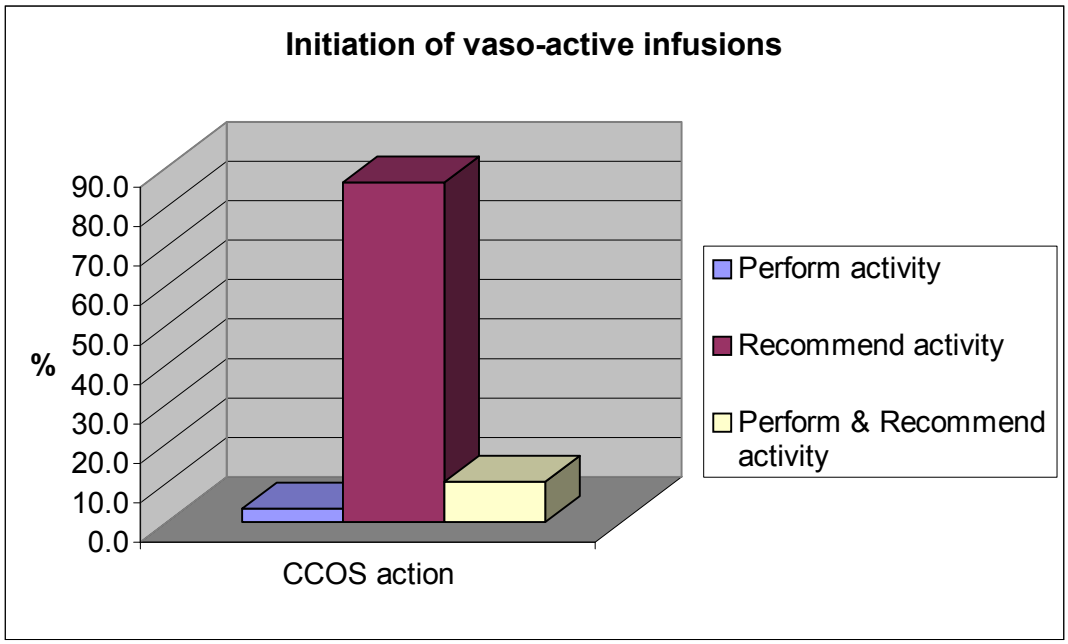
CCOS critical care outreach service(s)

Figure A1.29: Reported involvement of CCOS staff in initiation of blood/colloid transfusion



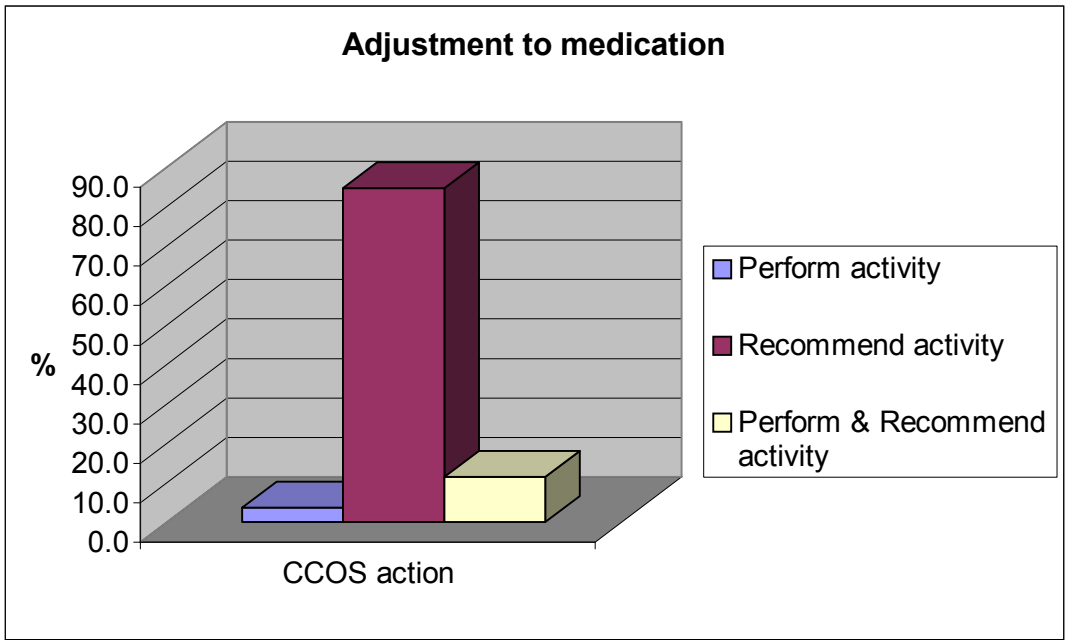
CCOS critical care outreach service(s)

Figure A1.30: Reported involvement of CCOS staff in initiation of vasoactive infusions



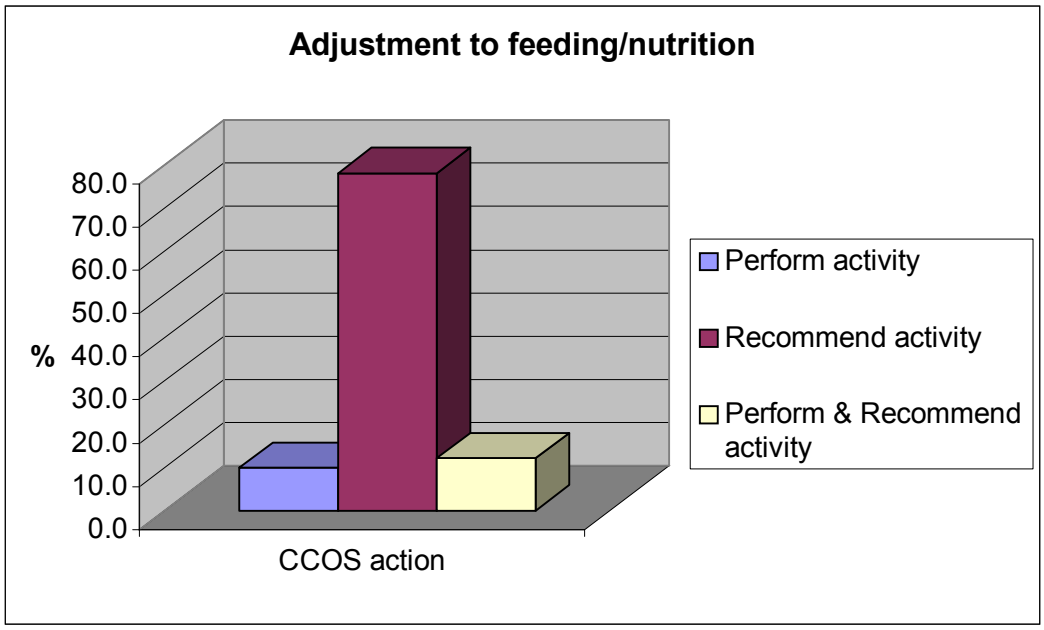
CCOS critical care outreach service(s)

Figure A1.31: Reported involvement of CCOS staff in adjustment to medication



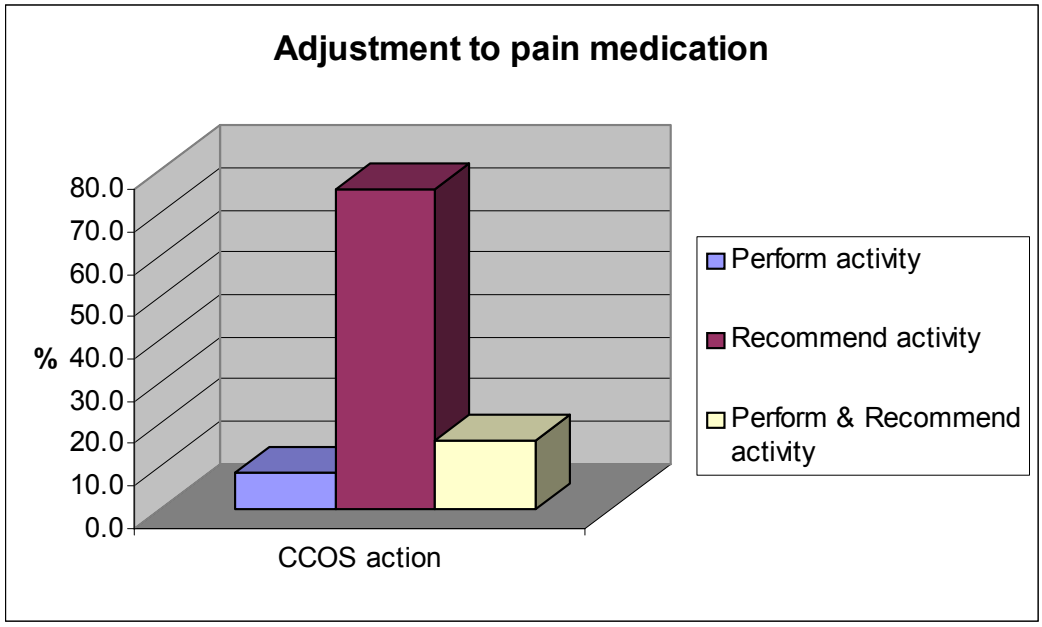
CCOS critical care outreach service(s)

Figure A1.32: Reported involvement of CCOS staff in adjustment to feeding/nutrition



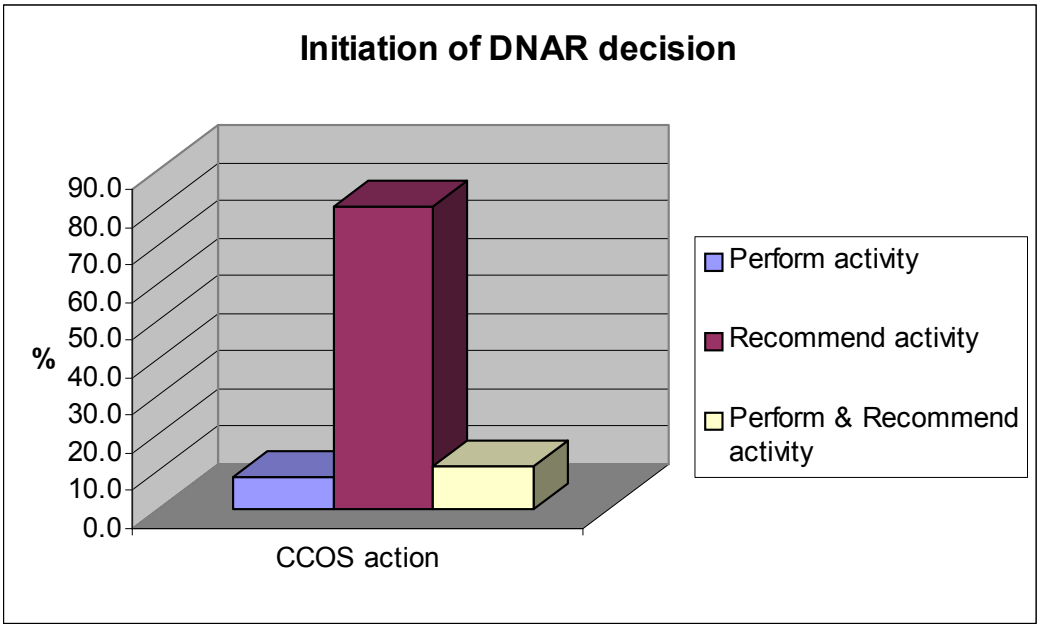
CCOS critical care outreach service(s)

Figure A1.33: Reported involvement of CCOS staff in adjustment to pain medication



CCOS critical care outreach service(s)

Figure A1.34: Reported involvement of CCOS staff in initiation of DNAR decisions



CCOS critical care outreach service(s), DNAR do not attempt resuscitation

All hospitals kept records of the involvement of the CCOS staff in patient care. These records were reportedly kept in a variety of locations, which are detailed in Table A1.22.

Table A1.22: Reported recording of involvement of CCOS staff in patient care

Record of CCOS involvement	n (%)
Ward medical notes	119 (86.2)
CCOS notes	119 (86.2)
Ward nursing notes	53 (39)
Other	43 (31.2)

CCOS critical care outreach service(s)

Educational activities of the CCOS

As in 2002, the vast majority of hospitals (99.3%, n = 137) reported that the CCOS provided training in the care of the critically ill to other hospital staff. Types of training reported are illustrated in Table A1.23.

Table A1.23: Educational activities of the CCOS

Educational activity	n (%)
Training in care, for example, care of tracheostomies, as part of follow-up	134 (97.8)
Informal bedside teaching in response to a deteriorating patient	133 (97.1)
Formal teaching of student nurses/medical students	115 (83.9)
ALERT course (or equivalent)	113 (83.1)
Informal group teaching in response to a deteriorating patient	110 (80.3)
Formal in-house competency based training	78 (56.9)
Course in developing High Dependency skills	73 (53.3)
Other	48 (35)
CCrISP course	10 (7.4)

CCOS critical care outreach service(s), ALERT acute life threatening events – recognition and treatment course, CCrISP care of the critically ill surgical patient

The most striking change since the last CCOS survey, was the number of hospitals offering the ALERT course, or similar, which had increased from 59% (n = 66) in 2002[26].

The reported median (IQR) number of days per year that each CCOS spent delivering formal training programmes was 30 (18 – 50).

Links with other specialist services
Only 14.6% (n = 20) of CCOS reported being formally integrated with another specialist support service. In the last Modernisation Agency survey, 19% of CCOS reported full integration with another service[26]. The nature of the current services is described in Table A1.24.

Table A1.24: Reported integration of CCOS with other specialist support services

Service	Number
Resuscitation team	8
Acute pain team	3
Acute pain and resuscitation team	3
Critical care medical staff/unit	2
Resuscitation and physiotherapy team	1
NIV team	1
Dietetics, speech, pain, resuscitation and ENT	1
Missing	1
Total	20

CCOS critical care outreach service(s), NIV non-invasive ventilation, ENT ear nose & throat

In 18.8% (n = 26) of CCOS, a team member was reported as also being a member of another specialist team. In 20 of these 26 CCOS, only one CCOS

team member was involved. The nature of these services and CCOS team members is described in Table A1.25.

Table A1.25: Reported services that share a team member with the CCOS

Service	Number	Team member
Critical care	6	Nurse Consultant (1) F Grade (2) G Grade (2) Senior II Physiotherapist (1)
Resuscitation team	6	Nurse Consultant (1) F Grade Nurse (2) G Grade Nurse (2) Missing (1)
Acute pain team	3	F Grade Nurse (1) G Grade Nurse (2)
Respiratory team	2	Respiratory Nurse Specialist (1) Senior 1 Physiotherapist (1)
Donor liaison	2	G Grade Nurse (2)
Midwifery team	1	CCOS Sister (1)

CCOS critical care outreach service(s)

As was the case in 2002, most (92.1%, n = 128) hospitals reported that CCOS could directly refer patients to other specialist support services (and vice versa) without the requirement to inform the medical team(s) involved. The nature of these services is described in Table A1.26. The vast majority (93.7%, n = 119) of hospitals reported that CCOS could refer to more than one other specialist support service.

Table A1.26: Reported services who could receive direct referrals (and vice versa) from CCOS

Service	n (%)
Acute pain team	119 (93.7)
Nutrition team	82 (64.6)
Physiotherapy service	121 (95.3)
Other	59 (46.5)

CCOS critical care outreach service(s)

The reported diversity of services which were linked to the CCOS can be seen in Table A1.27 - which breaks down the “other” category in Table A1.26.

Table A1.27: Reported "other" services who can receive direct referrals (and vice versa) from CCOS

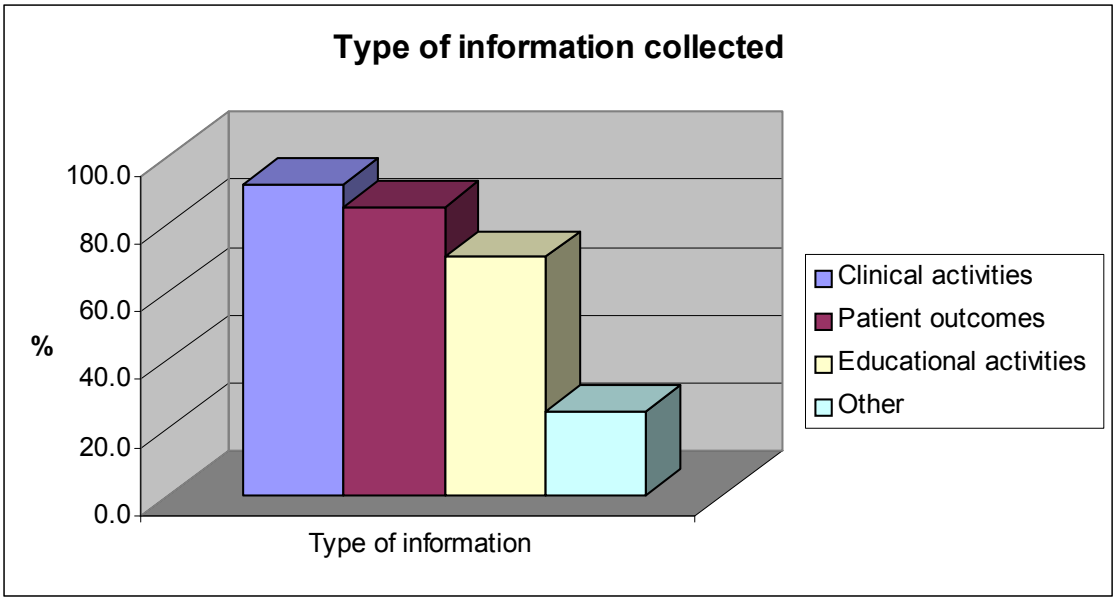
Other services	n
Speech and language therapy	20
Respiratory services	7
Critical care	5
Clinical psychology	5
Cardiac	4
Tracheostomy, head and neck specialist service	3
Resuscitation	2
Pharmacy	2
Missing	2
Palliative care	2
Renal outreach sister	1
Occupational therapy	1
NIV	1
Any that a patient may require	1
Dieticians	1
Chronic pain service	1
Vascular nurse specialist	1
Bowel nurse	1
Stoma nurse	1
Diabetes nurse	1

CCOS critical care outreach service(s), NIV non-invasive ventilation

CCOS and audit

Almost all hospitals reported that the CCOS collected information routinely. The nature of this information is described in Figure A1.33.

Figure A1.33: Reported type of information routinely collected by CCOS



CCOS critical care outreach service(s)

Members of the CCOS were involved in collecting these data in most hospitals (Table A1.28).

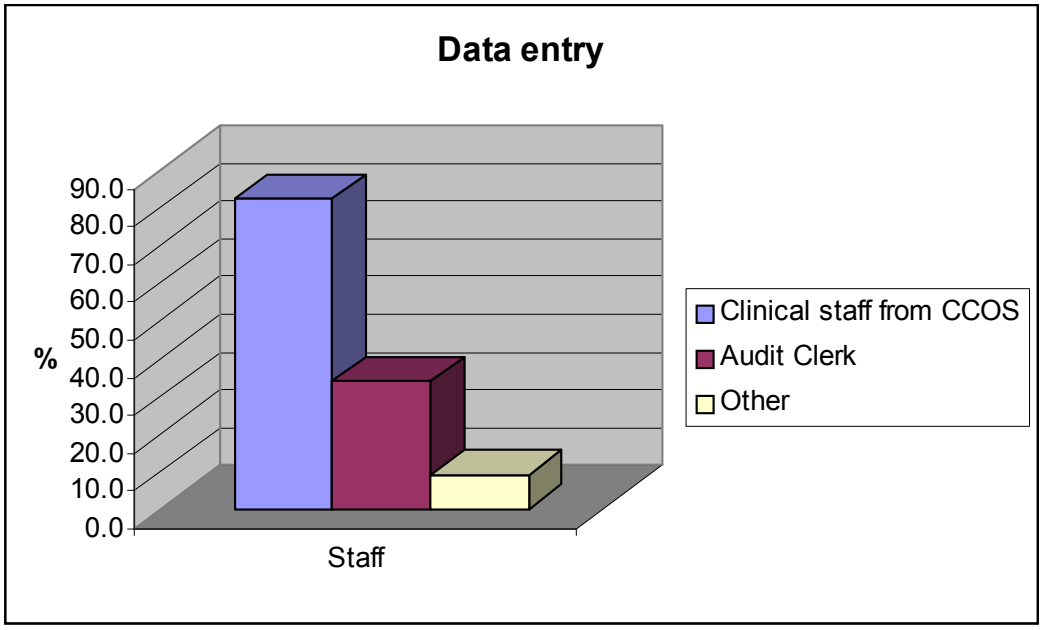
Table A1.28: Reported data collector for CCOS

Data collector	n (%)
Clinical staff from CCOS	136 (99.3)
Audit clerk	28 (20.4)
Other	9 (6.6)

CCOS critical care outreach service(s)

In 67.9% of hospitals, these data were reportedly stored in some form of paper record. Though most hospitals (83.9%, n = 115) reported storing these data in electronic form. For these hospitals, most data entry reportedly involved a member of the CCOS (Figure A1.34).

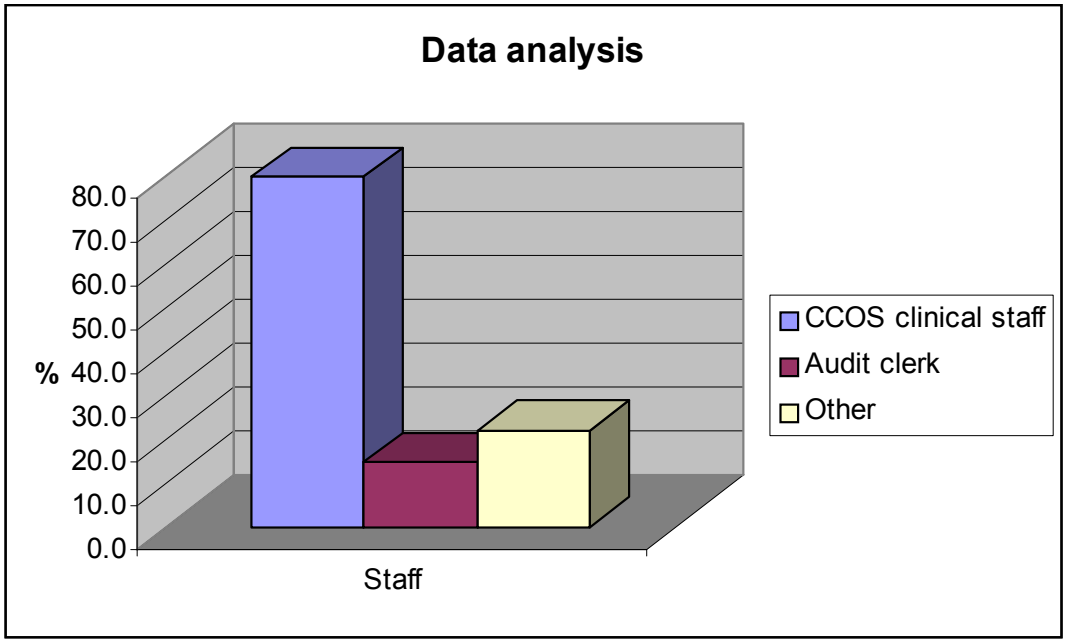
Figure A1.354: Reported staff performing data entry



CCOS critical care outreach service(s)

Most hospitals (89%, n = 121) reported formally analysing these data and, again, CCOS staff were heavily involved in this activity (Figure A1.35).

Figure A1.365: Reported staff performing data analyses



CCOS critical care outreach service(s)

The most common forum for presentation of CCOS activity or outcome data was at internal meetings, while only 12% of services had presented their data in peer reviewed journals (Table A1.29).

Table A1.29: Reported presentation of CCOS activity analyses

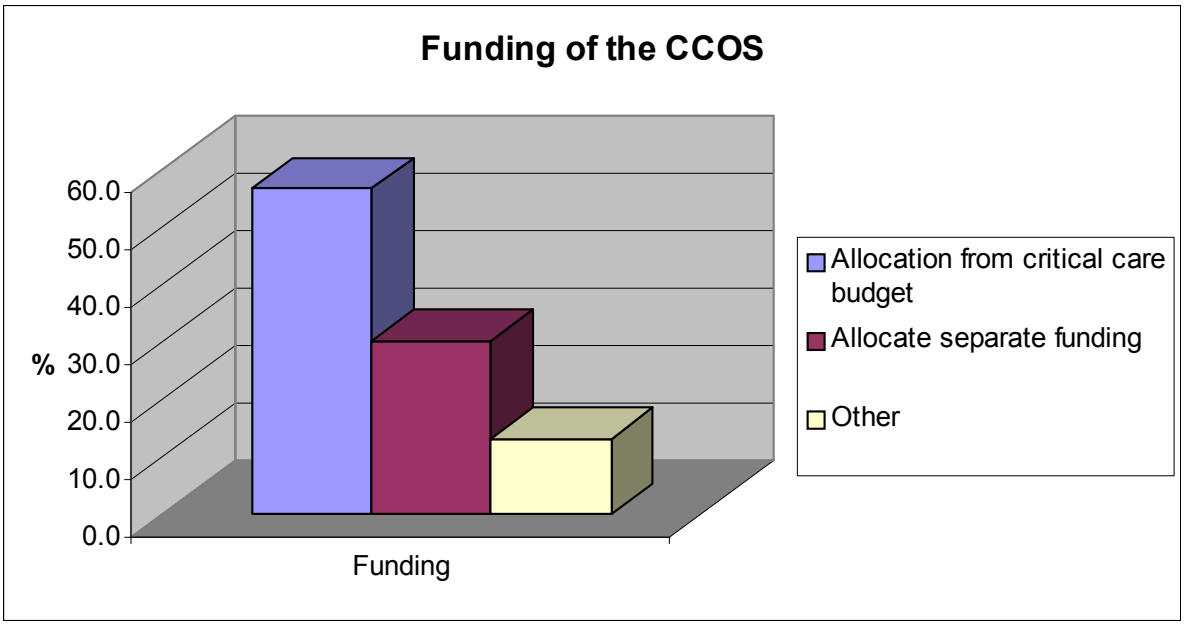
Presentation	n (%)
Internal meeting	107 (89.9)
Critical care group meetings	97 (81.5)
Critical care network meetings	65 (54.6)
National/international conferences	44 (37)
Other	20 (16.7)
Peer reviewed journals	14 (11.8)

CCOS critical care outreach service(s)

Funding of the CCOS

Most CCOS were reportedly funded from the critical care budget which was also the case in 2002[26] (Figure A1.36).

Figure A1.376: Reported source of CCOS funding



CCOS critical care outreach service(s)

"Other" reported sources of funding are described in Table A1.30.

Table A1.30: Reported "other" sources of CCOS funding

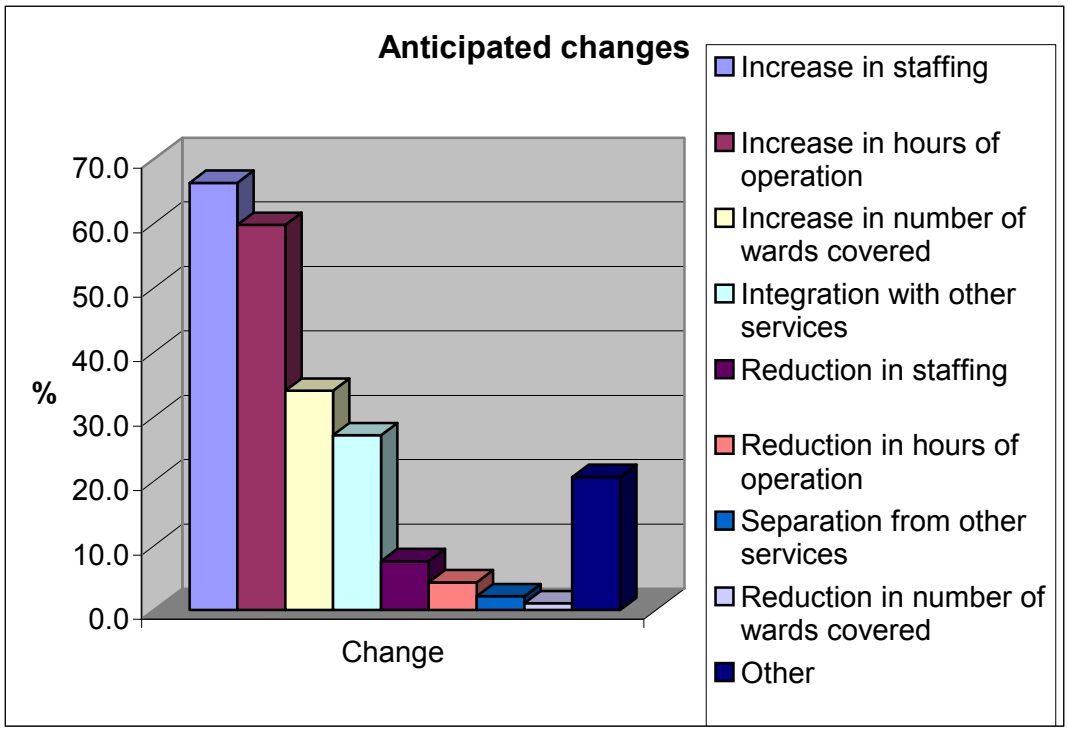
Other funding source	Number
Regional workforce directorate/confederation	3
External but not known	2
Other directorate	2
SIFT	2
UK Transplant	2
Missing	5
Critical care network	2
Total	18

CCOS critical care outreach service(s), SIFT service increment for teaching

60.9% (n = 84) services had purchased at least one item of equipment exclusively for the use of the CCOS.

Future plans for existing services
Most 67.9% (n = 93) hospitals reported that they anticipated changes to the overall structure and staffing of their CCOS within the next six months. The nature of these changes is described in Figure A1.37 The majority of changes related to the expansion, rather than the reduction, of service delivery and the integration of the CCOS with other support services rather than separation.

Figure A1.387: Reported anticipated changes to existing CCOS within next six months



CCOS critical care outreach service(s)

The breakdown of the "other" category in Figure A1.37 further illustrates the changing nature of CCOS (Table A1.31).

Table A1.31: Reported "other" anticipated changes to CCOS within next six months

Anticipated change	n
Collaboration with night services	4
Increase in consultant sessions	3
Introduction of out-patient follow-up	2
Collaboration with resuscitation service	2
Improved data collection	1
Change in funding source	1
Expansion of hospital	1
Missing	1
Moving hospital sites	1
Temporary reduction in service due to sickness	1
Service under review	1
Staff rotation	1
Total	19

CCOS critical care outreach service(s)

Factors that act as barriers to effective CCOS
Respondents were asked to list three factors which had hindered successful implementation or development of their CCOS. Responses reflect the varied picture of service development across organisations and are summarised in Table A1.32.

Table A1.32: Reported factors hindering implementation or development of CCOS

Hindering factor	Number
Resources (staffing: including recruitment and non-ring fenced staff)	68
Resources (funding staff and/or equipment)	55
Lack of physician support	35
Poor strategic planning (roles, politics, communications, education)	34
Ward issues (staffing, audit of documentation, attitudes, equipment)	22
Lack of Trust Board/administrative support	15
Other hospital/ward changes	7
Lack of evidence to prove worth	7
Organisational barriers	6
Lack of staff competence/education provision	6
Roles lack clarity (unable to prescribe)	5
CCOS motivation	4
Critical care support	2
Identification and referral	1
MDT	1
Pressure to combine services	1

CCOS critical care outreach service(s), MDT multi-disciplinary team

Conversely, Table A1.33 indicates the reported factors which respondents had found helpful in the implementation or development of their CCOS.

Table A1.33: Reported factors helping implementation or development of CCOS

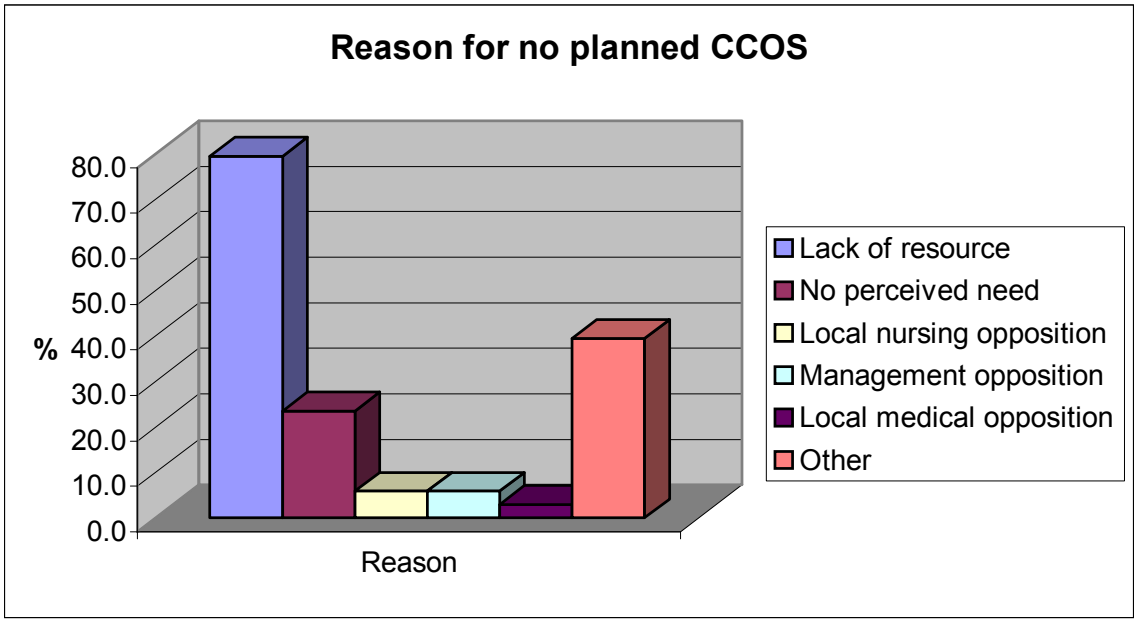
Helping factors	Number
Support (from physicians and critical care colleagues)	88
Team skills: diplomacy/motivation/enthusiasm/competence/IT	49
Support (from Directorates/Trust Board/Administration)	30
Improved working with wards	27
Strategic planning (selling service to wards, communications, clinical nurse lead, timing	25
Staffing issues including specific funding for staffing	19
Network, Regional, outside support	16
Educational activities (ALERT, running skills courses etc.)	12
Evidence through audit/risk management	12
Policy initiatives (e.g. Comprehensive Critical Care)	8
Other teams examples/support (e.g. Acute Pain, Hospital at Night)	7

Helping factors	Number
Rotation of senior staff	7
EWS system	7
Developing facilities and kit	5
Team make-up and roles	4
24 hour/ 7 day service	2
Links with Education Department	1
Style: proactive nursing rather that reactive medicine	1
Satisfaction of the team	1
Support from users	1
Positive feedback	1

CCOS critical care outreach service(s), ALERT acute life threatening events – recognition and treatment course, EWS early warning score

Future plans for hospitals with no CCOS
Of respondents who did not have a CCOS, only a third (33.3%, n = 17) reported plans to introduce a service in the next six months. Reported reasons why a service had not been planned are described in Figure A1.38.

Figure A1.38: Reported reasons for lack of plans for CCOS



CCOS critical care outreach service(s)

The breakdown of the "other" category in Figure A1.38 again illustrated the complexity and diversity of the constraints to organisational development in NHS hospitals (Table A1.34).

Table A1.34: Reported "other" reasons for no planned CCOS

Other reason	n
Merging of hospitals	1
Not a funding priority	4
Aware of need but no resource	3
Need not established	2
Business plan submitted, awaiting response	1
Financial and recruitment issues	1
Hospital closing down	1
Unsure of CCOS model to introduce	1
Tracheostomy service to be introduced first	1
Total	15

CCOS critical care outreach service(s)

Variation in CCOS models

Table A1.35 illustrates the reported variation in CCOS models in terms of staffing, availability and ward coverage.

Table A1.35: Matrix of reported variation in staffing, availability and ward coverage of CCOS

		Select d, <12 h	Select d, 12-23 h	7 d, <12 h	7 d, 12-23 h	7 d, 24 h
<100% ward coverage	No med, <=4 WTE nurses	10	1	3	1	0
	Some med, <=4 WTE nurses	5	0	1	0	0
	No med, >4 WTE nurses	0	1	1	2	0
	Some med, >4 WTE nurses	0	0	3	1	1
100% ward coverage	No med, <=4 WTE nurses	30	0	12	2	3
	Some med, <=4 WTE nurses	7	0	2	1	1
	No medical staff, >4 WTE nurses	5	0	6	4	6
	Some med, >4 WTE nurses	1	0	6	5	4
	Total number of hospitals	58	2	34	16	15

CCOS critical care outreach service(s), WTE whole-time equivalent

Table A1.36 illustrates the reported variation in CCOS models in terms of the aims of the service when first established.

Table A1.36: Matrix of reported variation in aims of CCOS when established

		Admission model			
		Strong		Not strong	
		Post-discharge model		Post-discharge model	
		Strong	Not strong	Strong	Not strong
Education model	Strong	5	3	0	12
	Medium	1	68	5	0
	No preference	0	31	2	0
Total number of hospitals		6	102	7	12

CCOS critical care outreach service(s)

Appendix 2

A systematic review of TTs

Publication:

Gao H, McDonnell A, Harrison DA, Moore T, Adam S, Daly K, Esmonde L, Goldhill DR, Parry GJ, Rashidian A, Subbe CP, Harvey S. Systematic review and evaluation of physiological track and trigger warning systems for identifying at risk patients on the ward. Intensive Care Medicine 2007;33(4):667-79.

Abstract

Objective

Physiological track and trigger warning systems are used to identify patients outside critical care areas at risk of deterioration and to alert a senior clinician, Critical Care Outreach Service (CCOS), or equivalent. The aims of this work were to identify and describe the range of published TTs, as used by a CCOS or equivalent, and to explore the extent to which each system has been developed according to established procedures.

Design

Systematic review of studies identified from electronic-, citation- and hand-searching, and expert informants.

Measurements and results

Thirty-six papers were identified describing 25 distinct systems. Thirty-one papers described the use of a system, and five were studies examining the development or testing of systems. None of the studies met all methodological quality standards.

Conclusion

A wide variety of systems were in use with little evidence of validity, reliability and utility.

Introduction

The use of physiological track and trigger warning systems (TTs) outside critical care areas seeks to ensure timely recognition of all patients with potential or established critical illness and to ensure timely attendance from appropriately skilled staff[1].

TTs use periodic observation of selected basic vital signs (the 'tracking') with predetermined criteria (the 'trigger') for requesting the attendance of more experienced staff. In most cases, TTs are drawn from routine observations of vital signs carried out by ward staff, allowing a large number of patients to be monitored without incurring major additional workload. A variety of systems exist to detect patients whose condition is deteriorating.

TTs have predominantly evolved as a means to alert Critical Care Outreach Services (CCOS) in the UK or the Medical Emergency Team (MET) in Australia, but the concept is rapidly gaining momentum worldwide. In the US, Rapid Response Teams are a key component of the Institute for Healthcare Improvement 100 000 Lives Campaign[3], and the International Partnership for Acute Care Safety (IPACS) initiative, endorsed by the World Health Organisation, is shortly to commence a global study to investigate antecedents to cardiac arrest, death and emergency intensive care admission. A wide variety of TTs are in use[1] but, as yet, there is no clear evidence to indicate which is best. Furthermore, the extent to which existing systems are valid and reliable tools for detecting patients with impending critical illness is not known.

The primary objective of the systematic review of published papers was to identify and describe the range of published TTs, as used by a CCOS or equivalent. Secondary objectives were to explore the extent to which each TT had been developed according to established procedures; to review the evidence on all aspects of the validity and reliability of existing TTs and to review the evidence on their utility.

Methods

Search strategy and data sources

The following electronic databases were searched from 1990 to 2004: MEDLINE, MEDLINE in Progress, EMBASE, CINAHL, PsycInfo, Cochrane Library and Web of Science. A broad search plan was employed with free text searching using keywords in title, abstract or full text where available. Search terms were also included to describe the variety of forms of CCOS. Citation searches were performed on Web of Science for two of the original key articles on MET[2] and early warning scores[58]. Details of the search strategy for each database are available from the authors.

In addition, the following journals, known to the researchers to have previously published articles on TTs, were hand-searched from 1999 to 2004: Anaesthesia; British Journal of Anaesthesia; Critical Care Medicine; and New England Journal of Medicine. Reference lists of key reports[1,38-41] were also reviewed, as were the reference lists of all review articles retrieved.

Abstracts of all papers identified through any of the search strategies described above were reviewed against the inclusion criteria, and a list of all the potentially relevant papers was sent to relevant professional bodies and known experts in critical care (Intensive Care Society, RCN Critical Care Forum, Royal College of Anaesthetists, British Association of Critical Care Nurses, National Outreach Forum, Royal College of Physicians, Royal College of Physicians and Surgeons of Glasgow, Royal College of Surgeons of England, Steering Group members/research team (n = 21) and other clinical experts (n = 9)) with a request to review the list for completeness.

The full text of all papers on the final list was obtained and reviewed according to the inclusion criteria. All papers were reviewed independently by two members of the study team.

Study selection and inclusion criteria

Papers were included if they were published in full and in English, and described either the use of a TT or were concerned with the development or testing of TTs based on a population of adult in-patients outside of critical care areas.

Data extraction

Two data extraction forms were developed, one for papers which described the use of a TT and the other for studies concerned with the development or testing of TTs. The design of these forms was informed by published

methodological standards and checklists[59,60]. All data extraction was checked by a second reviewer.

Data synthesis and quality assessment
A broad overview of both types of included papers was conducted. Key elements considered were: hospital setting; characteristics of patients; type, purpose and origin of TT; physiological parameters included; scoring system/trigger thresholds; frequency of completion; and nature of response. For the studies concerned with the development/testing of TT, additional elements were taken into account. These included: study design; methodological quality; number of patients; outcomes measured; completeness of follow-up; and estimates of diagnostic accuracy.

TTs were classified as:

- single parameter systems – periodic observation of selected vital signs which are compared to a simple set of criteria with predefined thresholds, with a response algorithm being activated when any criterion is met;
- multiple parameter systems – where the response algorithm involves more than one criterion being met or differs according to the number of criteria met;
- aggregate weighted scoring systems – where weighted scores are assigned to physiological values and compared to predefined trigger thresholds; or
- combination systems – involving single or multiple parameter systems in combination with aggregate weighted scoring systems.

The research studies were assessed against the methodological quality standards described by Laupacis et al[59] and validity criteria for clinical decision rules defined by McGinn et al[28] by a single reviewer and checked by a second reviewer.

Results

The literature searches identified 36 papers, of which five were research studies concerning the development or testing of TTs[29,35,48,61,62]. In four of these studies, a description of how the TT was used was also provided[29,35,48,61]. Therefore, in total, detailed descriptions of the use of a TT were available for 35 of the 36 papers, providing details of 25 distinct TTs (Table A2.1).

Twenty-one papers described 13 single parameter systems[2,45,46,49,61,63-78]. Nine of these were variations of the MET calling criteria, all in Australian settings except one in the US. The designated response to a trigger was to call the MET which, in many Australian hospitals, had replaced the cardiac arrest/resuscitation team. The other TTs were described as Medical crisis response team 'Condition C' calling criteria (US), Patient Emergency Response Team (PERT) calling criteria (UK), and two versions of trauma team calling criteria (Australia/Canada). Most of these calling criteria were in use in a wide range of clinical areas. The single parameter systems incorporated between 4 and 11 physiological parameters, and often included

additional calling criteria relating to specific events, e.g. cardio-pulmonary arrest and seizures. A number of the systems also included explicit instructions to put out a call for any patients "causing concern". All systems included some measure of blood pressure and consciousness, and most included heart rate and respiratory rate. Most physiological parameters were triggered at specific thresholds, which varied considerably between systems e.g. from 110 to 160 min^{-1} for tachycardia. However, one system used exclusively subjective triggers, e.g. "rapidly deteriorating blood pressure"[74]. Limited information was given on the origins of the single parameter systems.

Two papers described one multiple parameter system, the Patient At Risk Team (PART) calling criteria, developed and used in a UK hospital setting[48,79]. This included a graded response depending on the number of criteria triggered. Thresholds for triggering a response varied accordingly. The criteria in the multiple parameter system were based on values from a research study[80].

Eleven papers described 10 aggregate scoring systems[29,35,36,43,81-87]. All of the aggregate scoring systems were used in UK hospital settings. All systems included heart rate, respiratory rate, systolic blood pressure and a measure of consciousness, usually AVPU (alert/voice/pain/unresponsive). All but one included urine output, and all but three included temperature. Four systems included oxygen saturation and one of these additionally allocated points for respiratory support and oxygen therapy. Three systems allocated points for pain. One of the systems was extremely complex, incorporating 17 physiological parameters, many of which were not routinely recorded on the ward[29]. This system was also the only aggregate scoring system to explicitly allocate points to patients "causing concern". The nature of the response triggered when the score passed a predefined threshold varied and did not necessarily result in a call to the CCOS. This variation was due in part to the available resources within individual hospitals. Few of these TTs were in widespread use across all hospital areas. Most aggregate scoring systems appeared to be based on local modifications of either the original Early Warning Score (EWS), developed by Morgan et al[58], or a later modification of this by Stenhouse et al[8].

One paper described a combination system, the Early Warning Scoring System (EWSS), used in a UK hospital setting[88]. This system included an aggregate score, but also triggered a response if any individual parameter was scored at the highest level.

Of the five papers concerning the development or testing of TTs, one derived and validated a scoring system by a stratified case-cohort design[29] and four tested or validated previously derived TTs by cohort study designs[35,61,62] or by a case-control study[48]. None of the studies met all methodological quality standards[59], although the outcomes in all five studies were clearly defined. The reporting of diagnostic accuracy was variable (Table A2.2) and no studies provided a measure of variability around estimates of diagnostic accuracy or described the reproducibility of the individual predictor variables or of the TTs themselves.

None of the TTs achieved the requirements for a Level 1 clinical decision rule – a rule that has been validated for use in a wide variety of settings with confidence that it can change clinical behaviour and improve patient outcomes[28] (Table A2.3). In particular, the PART calling criteria[48,62] were found to be poor predictors of mortality or admission for critical care and were likely to result in inappropriate activation of the CCOS.

Table A2.1: Overview of papers describing physiological track and trigger warning systems

Name of system	Papers	Country	Setting	Parameters									
				Number	Heart rate	Respiratory rate	Blood pressure	Temperature	Urine	O_2 saturation	Consciousness	Concern	Other
Single parameter systems													
MET calling criteria (1)	Bellomo R et al. (2003)[46], (2004)[63]	Australia	All wards/surgical wards	7	✓	✓	✓		✓	✓	✓	✓	
MET calling criteria (2)	Crispin C, Daffurn K (1998)[66], Hillman K et al. (1996)[67], (2001)[68], (2003)[69], Hourihan F et al. (1995)[70], Lee A et al (1998)[71], Parr MJ et al. (2001)[72], Bristow PJ et al. (2000)[49]	Australia	All wards/critical care areas and recovery/entire hospital	9	✓	✓	✓				✓	✓	Airway threatened; cardiac arrest; pulmonary arrest; repeated/prolonged seizures
MET calling criteria (3)	Lee A et al. (1995)[2]	Australia	All wards, critical care areas and ED	32	✓	✓	✓	✓	✓		✓		Base excess; blood sugar; pH; potassium; sodium; 21 other specific events
MET calling criteria (4)	Buist M et al. (2004)[61]	Australia	Selected general wards	6	✓	✓	✓			✓	✓		Seizures
MET calling criteria (5)	Buist MD et al. (2002)[45]	Australia	Entire hospital	14	✓	✓	✓			✓	✓	✓	Agitation/delirium; airway threatened; difficulty speaking; failure to respond to treatment; repeated/prolonged seizures; respiratory distress; unable to get prompt assistance; uncontrolled pain
MET calling criteria (6)	Cioffi J (2000)[73]	Australia	Not reported	5	✓	✓	✓				✓	✓	
MET calling criteria (7)	Daly FF et al. (1998)[74]	Australia	Entire hospital (except theatre/recovery, ED)	6			✓				✓		Active seizures; cardiac chest pain; cardio-pulmonary arrest; severe respiratory distress
MET calling criteria (8)	DeVita MA et al. (2004)[65]	US	Not reported	12	✓	✓	✓			✓	✓		Colour change; pain; respiratory difficulty; suicide attempt; uncontrolled bleeding; unexplained agitation

Name of system	Papers	Country	Setting	Parameters									
				Number	Heart rate	Respiratory rate	Blood pressure	Temperature	Urine	O_2 saturation	Consciousness	Concern	Other
MET calling criteria (9)	Salamonson Y et al. (2001)[64]	Australia	All wards, critical care areas, ED and theatres	9	✓	✓	✓			✓	✓	✓	Airway threatened; repeated/prolonged seizures; respiratory arrest
Medical crisis response team Condition C calling criteria	Foraida MI et al. (2003)[75]	US	Entire hospital	19	✓	✓	✓			✓	✓		Bleeding into airway; breathing difficulty; colour change; lethargy/difficulty walking; naxolone use without response; pain; seizure; sudden collapse; sudden loss of movement; suicide attempt; trauma/chest pain/stroke; uncontrolled bleeding; unexplained agitation
PERT calling criteria	Hartin J et al. (2002)[76]	England	Not reported	8	✓	✓	✓		✓	✓	✓	✓	Repeated hypoglycaemia
Trauma team calling criteria (1)	Sugrue M et al. (1995)[77]	Australia	ED	20	✓		✓				✓		17 trauma-specific criteria
Trauma team calling criteria (2)	Dodek P et al. (2000)[78]	Canada	ED	15	✓	✓	✓				✓		11 trauma-specific criteria
Multiple parameter systems													
PART calling criteria	Goldhill DR et al. (1999)[48], Goldhill DR (2000)[79]	England	All wards	7	✓	✓	✓		✓	✓	✓		Not fully alert and oriented
Aggregate scoring systems													
MEWS (1)	Subbe CP et al. (2001)[35], (2003)[36]	Wales	Medical admissions unit	5	✓	✓	✓	✓			✓		
MEWS (2)	Odell M et al. (2002)[82]	England	Surgical wards	5	✓	✓	✓		✓		✓		
MEWS (3)	Carberry M (2002)[83]	Scotland	Selected surgical wards	6	✓	✓	✓	✓	✓		✓		

Name of system	Papers	Country	Setting	Parameters									
				Number	Heart rate	Respiratory rate	Blood pressure	Temperature	Urine	O_2 saturation	Consciousness	Concern	Other
Derby MEWS	Day BA (2003)[84]	England	Selected surgical wards and surgical day unit	6	✓	✓	✓	✓	✓		✓		
Modified MEWS	Pittard AJ (2003)[81]	England	Selected surgical wards and surgical HDU	7	✓	✓	✓		✓	✓	✓		Respiratory support/oxygen therapy
PARS (1)	Fox N, Rivers J et al. (2001)[85]	England	Surgical and orthopaedic wards	6	✓	✓	✓	✓	✓		✓		
PARS (2)	Priestley G et al. (2004)[43]	England	Selected wards	5	✓	✓	✓		✓		✓		
Lewisham PAR-T	Sterling C, Groba CB (2002)[86]	England	Selected wards	8	✓	✓	✓	✓	✓	✓	✓		Pain
Lewisham EWS	Welch J (2004)[87]	England	Not reported	8	✓	✓	✓	✓	✓	✓	✓		Pain
MET activation criteria	Hodgetts TJ et al. (2002)[29]	England	Not reported	21	✓	✓	✓	✓	✓	✓	✓	✓	Base excess; creatinine; haemoglobin; $PaCO_2$; PaO_2; pH; potassium; sodium; urea; abdominal aortic aneurysm pain; chest pain; shortness of breath
Combination systems													
EWSS	Sharpley JT, Holden JC (2004)[88]	England	Selected wards	6	✓	✓	✓	✓	✓		✓		

MET medical emergency team, ED emergency department, PERT patient emergency response team, PART patient at risk team, MEWS modified early warning score, HDU high dependency unit, PARS patient at risk score, PAR-T patient at risk trigger, EWS early warning score, EWSS early warning scoring system

Table A2.2: Overview of papers reporting diagnostic accuracy of physiological track and trigger warning systems

Name of system	Papers	Patients	Outcomes measured	Diagnostic accuracy
Single parameter systems				
MET calling criteria (4)	Buist M et al. (2004)[61]	6303	Hospital mortality	PPV was 16.2% but 88.2% with four or more abnormal observations. Sens/Spec, NPV and ROC curve not reported.
Multiple parameter systems				
PART calling criteria	Goldhill DR et al. (1999)[48]	63	Critical care unit (ICU) admission	Sens/Spec were 97%/18%, 80%/41% and 27%/67% for patients with at least one, two and three abnormal observations, respectively. PPV, NPV and ROC curve not reported.
	Goldhill DR, McNarry AF (2004)[62]	548	30-day mortality	Sens/Spec were 7.7%/99.8%; PPV 66.7%. NPV and ROC curve not reported.
Aggregate scoring systems				
MEWS (1)	Subbe CP et al. (2001)[35]	709	Critical care unit (ICU and HDU) admission; CPR; 60-day mortality; composite of above	ROC curve on composite endpoint only.
MET activation criteria	Hodgetts TJ et al. (2002)[29]	250	CPR	Sens/Spec were 100%/17%, 98%/36%, 94%/61%, 89%/77%, 86%/89%, 84%/96% and 52%/99% for scores of 1, 2, 3, 4, 5, 7 and 8, respectively. ROC curve reported. PPV and NPV not reported.

MET medical emergency team, PPV positive predictive value, Sens/Spec sensitivity/specificity, NPV negative predictive value, ROC receiver operating characteristic, PART patient at risk team, ICU intensive care unit, MEWS modified early warning score, HDU high dependency unit, CPR cardiopulmonary resuscitation

Table A2.3: Methodological standards for studies developing or testing physiological track and trigger warning systems (based on Laupacis A et al., 1997[59])

Standard	Subbe CP et al. (2001)[35]	Buist M et al. (2004)[61]	Hodgetts TJ et al. (2002)[29]	Goldhill DR et al. (1999)[48]	Goldhill DR, McNarry AF (2004)[62]
Outcome: Clear definition	√	√	√	√	√
Clinical importance	√	√	√	√	√
Blind assessment	x	x	x	x	x
Predictive variables: Identification and definition	√	√	√	√	√
Blind assessment	√	√	x	x	√
Patient characteristics described	√	x	√	√	x
Study site described	√	√	√	√	√
Results of the rule described	√	√	√	√	√
Reproducibility: Of predictor variables	x	x	x	x	x
Of the tool	x	x	x	x	x
Sensibility: Clinically sensible	?	?	?	?	?
Easy to use	√	√	x	√	√
Probability of outcome described	x	√	x	x	√
Course of action described	√	√	√	√	√
Prospective validation	√	x	x	x	√

Appendix 3

Additional results for evaluation of TTs

Figure A3.1: TT dataset questionnaire

To gain an understanding of the electronic datasets available for this analysis we would be grateful if you could provide the following information about your data:

Setting	Type your answers in the boxes below
Number & location of hospitals where data collected?	
Number & type of wards where data collected?	
Patient selection? (e.g. all those seen by CCOS only, all except those admitted and discharged on same day, all except <18y old)	
Do you include patients after discharge from critical care unit (ICU/HDU)/CCU? If so can these be identified?	
Time period(s) of data collection (give dates)? Also please indicate whether CCOS were operating during these periods	
Number of patients studied?	
Do you have >1 assessment on these patients? If so describe when assessments were made and frequency (e.g. on admission then twice daily, daily until an event occurred)	
Do you have any information on how representative patients you studied were? (e.g. % of all ward patients, % of all CCOS referrals)	
Have you validated your data? (e.g. logic, range and consistency check)	
Physiological track and trigger warning system	
Name (if any) used? (e.g. EWS, MEWS, PAR)	
Variables available for analysis? (e.g. age, HR, BP, respiratory rate, CNS assessment). Please indicate if total score only recorded	
Type of CNS assessment? (e.g. GCS, AVPU, ACVPU)	
Please indicate the amount (%) of missing data in these variables	
Outcomes	
What outcomes did you record? (e.g. death, DNAR, critical care unit (ICU/HDU)/CCU admission, continue monitoring, no action taken, CPR, unplanned surgery/procedure)	
On what % of patients is the outcome unknown? (i.e. missing data)	

CCOS critical care outreach service(s), ICU intensive care unit, HDU high dependency unit, CCU coronary care unit, EWS early warning score, MEWS modified early warning score, PAR patient at risk, HR heart rate, BP blood pressure, CNS central nervous system, GCS Glasgow coma score, AVPU alert/voice/pain/unresponsive, ACVPU alert/confused/voice/pain/ unresponsive, DNAR do not attempt resuscitation, CPR cardiopulmonary resuscitation

Figure A3.2: Users' guide to modified DOCDat criteria

Coverage
A) Was the spectrum of patients representative of the patients who will be monitored with the TTs in practice?
Definition: Differences in demographic and clinical features between populations may produce measures of diagnostic accuracy that vary considerably, this is known as spectrum bias. It refers more to the generalisability of results than to the possibility that the study may produce biased results. Reported estimates of diagnostic accuracy may have limited clinical applicability (generalisability) if the spectrum of tested patients is not similar to the patients in whom the test will be used in practice. The spectrum of patients refers not only to the severity of the underlying target condition, but also to demographic features and to the presence of differential diagnosis and/or co- morbidity. It is therefore important that diagnostic test evaluations include an appropriate spectrum of patients for the test under investigation and also that a clear description is provided of the population actually included in the study
Level 1: No evidence or unlikely to be representative The sample is unlikely to be representative if those included represent a sub-group (e.g. only patients referred to CCOS)
Level 2: Some evidence that eligible population is representative Basic comparisons have been made with the reference population (all those in the current setting with the common circumstance) (e.g. all patients seen by the CCOS with follow-up can be identified)
Level 3: Good evidence the eligible population is representative One or more of the following: comparisons between the eligible population and the reference population show similar characteristics; a sampling frame has been used that captures a representative sample (e.g. all patients on selected wards)
Level 4: Total population in your current setting Every individual who has the common circumstance that determines inclusion in your current setting from which data are collected is included in the database (e.g. all patients on all wards that could be attended by the CCOS)
B) Were selection criteria clearly described?
Definition: This refers to whether the database has a clear definition of the criteria used as inclusion and exclusion criteria
Level 1: No
Level 4: Yes
C) Completeness of TT variables
Definition: A TT dataset must contain, at the least, either summary TT variables (e.g. trigger events) or scores, but will ideally contain the raw physiological data from which the TT can be calculated. One or more outcomes (observed at the end of the CCOS episode) may be recorded. The most commonly recorded outcomes are admission to critical care and death. Additional outcomes that may be recorded include: no action/manage on ward, discharge from CCOS following multiple visits, cardiac arrest/CPR, DNAR, treatment limitation. In addition to these variables, the presence of important confounders (e.g. age, ward, speciality) enables the performance of the TT to be evaluated in different patient groups or settings
Level 1: Only summary TT variables or score
Level 2: Summary TT variables or scores; admission to critical care and death were recorded as minimum CCOS outcomes
Level 3: Raw physiological data; admission to critical care and death were recorded as minimum CCOS outcomes
Level 4: Raw physiological data; all outcomes; important confounders
D) Completeness of data (% of variables at least 95% complete)
Definition: The percentage of variables at least 95% complete. The number of variables at least 95% complete is divided by the total number of variables in the database
Level 1: Unknown or few (<50%)
Level 2: Many (50–79%)
Level 3: Most (80–97%)
Level 4: All or almost all (>97%)

Accuracy
E) Use of explicit definitions and rules for variables
Definition: The percentage of variables that have clear definitions and rules laid out in a document. This is calculated by dividing the number of variables in the database that have clearly definitions or rules by the total number of variables which need to have definitions or rules. A definition is a clear description of what the variable means. A rule is a clear description of how variables are recorded. For example, if blood pressure is measured twice, is there a rule determining which reading should be recorded, or if a patient has two addresses, is there a rule to determine which one is reported in the database?
Level 1: None
Level 2: Some (<50%)
Level 3: Most (50-97%)
Level 4: All or almost all (>97%)
F) Extent to which data are validated
Definition: What measures are taken to ensure that the data are valid (reflect something real)?
Level 1: No audit No data validation is conducted
Level 2: Range or consistency checks Range checks ensure that data outside of the permitted range are not allowed, for example a temperature of 55. Range checks may be pre-programmed into data entry programmes and performed automatically at data entry, or performed manually at the data analysis stage. Consistency checks can be performed manually or automatically, and involve highlighting areas where the data are inconsistent. Some databases may go back to the original records to validate the data by retrieving the correct value, for example by sending back a list of queries to those who collect the data.
Level 3: Range and consistency checks
Level 4: Range and consistency checks plus external validation using an alternative source. External validation involves going back to the original record and comparing the information with that held by the database to ensure that the database records are accurate. This would normally take the form of an audit whereby, for instance, a 1% sample of all database records is compared to the original medical notes. Going back to the records to check inconsistencies or range checks by setting up a series of queries does not constitute external validation

TT physiological track and trigger warning system(s), CCOS critical care outreach service(s), CPR cardiopulmonary resuscitation, DNAR do not attempt resuscitation

Figure A3.3: Details of each hospital's physiological track and trigger warning systems and referral algorithm used in the analysis

PART score

score	3	2	1	0	1	2	3
temp		<35.0	35.0-35.9	36.0-37.4	37.5-38.4	>=38.5	
HR	<40		40-49	50-99	100-114	115-129	>=130
SBP	<70	70-79	80-99	100-179		>=180	
resp		<10		10-19	20-29	30-39	>=40
SpO_2	<85%	85-89%	90-94%	>=95%			
CNS				A	C	V	P or U
urine	nil	<0.5/k/h	dialysis	0.5-3/k/h	>3/k/h		

The trigger is a total score of 5 or a score of 3 for any single parameter

PAR

(Patient at Risk)

This score is to aid nurses and doctors in the early detection of critical illness

<u>This does not replace the crash call</u>

In other emergencies the Intensive Care Unit may be called directly

<u>IS YOUR PATIENT'S CONDITION GIVING CAUSE FOR CONCERN?</u>

If "Yes", do the following observations and score your patient:

	3	2	1	0	1	2	3	Score
Conscious Level				ALERT	Responds only to VOICE	Responds only to PAIN	UN RESPONSIVE	
Resp Rate per minute		Less than 8		9-14	15-20	21-29	Greater than 30	
Heart Rate per minute		Less than 40	41-50	51-100	101-110	111-129	Greater than 130	
BP Systolic	Less than 70	71-80	81-100	101-199		Greater than 200		
Urine Output over 4 hours	Less than 80	80-120						
							TOTAL PAR SCORE	

<u>IS THE TOTAL SCORE FOR YOUR PATIENT 3 OR MORE?</u>

If YES, Bleep the Junior Doctor responsible for the patient
and the Critical Care Outreach Nurse on Bleep 745
A doctor will come promptly (within 30 minutes) and your patient will be assessed.
If immediate management does not improve the patient's condition, the doctor responsible should then seek further advice from their Consultant

ADULT EARLY WARNING SCORING SYSTEM

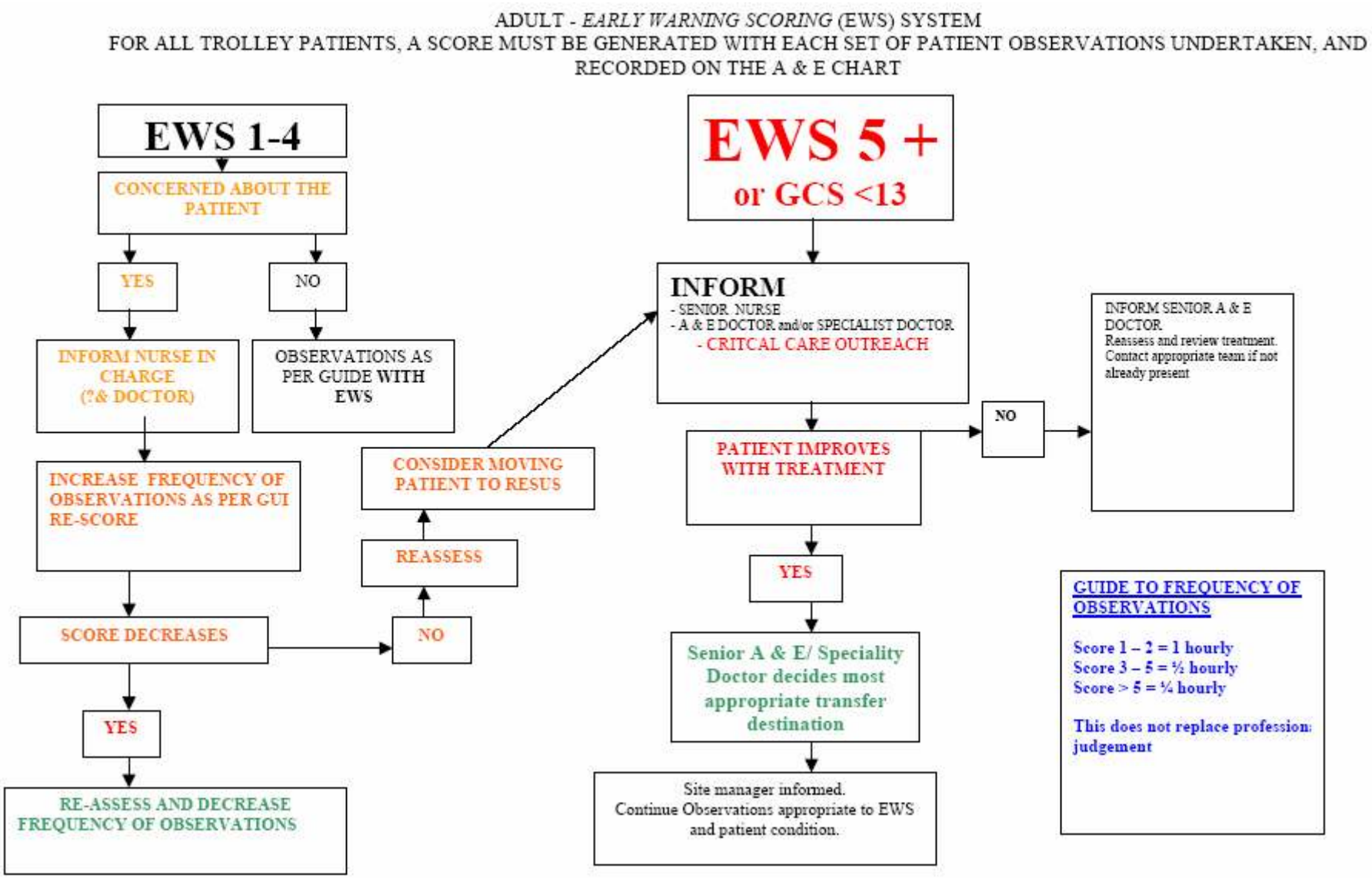
Score	5	3	2	1	0	1	2	3	5
Heart Rate	<40		40-60		61-100	101-119	120-150		>150
Blood Pressure Systolic	<80	81-90		91-100	101-179	180-199	200-219	220-249	>250
Respiration	<7		8-10		11-20	21-29		30-40	>40
Oxygen Saturation	<85	85-90		91-92	93-100				
Glasgow Coma Scale	<8	8 – 10	11-12	13-14	15				

Each measurement is given a score from the above table. If the patient triggers any score, or you are concerned with their condition, follow the EWS FLOW CHART to initiate appropriate intervention.
Advice may be sought directly from the Critical Care Outreach Nurse.

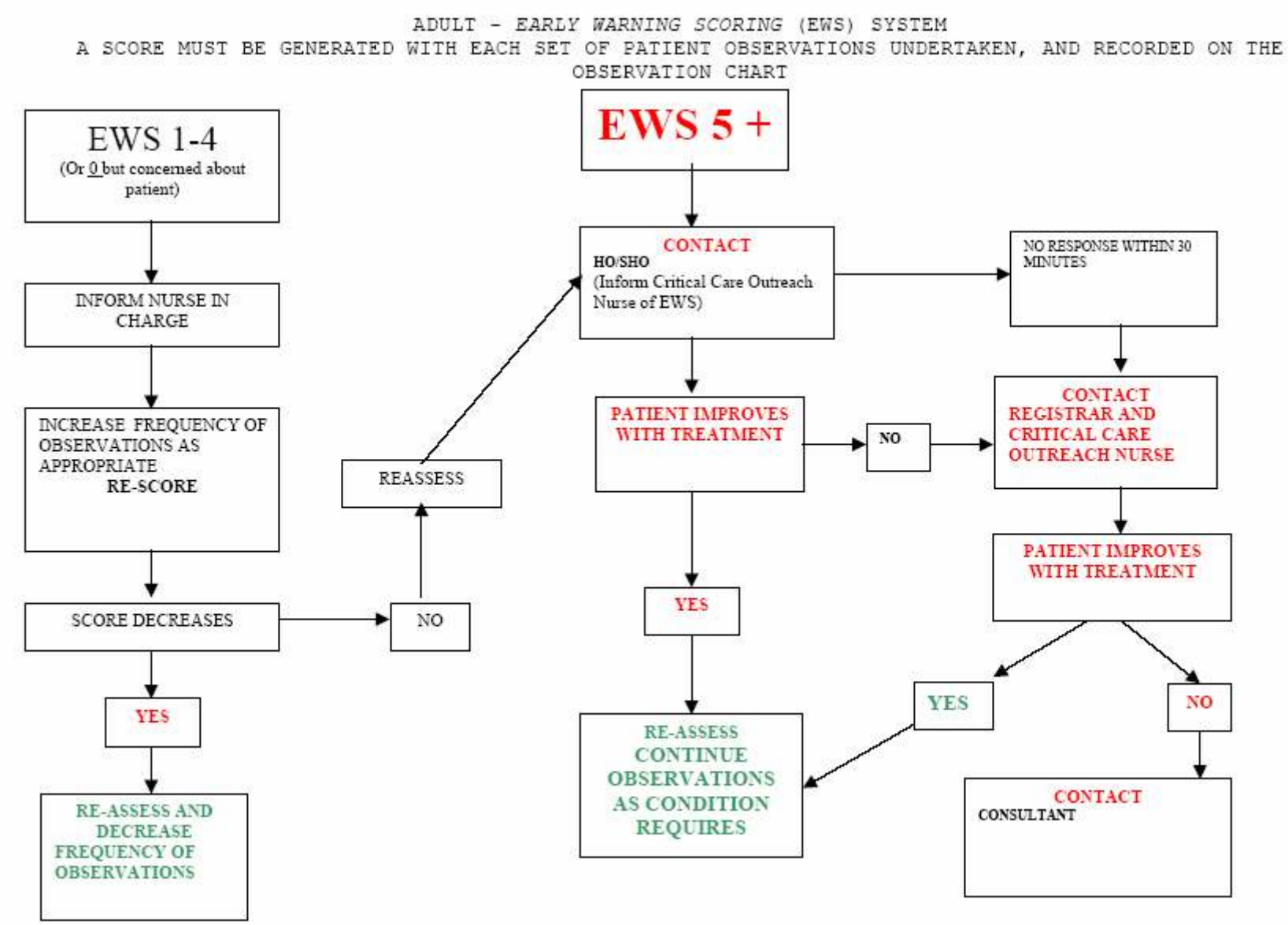
The score is a tool to aid assessment. It should be remembered that the patient might be more ill than the score suggests. Some patients' conditions may not score immediately. Other factors should be taken into consideration during the patient's assessment, e.g.; skin colour/temperature - warm cool, cold, clammy.
If the patients score is less than 5 but their condition is causing you concern, help should be sought as above.

SURGICAL PATIENTS ONLY

Pain Scoring System		Nausea and Vomiting Scoring System	
0	No pain.	0	No nausea, retching or vomiting; or patient asleep.
1	No pain at rest, mild to moderate pain on movement.	1	Slight nausea, but not distressing to the patient.
2	Mild to moderate pain at rest, severe pain on movement.	2	Nausea which is distressing to the patient.
3	Severe pain at rest.	3	Currently vomiting or retching.


ADULT - *EARLY WARNING SCORING* (EWS) SYSTEM
FOR ALL TROLLEY PATIENTS, A SCORE MUST BE GENERATED WITH EACH SET OF PATIENT OBSERVATIONS UNDERTAKEN, AND RECORDED ON THE A & E CHART
EWS 1-4
CONCERNED ABOUT THE PATIENT
YES
NO
INFORM NURSE IN CHARGE (?& DOCTOR)
OBSERVATIONS AS PER GUIDE WITH EWS
INCREASE FREQUENCY OF OBSERVATIONS AS PER GUI RE-SCORE
SCORE DECREASES
NO
YES
RE-ASSESS AND DECREASE FREQUENCY OF OBSERVATIONS
CONSIDER MOVING PATIENT TO RESUS
REASSESS
EWS 5 +
or GCS <13
INFORM
- SENIOR NURSE
- A & E DOCTOR and/or SPECIALIST DOCTOR
- CRITCAL CARE OUTREACH
PATIENT IMPROVES WITH TREATMENT
NO
INFORM SENIOR A & E DOCTOR
Reassess and review treatment.
Contact appropriate team if not already present
YES
Senior A & E/ Speciality Doctor decides most appropriate transfer destination
Site manager informed.
Continue Observations appropriate to EWS and patient condition.
GUIDE TO FREQUENCY OF OBSERVATIONS
Score 1 – 2 = 1 hourly
Score 3 – 5 = ½ hourly
Score > 5 = ¼ hourly
This does not replace professional judgement

Hospital C


ADULT - EARLY WARNING SCORING (EWS) SYSTEM
A SCORE MUST BE GENERATED WITH EACH SET OF PATIENT OBSERVATIONS UNDERTAKEN, AND RECORDED ON THE OBSERVATION CHART
EWS 1-4
(Or 0 but concerned about patient)
INFORM NURSE IN CHARGE
INCREASE FREQUENCY OF OBSERVATIONS AS APPROPRIATE
RE-SCORE
SCORE DECREASES
NO
REASSESS
YES
RE-ASSESS AND DECREASE FREQUENCY OF OBSERVATIONS
EWS 5 +
CONTACT
HO/SHO
(Inform Critical Care Outreach Nurse of EWS)
NO RESPONSE WITHIN 30 MINUTES
PATIENT IMPROVES WITH TREATMENT
NO
CONTACT REGISTRAR AND CRITICAL CARE OUTREACH NURSE
YES
PATIENT IMPROVES WITH TREATMENT
YES
NO
RE-ASSESS CONTINUE OBSERVATIONS AS CONDITION REQUIRES
CONTACT
CONSULTANT

PAR SCORING SYSTEM
FOR ADULT PATIENTS AT RISK

SCORE	3	2	1	0	1	2	3	score
Heart Rate per minute		≤ 40	41-50	51-100	101-110	111-130	≥ 131	
Systolic Blood Pressure	≤ 70	71-80	80-100	101-199		≥ 200		
Respiratory Rate per minute		≤ 8		9-14	15-20	21-29	≥ 30	
Temperature		≤ 35				≥ 39.5		
Level of Consciousness				Alert	Drowsy or Confused	Responds Only to Painful Stimuli	Un-responsive	
Urine Output total over last 2 hours					< 60 mls	< 40 mls	0	

If the patient's observations fall into the grey area on the observation chart inform a trained nurse. The trained nurse should assess the patient and calculate a PAR score.

Referral Algorithm

Score 1-3	→ Increase observations to at least 4-hourly.
Score 3 in one category	→ Nurse should contact SHO for immediate patient review. Increase frequency of observations.
Score total greater than 3	→ Nurse should contact SHO for patient review within 30 minutes. Increase frequency of observations.
Score total greater than 6	→ Urgent referral required to the Registrar. Patient needs immediate review.

PATIENT AT RISK SCORE

Score	3	2	1	0	1	2	3
Systolic blood pressure (mmHg)	<60	61-80	81-110	111-160		>161	
Heart rate	<40		41-60	61-110	111-130	131-150	>150
Respiratory rate	<6		6-9	10-20		21-30	>30
Conscious level				Normal	Drowsy	Responsive to pain	Unresponsive
Urine output		<0.5ml/ kg/h					
Temperature	<34°	34° - 35.9°		36° - 37.7°	37.8° - 38°	38.1° - 39.5°	>39.5°

REFERRAL ALGORITHIM

Score = 3 or above Call a senior Nurse or Doctor immediately

Score = 2 Increase frequency of observations and inform Doctor who should be requested to attend within 6 hours of carrying out observations.

MINIMUM FREQUENCY OF OBSERVATIONS 4 HOURLY

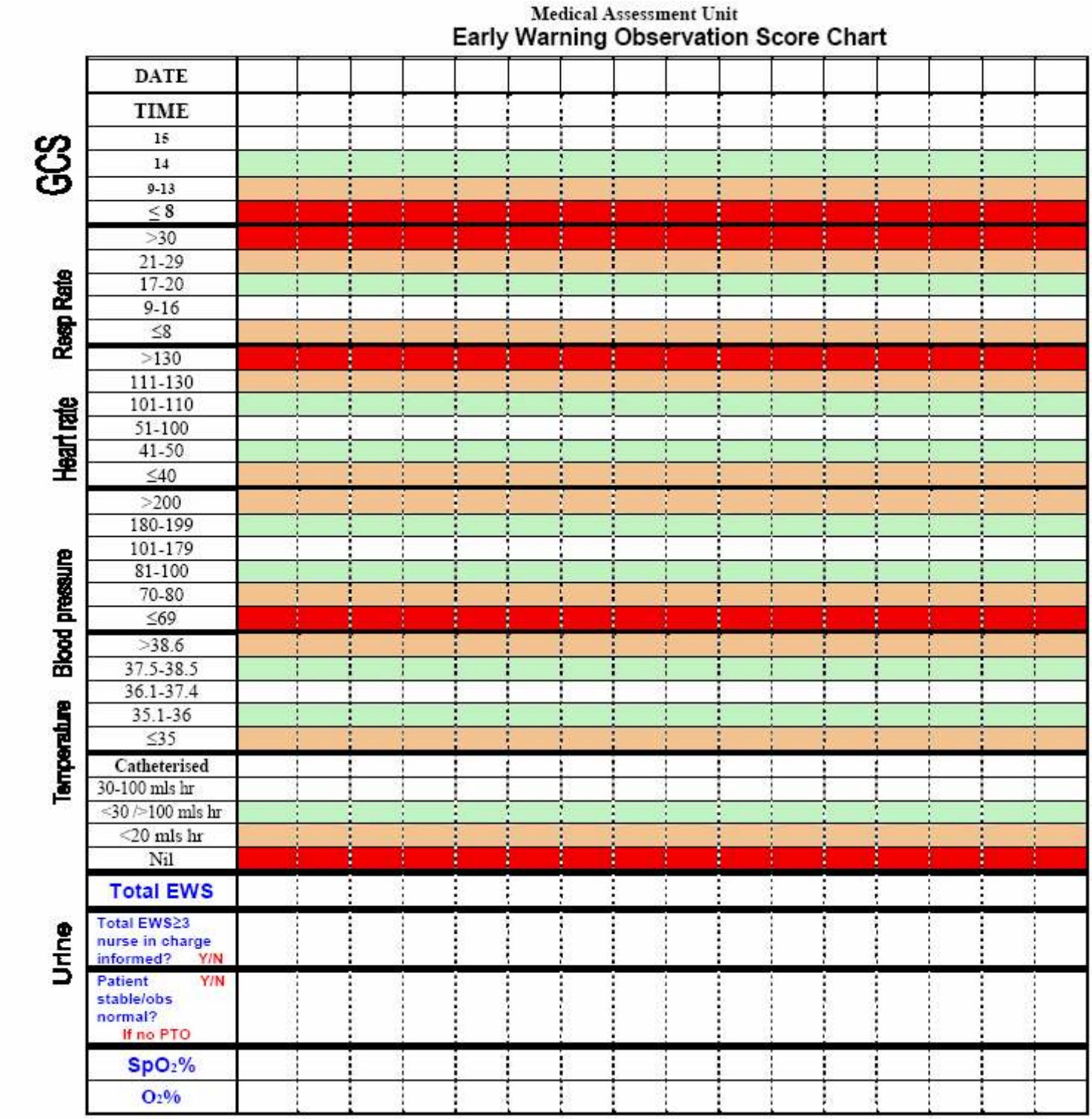
Score = 0 or 1 Continue observations at current frequency

PLEASE INFORM THE CCOS OF ALL SCORES OF 2 AND ABOVE

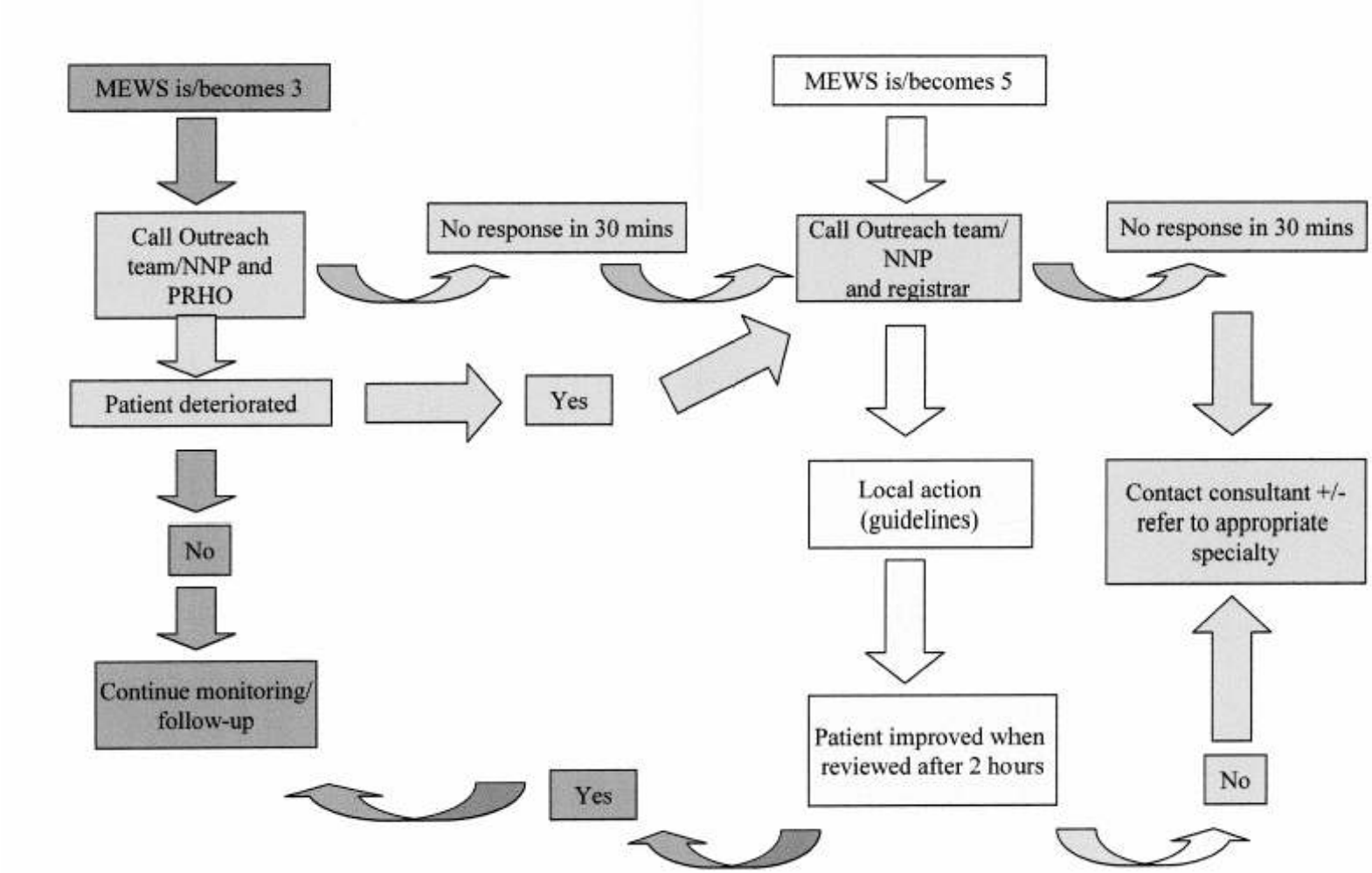
EARLY WARNING SCORE

	3	2	1	0	1	2	3
TEMP		≤ 35.0		35.0 – 38.4		≥ 38.5	
BP Systolic	< 70	71 - 80	81 - 100	101 - 199		> 200	
PULSE		< 40	41 - 50	51 - 100	101 - 110	111 - 129	≥ 130
RESPS		≤ 8		9 - 14	15 - 20	21 - 29	≥ 30
CNS				ALERT	VOICE	PAIN	UNCONC
URINE mls/hour	< 10	< 30		Not Measured			

If EWS score is ≥ 3 follow Early Warning Score Cascade


Medical Assessment Unit
Early Warning Observation Score Chart
DATE
TIME
GCS
15
14
9-13
≤ 8
Resp Rate
>30
21-29
17-20
9-16
≤8
Heart rate
>130
111-130
101-110
51-100
41-50
≤40
Blood pressure
>200
180-199
101-179
81-100
70-80
≤69
Temperature
>38.6
37.5-38.5
36.1-37.4
35.1-36
≤35
Urine
Catheterised
30-100 mls hr
<30 />100 mls hr
<20 mls hr
Nil
Total EWS
Total EWS≥3 nurse in charge informed? Y/N
Patient stable/obs normal? Y/N
If no PTO
SpO2%
O2%

Hospital H



If MEWS greater than 10 contact Patients own Consultant, Outreach team and ICU Directly

ADULT EARLY WARNING SCORING SYSTEM

This scoring system has been designed to help both nursing and medical staff identify patients who are **seriously ill** or **at risk of deterioration**.

It should be used on adult patients immediately after their observations have been done.

Score	3	2	1	0	1	2	3
Heart Rate - HR		<40	41-50	51-100	101-110	111-130	>130
Blood Pressure - BP (systolic)	<70	71-80	81-100	101-179	180-199	200-220	> 220
Respiratory Rate - RR		<8	8- 11	12- 20	21- 25	26- 30	>30
Oxygen Saturations	<85%	86-89%	90-94%	>95%			
Respiratory Support/ Oxygen Therapy	BIPAP/ CPAP	Hi-Flow	Oxygen Therapy				
Urine Output in last 4 hours/mls	<80	80-120	120-200		>800		
Central Nervous System- CNS			Confusion	Awake and Responsive	Responds To Verbal Command	Responds to Painful Stimuli	Unresponsive

Each measurement is given a score from the table above. If the patient's **total score is 3** or more, **the call out algorithm is triggered** and you must call for help. Please follow as directed.
If the patients score is less than 3, but their condition is causing you concern please discuss with your immediate senior in the usual way. In addition, the Outreach Team may be contacted for help or advice

May 2001 Adapted from the Great Yarmouth Scoring System by Richard Morgan.

PATIENT AT RISK EARLY WARNING ASSESSMENT SCORE

Score	3	2	1	Normal 0	1	2	3	score
HR		≤ 40	41-50	**51-100**	101-110	111-130	> 130	
BP (systolic)	≤ 70	71-80	81-100	**101-199**		>200		
Respiratory Rate		< 8		**9-25**		26-30	> 30	
SpO_2	≤ 88%	89-90%	91-94%	**≥ 95%**				
Air / % oxygen					≥ 8/lits or 40%			
Temp (core)		< 35	35.1–35.9	**36.0-37.4**	≥ 37.5	≥ 38.5		
Level of consciousness				**Alert**	Drowsy Responds to voice	Acute confusion or agitation	Responds to pain only	
Urine output	≤ 20 mls/hr for 2 hours	<1ml/kg over 2 hours		**>500 in 24 hours**	250-500 in 24 hours	< 250 in 24 hours	Nil	
Total score	**SCORE =**						**TOTAL**	
	If total score ≥ 4 please inform the nurse in charge and contact PART							

Modified Early Warning Score (MEWS)

Score	3	2	1	0	1	2	3
Heart Rate	< 40	-	40 – 50	51 – 100	101-110	111-129	=130 or >130
Resp Rate	< 8	-	-	8 - 20	21 - 25	26 - 30	>30
Temp ^{0}C	-	= 35 or <35	-	35.1-38.4	-	= 38.5 or >38.5	-
AVPU	New Weakness	Confused	-	Alert	Voice	Pain	Unresponsive
Systolic BP	< 80	80 – 89	90 – 109	110 - 160	161 - 180	181 - 200	> 200

* NB:- IF ANY PATIENT SCORES GREATER THAN 0 ON MEWS A TRAINED NURSE MUST BE INFORMED

Score = 1 - 2 →
- Inform a trained nurse who must assess patient
- **Trained nurse to decide if patient requires BD or 4 hrly observations.**
- *** Patient requires a minimum of BD observations**

Score = 3 →
- **Increase frequency of patient observations to at least 4 hrly.**

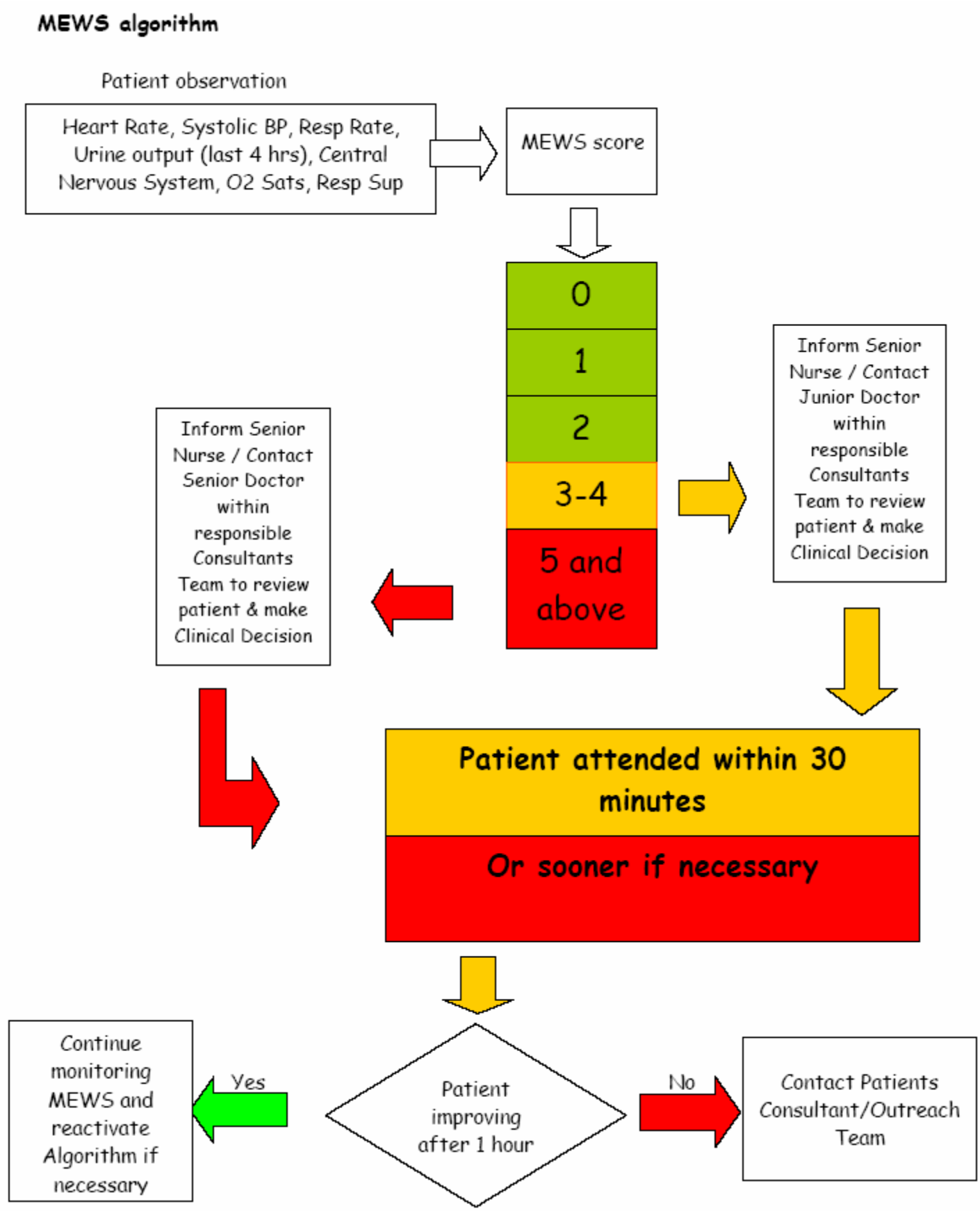
Score is 3 in ONE category →
- **Increase frequency of patient observations to at least 1hrly**
- **Commence fluid balance monitoring**
- **Nurse to contact HO / SHO & inform patient requires urgent medical review.**

Total score is 4 or above →
- **Increase frequency of patient observations to at least 1hrly**
- **Commence on strict fluid balance charting**
- **Nurse to contact HO / SHO & inform patient requires urgent medical review.**
- **HO / SHO should seek senior advice as needed from parent team Registrar and / or Consultant**

Total Score is greater than 6 →
- **Immediate review by Registrar (own team or on call out of hours)**
- **Registrar to discuss patient with own Consultant**
- **Contact critical care outreach team (Blp 2909) or**
- **On call ITU team if appropriate for critical care referral.**

- If at any time there is no response from the patients medical team in terms of action taken or if the patients condition does not improve within 2 hours the next most senior doctor must be contacted. If unsure about the MEWS or you are concerned about a patients condition please contact the :- *CRITICAL CARE OUTREACH TEAM FOR ADVICE ON:- BLEEP 2909*

Modified Early Warning Score (MEWS)							
SCORE	3	2	1	0	1	2	3
Heart Rate		40 or Less	41 - 50	51-100	101-110	111-130	More than 130
Systolic BP	70 or Less	71-80	81-100	101-179	180-199	200-220	More than 220
Resp rate		Less than 8	8-11	12-20	21-25	26-30	More than 30
Urine output last 4 hrs/mls	80 mls or Less	81-120 mls	121-200 mls	201-800 mls	More than 800 mls		
Conscious Level			**C**	**A**	**V**	**P**	**U**
			Confused	Awake & Responsive	Responds Verbal Commands	Responds Painful Stimuli	Unresponsive
O_2 sats	85% or Less	86-89%	90-94%	95-100%			
Resp Support	CPAP BIPAP NIPPV	02>35% or Mask with Non Re-Breath Bag	O2 35% & below Nasal Cannula 2-4 Ltr	Room Air			


MEWS algorithm
Patient observation
Heart Rate, Systolic BP, Resp Rate, Urine output (last 4 hrs), Central Nervous System, O2 Sats, Resp Sup
MEWS score
0
1
2
3-4
5 and above
Inform Senior Nurse / Contact Junior Doctor within responsible Consultants Team to review patient & make Clinical Decision
Inform Senior Nurse / Contact Senior Doctor within responsible Consultants Team to review patient & make Clinical Decision
Patient attended within 30 minutes
Or sooner if necessary
Patient improving after 1 hour
Yes
Continue monitoring MEWS and reactivate Algorithm if necessary
No
Contact Patients Consultant/Outreach Team

Patient-at-Risk (PAR) Scoring

any patient giving cause for concern needs scoring

Score	3	2	1	0	1	2	3
Heart rate		Less than 40	40 to 49	50 to 99	100 to 130		More than 130
Systolic BP	Less than 70	70 to 80	81 to 100	101 to 200		More than 200	
Respiratory rate		Less than 9		9 to 15	16-24	25 to 30	More than 30
Temperature			Less than 35°C	35 to 38.5°C	More than 38.5°C		
Urine output			Less than 35mls/hr over 2 hrs				
Sedation score	Unresponsive	Responds to pain	Responds to voice	Alert			

Hourly observations are required for at risk patients. Any observation unavailable eg. urine output if no catheter, scores zero.

Modified Early Warning Score

	3	2	1	0	1	2	3
Systolic Blood pressure (mmHg)	<70	71–80	81–100	101–199		≥200	
Heart rate (bpm)		<40	41–50	51–100	101–110	111–129	≥130
Respiratory rate (bpm)		<9		9–14	15–20	21–29	≥30
Temperature (°C)		<35		35–38.4		≥38.5	
AVPU score				Alert	Reacting to Voice	Reacting to Pain	Unresponsive

Patients on PCA or analgesic infusions must have hourly observations for the first 12 hours, then two hourly. Pain assessment must be recorded while the patient is receiving any analgesia.

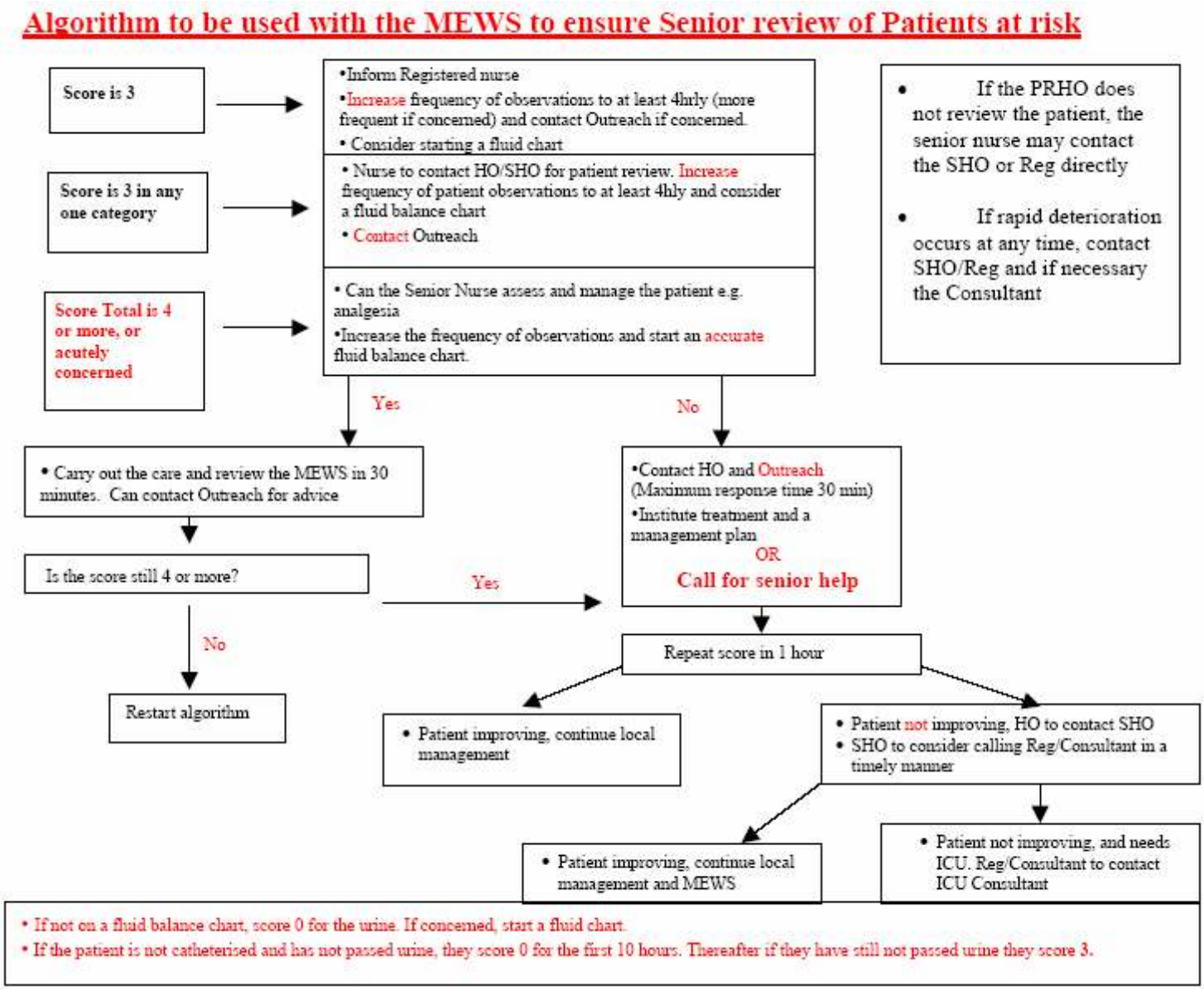
Sedation Score - Mark 0 in box
0 = Patient alert
1 = Occasionally drowsy, easy to arouse
2 = Frequently drowsy, easy to arouse
3 = Somnolent, difficult to arouse
Sleep normal, easy to arouse

Pain Score - Mark X in box
0 = No pain at rest or on movement
1 = No pain at rest, slight pain on movement
2 = Intermittent pain at rest, moderate pain on movement
3 = Continuous pain at rest and severe pain on movement

Nausea Score	
0	No nausea or vomiting
1	Nausea only
2	One episode of retching/vomiting in last hour
3	More than one episode of retching/vomiting in the last hour

If patient scores 1 or > 1 then commence treatment according to PONV (Peri-operative nausea and vomiting Algorithm)

MEWS Score:	3	2	1	0	1	2	3
Heart rate		<40	41-50	51-100	101-110	111-129	>130
Resp Rate		<8		9-14	15-20	21-29	>30
Temp		<35		35-38.4		38.5-39	>39
Sys. BP	<70	71-80	81-100	101-199		>199	
Response	Unresp	Pain	Voice	Alert	Confused/ Agitated		
Urine weight .....Kg	<10ml in 2 consecutive hours	<1ml/kg in 2hr's	<1ml/kg/h				>400ml/h


Algorithm to be used with the MEWS to ensure Senior review of Patients at risk
Score is 3
•Inform Registered nurse
•Increase frequency of observations to at least 4hrly (more frequent if concerned) and contact Outreach if concerned.
• Consider starting a fluid chart
Score is 3 in any one category
• Nurse to contact HO/SHO for patient review. Increase frequency of patient observations to at least 4hly and consider a fluid balance chart
• Contact Outreach
Score Total is 4 or more, or acutely concerned
• Can the Senior Nurse assess and manage the patient e.g. analgesia
•Increase the frequency of observations and start an accurate fluid balance chart.
• If the PRHO does not review the patient, the senior nurse may contact the SHO or Reg directly
• If rapid deterioration occurs at any time, contact SHO/Reg and if necessary the Consultant
Yes
No
• Carry out the care and review the MEWS in 30 minutes. Can contact Outreach for advice
•Contact HO and Outreach (Maximum response time 30 min)
•Institute treatment and a management plan
OR
Call for senior help
Is the score still 4 or more?
Yes
No
Restart algorithm
Repeat score in 1 hour
• Patient improving, continue local management
• Patient not improving, HO to contact SHO
• SHO to consider calling Reg/Consultant in a timely manner
• Patient improving, continue local management and MEWS
• Patient not improving, and needs ICU. Reg/Consultant to contact ICU Consultant
• If not on a fluid balance chart, score 0 for the urine. If concerned, start a fluid chart.
• If the patient is not catheterised and has not passed urine, they score 0 for the first 10 hours. Thereafter if they have still not passed urine they score 3.

Patient Assessment Tool

EARLY WARNING INDICATOR

A patient who fulfils any one or more of the criteria below, or is causing concern, needs urgent intervention.

BREATHING
• Respiratory rate of less than 8 or greater than 30 per minute. • Oxygen saturation of less than 90% or a PaO2 of less than 8 kPa despite 60% oxygen. • A requirement for more than 60% oxygen.
CIRCULATION
• Pulse of less than 40 or sinus rhythm greater than 130 per min • Systolic blood pressure of less than 90 mmHg. • pH of less than 7.2 or bicarbonate of less than 20.
RENAL
• Oliguria – urine output less than 30 mls/hour for 3 consecutive hours.
CONSCIOUS LEVEL
• Patient does not respond to commands.

Care of all patients remains the responsibility of the admitting team.

Critical Care Liaison Nurses - bleep 453.
Out of hours - the bleep will be answered by GITU/HDU staff for advice.

PATIENT REFERRAL ALGORITHM

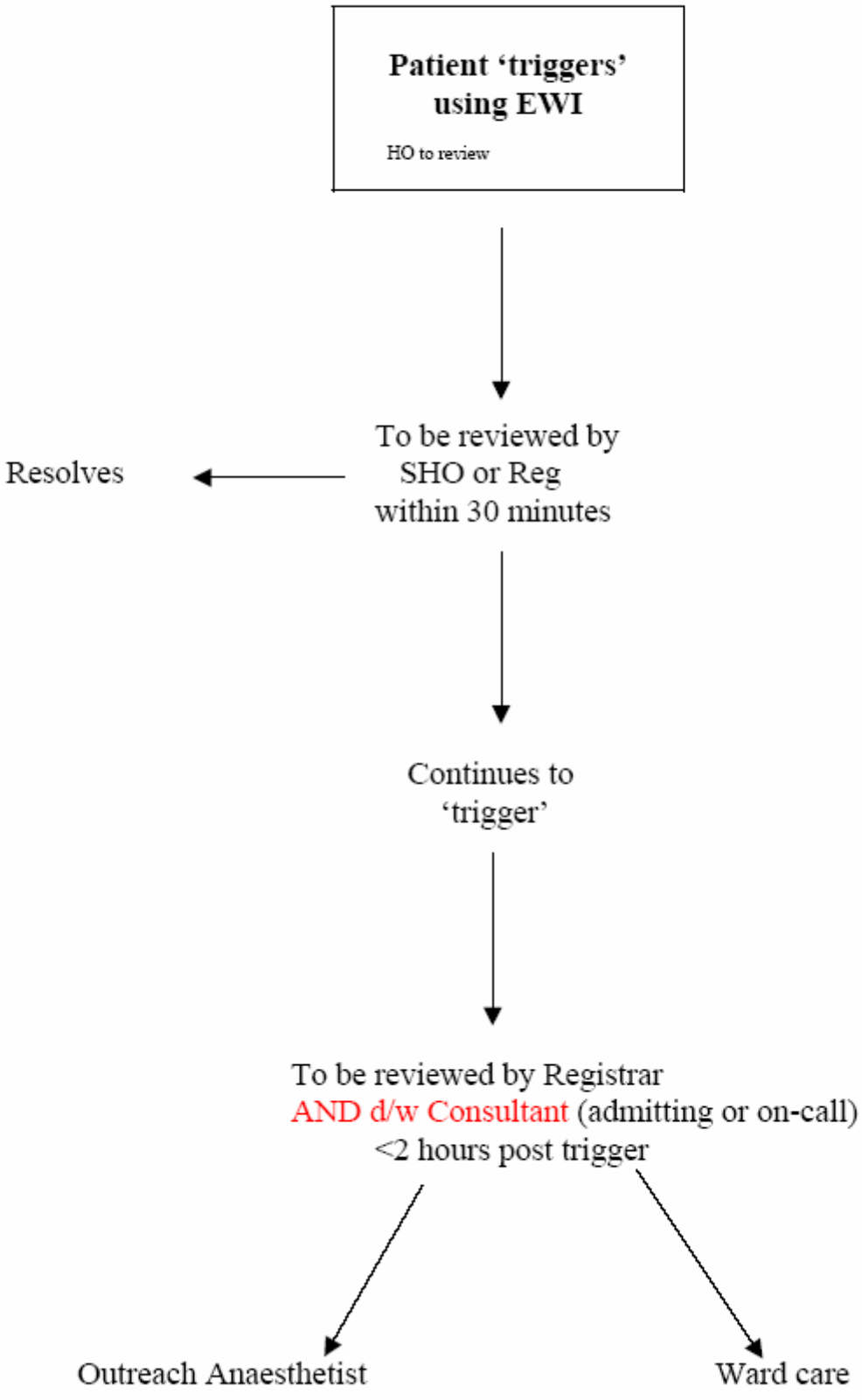


Table A3.1: Summary of age and physiological parameters based on initial assessment mean (standard deviation), median [quartiles]

Hospital	Age	Respiratory rate	Systolic blood pressure	Heart rate	Temperature
A	55.5 (20.3)	21.9 (7.4)	130.8 (24.4)	90.1 (20.0)	36.9 (0.8)
	58.0 [39.0-72.0]	20 [17-25]	130 [114-146]	88 [75-103]	36.8 [36.4-37.2]
B	64.8 (17.2)				
	68.0 [57.0-78.0]				
D	63.7 (18.0)				
	68.0 [51.0-77.0]				
E	67.0 (16.7)	20.7 (6.5)	129.0 (25.2)	88.2 (19.4)	36.7 (0.8)
	70.7 [59.0-78.8]	20 [16-24]	128 [112-145]	86 [75-100]	36.6 [36.2-37.1]
F	65.8 (16.5)				
	70.0 [57.0-77.0]				
G	61.0 (22.2)	19.3 (4.9)	141.4 (32.2)	85.2 (19.5)	36.7 (0.8)
	67.0 [44.0-79.0]	18 [16-20]	139 [116-161]	84 [71-98]	36.6 [36.2-37.2]
H	58.8 (20.6)				
	63.0 [47.0-75.0]				
I	64.9 (17.1)	26.2 (8.4)	119.9 (31.0)	99.7 (25.9)	37.0 (1.0)
	68.5 [55.0-78.0]	26 [20-31]	120 [98-140]	100 [80-115]	36.9 [36.3-37.5]
J		19.5 (8.0)	121.4 (39.6)	89.5 (19.8)	36.8 (0.8)
		18 [16-22]	127 [110-144]	86 [76-100]	36.8 [36.3-37.2]
K	61.1 (20.0)				
	66.3 [49.5-75.6]				
L	63.2 (18.0)	24.7 (7.3)	116.4 (29.9)	104.5 (21.9)	36.8 (0.9)
	67.6 [52.2-76.8]	24 [20-30]	115 [95-135]	105 [90-118]	36.7 [36.2-37.3]
M	63.9 (19.4)	20.1 (5.5)	139.1 (27.0)	86.1 (20.5)	36.6 (0.8)
	68.7[51.0-79.0]	19[16-22]	136 [121-154]	84.5 [72-99]	36.6[36.1-37.0]
N	70.8 (17.3)				
	75.0 [63.0-83.0]				
O	68.8 (15.5)	25.1 (7.9)	115.7 (31.7)	103.3 (25.3)	36.9 (1.1)
	71.9 [60.1-80.1]	24 [19-30]	112 [90-132]	100 [85-120]	36.7 [36.2-37.7]
Hospital	Urine output	SpO_2	FiO_2	pH	Bicarbonate
A		95.9 (5.0)			
		97 [95-98]			
I		92.4 (7.4)			
		94 [90-97]			
L	118.9 (72.4)				
	110 [66-150]				
O	95.6 (73.8)	94.0 (6.0)	0.53 (0.30)	7.34 (0.13)	22.0 (5.3)
	80 [36-135]	96 [93-98]	0.40 [0.28-0.87]	7.37 [7.30-7.42]	22.0 [18.5-25.4]

Hospital	Conscious level, n (%)					
	A	V	C	P	U	W
A	667 (70.8)	116 (12.3)	96 (10.2)	40 (4.3)	23 (2.4)	
E	2-671 (85.1)	404 (12.9)		32 (1.0)	33 (1.1)	
G	591 (93.7) GCS=15	20 (3.2) GCS=14		16 (2.5) GCS=9~13	4 (0.6) GCS<9	
I	755 (44.9)	318 (18.9)	461 (27.4)	149 (8.9)		
J	1648 (89.1)	104 (5.7)	37 (2.1)	20 (1.1)	25 (1.4)	1 (0.1)
L	246 (73.2)	81 (24.1)		5 (1.5)	4 (1.2)	
M	2003 (93.3)	79 (3.7)		30 (1.4)	36 (1.7)	
O	459 (80.8)	85 (15.0)		11 (1.94)	13 (2.3)	

SpO_2 oxygen saturation, FiO_2 fraction of inspired oxygen
Conscious level: A alert/normal; V responds to voice/drowsy; C confused/agitation; P responds to pain; U unresponsive/unconscious; W new weakness, GCS Glasgow coma score

Table A3.2: Summary of physiological parameters when trigger happened mean (standard deviation), median [quartiles]

Hospital	Respiratory rate	Systolic blood pressure	Heart rate	Temperature	Urine output
A	25.5 (9.3)	127.1 (28.4)	96.2 (24.2)	37.0 (0.9)	
	24 [18- 31]	127 [107-145]	96 [77-114]	36.9 [36.5-37.5]	
E	24.0 (7.9)	127.0 (31.7)	96.0 (22.0)	36.7 (1.1)	
	24 [18-28]	124 [104-148]	95 [80-110]	36.6 [36.2-37.2]	
G	22.2 (6.2)	139.8 (40.9)	94.1 (25.7)	36.8 (1.2)	
	20 [18-24]	135 [106-165]	95 [76-111]	36.7 [36.0-37.5]	
I	26.2 (8.4)	119.9 (31.0)	99.7 (25.9)	37.0 (1.0)	
	26 [20-31]	120 [98-140]	100 [80-115]	36.9 [36.3-37.5]	
J	19.2 (12.5)	94.0 (58.8)	102.1 (21.7)	36.9 (1.0)	
	22 [14-28]	110 [64-135]	102 [88-115]	36.8 [36.3-37.5]	
L	25.2 (7.4)	117.2 (30.3)	104.9 (21.6)	36.8 (0.9)	123.2 (74.8)
	26 [20-30]	115 [95-135]	105 [90-118]	36.7 [36.2-37.4]	110 [68-160]
M	28.0 (7.6)	134.4 (39.8)	111.6 (27.2)	36.8 (1.6)	
	26 [22-32]	128 [103-158]	114 [102-130]	36.8 [35.7-37.9]	
O	25.8 (8.3)	113.3 (31.4)	103.5 (25.6)	36.9 (1.0)	92.1 (74.5)
	24 [20-32]	110 [88-130]	102 [85-120]	36.7 [36.2-37.6]	76 [30-130]

Hospital	SpO2	FiO2	pH	Bicarbonate
A	94.5 (7.5)			
	97 [94-98]			
I	92.4 (7.4)			
	94 [90-97]			
O	93.7 (6.3)	0.53 (0.30)	7.34 (0.13)	21.9 (5.3)
	96 [92-97]	0.40 [0.28-0.87]	7.37 [7.30-7.42]	22.0 [18.5-25.2]

Hospital	Conscious level, n (%)					
	A	V	C	P	U	W
A	194 (54.8)	68 (19.2)	47 (13.3)	22 (6.2)	23 (6.5)	
E	194 (54.8)	68 (19.2)	47 (13.3)	22 (6.2)	23 (6.5)	
G	190 (79.5) GCS=15	16 (6.7) GCS=14		20 (8.4) GCS=9~13	13 (5.4) GCS<9	
I	755 (44.9)	318 (18.9)	461 (27.4)	149 (8.9)		
J	815 (80.1)	102 (10.0)	41 (4.0)	23 (2.3)	34 (3.4)	1 (0.1)
L	234 (72.9)	78 (24.3)		5 (1.6)	4 (1.3)	
M	2003 (86.30)	79 (3.40)		30 (1.29)	173 (7.45)	
O	395 (79.2)	81 (16.2)		10 (2.0)	13 (2.6)	

Conscious level: A alert/normal; V responds to voice/drowsy; C confused/ agitation; P responds to pain; U unresponsive/unconscious; W new weakness, GCS Glasgow coma score

Table A3.3: Sensitivity and specificity of TTs by hospital for critical care unit follow-up and referrals from the ward by age (where age recorded in TT dataset)

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Hospital A – Follow up:								
Age 12~17								
Triggered	1	6	7	100	0	14.3		14.3
Not triggered	0	0	0	(2.5-100)	(0.0-45.9)	(0.4-57.9)		(0.4-57.9)
Total	1	6	7					
Age 18~49								
Triggered	4	45	49	22.2	83.9	8.2	94.4	6.1
Not triggered	14	234	248	(6.4-47.6)	(79.0-88.0)	(2.3-19.6)	(90.7-96.9)	(3.6-9.4)
Total	18	279	297					
Age 50~69								
Triggered	6	31	37	40	85	16.2	95.1	6.8
Not triggered	9	176	185	(16.3-67.7)	(79.4-89.6)	(6.2-32.0)	(91.0-97.8)	(3.8-10.9)
Total	15	207	222					
Age 70~79								
Triggered	4	11	15	33.3	88.9	26.7	91.7	10.8
Not triggered	8	88	96	(9.9-65.1)	(81.0-94.3)	(7.8-55.1)	(84.2-96.3)	(5.7-18.1)
Total	12	99	111					
Age 80+								
Triggered	6	6	12	40	87.8	50	82.7	23.4
Not triggered	9	43	52	(16.3-67.7)	(75.2-95.4)	(21.1-78.9)	(69.7-91.8)	(13.8-35.7)
Total	15	49	64					
Hospital A – Referral:								
Age 12~17								
Triggered	1	1	2			50		
						(1.3-98.7)		
Age 18~49								
Triggered	22	38	60			36.7		
						(24.6-50.1)		
Age 50~69								
Triggered	28	38	66			42.4		
						(30.3-55.2)		
Age 70~79								
Triggered	33	36	69			47.8		
						(35.6-60.2)		
Age 80+								
Triggered	34	14	48			70.8		
						(55.9-83.0)		
Hospital B – Follow-up:								
Age 18~49								
Triggered	1	0	1	50	100	100	96.7	6.5

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Not triggered	1	29	30	(1.3-98.7)	(88.1-100)	(2.5-100)	(82.8-99.9)	(0.8-21.4)
Total	2	29	31					
Age 50~69								
Triggered	0	5	5	0	92.6	0	98.4	1.4
Not triggered	1	63	64	(0.0-97.5)	(83.7-97.6)	(0.0-52.2)	(91.6-100)	(0.0-7.8)
Total	1	68	69					
Age 70~79								
Triggered	4	3	7	66.7	93.9	57.1	95.8	10.9
Not triggered	2	46	48	(22.3-95.7)	(83.1-98.7)	(18.4-90.1)	(85.7-99.5)	(4.1-22.2)
Total	6	49	55					
Age 80+								
Triggered	1	0	1	20	100	100	87.9	14.7
Not triggered	4	29	33	(0.5-71.6)	(88.1-100)	(2.5-100)	(71.8-96.6)	(5.0-31.1)
Total	5	29	34					
Hospital B – Referral:								
Age 12~17								
Triggered	1					100		
						(2.5-100)		
Age 18~49								
Triggered	12	42	54			22.2		
						(12.0-35.6)		
Age 50~69								
Triggered	20	72	92			21.7		
						(13.8-31.6)		
Age 70~79								
Triggered	32	47	79			40.5		
						(29.6-52.1)		
Age 80+								
Triggered	25	29	54			46.3		
						(32.6-60.4)		
Hospital D – Follow-up:								
Age 12~17								
Triggered	9							
Not triggered								
Total								
Age 18~49								
Triggered	0	4	4	0	98.6	0	97.8	2.1
Not triggered	6	273	279	(0.0-45.9)	(96.3-99.6)	(0.0-60.2)	(95.4-99.2)	(0.8-4.6)
Total	6	277	283					
Age 50~69								
Triggered	1	1	2	8.3	99.7	50	97.2	3.1
Not triggered	11	378	389	(0.2-38.5)	(98.5-100)	(1.3-98.7)	(95.0-98.6)	(1.6-5.3)
Total	12	379	391					
Age 70~79								

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Triggered	0	2	2	0	99.3	0	96.4	3.5
Not triggered	10	270	280	(0.0-30.8)	(97.4-99.9)	(0.0-84.2)	(93.5-98.3)	(1.7-6.4)
Total	10	272	282					
Age 80+								
Triggered	0	2	2	0	98.5	0	97.7	2.3
Not triggered	3	128	131	(0.0-70.8)	(94.6-99.8)	(0.0-84.2)	(93.5-99.5)	(0.5-6.5)
Total	3	130	133					
Hospital D - Referral:								
Age 12~17								
Triggered	4					100		
						(39.8-100)		
Age 18~49								
Triggered	82	154	236			34.7		
						(28.7-41.2)		
Age 50~69								
Triggered	118	220	338			34.9		
						(29.8-40.3)		
Age 70~79								
Triggered	117	232	349			33.5		
						(28.6-38.7)		
Age 80+								
Triggered	127	213	340			37.4		
						(32.2-42.7)		
Hospital E – Follow-up:								
Age 12~17								
Triggered	2			22.2		100	0	100
Not triggered	7			(2.8-60.0)		(15.8-100)	(0.0-41.0)	(66.4-100)
Total	9							
Age 18~49								
Triggered	5	17	22	50	94.4	22.7	98.3	3.2
Not triggered	5	284	289	(18.7-81.3)	(91.1-96.7)	(7.8-45.4)	(96.0-99.4)	(1.6-5.8)
Total	10	301	311					
Age 50~69								
Triggered	8	61	69	36.4	91.5	11.6	97.9	3
Not triggered	14	657	671	(17.2-59.3)	(89.2-93.4)	(5.1-21.6)	(96.5-98.9)	(1.9-4.5)
Total	22	718	740					
Age 70~79								
Triggered	15	53	68	44.1	90.5	22.1	96.4	5.8
Not triggered	19	504	523	(27.2-62.1)	(87.7-92.8)	(12.9-33.8)	(94.4-97.8)	(4.0-7.9)
Total	34	557	591					
Age 80+								
Triggered	9	34	43	52.9	87.5	20.9	96.7	5.9
Not triggered	8	238	246	(27.8-77.0)	(83.0-91.2)	(10.0-36.0)	(93.7-98.6)	(3.5-9.3)
Total	17	272	289					

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Hospital E – Referral:								
Age 12~17								
Triggered	2					100		
						(15.8-100)		
Age 18~49								
Triggered	40	58	98			40.8		
						(31.0-51.2)		
Age 50~69								
Triggered	111	129	240			46.3		
						(39.8-52.8)		
Age 70~79								
Triggered	106	171	277			38.3		
						(32.5-44.3)		
Age 80+								
Triggered	144	171	315			45.7		
						(40.1-51.4)		
Hospital F – Follow-up:								
Age 12~17								
Triggered	1			100		100		100
Not triggered				(2.5-100)		(2.5-100)		(2.5-100)
Total								
Age 18~49								
Triggered	5	11	16	83.3	72.5	31.3	96.7	13
Not triggered	1	29	30	(35.9-99.6)	(56.1-85.4)	(11.0-58.7)	(82.8-99.9)	(4.9-26.3)
Total	6	40	46					
Age 50~69								
Triggered	12	29	41	52.2	61.3	29.3	80.7	23.5
Not triggered	11	46	57	(30.6-73.2)	(49.4-72.4)	(16.1-45.5)	(68.1-90.0)	(15.5-33.1)
Total	23	75	98					
Age 70~79								
Triggered	15	17	32	57.7	71.7	46.9	79.6	30.2
Not triggered	11	43	54	(36.9-76.6)	(58.6-82.5)	(29.1-65.3)	(66.5-89.4)	(20.8-41.1)
Total	26	60	86					
Age 80+								
Triggered	10	20	30	71.4	52.4	33.3	84.6	25
Not triggered	4	22	26	(41.9-91.6)	(36.4-68.0)	(17.3-52.8)	(65.1-95.6)	(14.4-38.4)
Total	14	42	56					
Hospital F – Referral:								
Age 12~17								
Triggered	1	2	3			33.3		
						(0.8-90.6)		
Age 18~49								
Triggered	1	2	3			33.3		
						(0.8-90.6)		
Age 50~69								
Triggered	3	7	10			30		

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
						(6.7-65.2)		
Age 70~79								
Triggered	4	12	16			25		
						(7.3-52.4)		
Age 80+								
Triggered	3	6	9			33.3		
						(7.5-70.1)		
Hospital G – All MAU patients:								
Age 12~17								
Triggered	4	0	4	21.1		100	0	100
Not triggered	15	0	15	(6.1-45.6)		(39.8-100)	(0.0-21.8)	(82.4-100)
Total	19	0	19					
Age 18~49								
Triggered	4	49	53	66.7	76	7.5	98.7	2.9
Not triggered	2	155	157	(22.3-95.7)	(69.5-81.7)	(2.1-18.2)	(95.5-99.8)	(1.1-6.1)
Total	6	204	210					
Age 50~69								
Triggered	8	67	75	66.7	61	10.7	96.3	6.5
Not triggered	4	105	109	(34.9-90.1)	(53.3-68.4)	(4.7-19.9)	(90.9-99.0)	(3.4-11.1)
Total	12	172	184					
Age 70~79								
Triggered	9	61	70	69.2	56.1	12.9	95.1	8.6
Not triggered	4	78	82	(38.6-90.9)	(47.5-64.5)	(6.1-23.0)	(88.0-98.7)	(4.6-14.2)
Total	13	139	152					
Age 80+								
Triggered	7	61	68	58.3	64.7	10.3	95.7	6.5
Not triggered	5	112	117	(27.7-84.8)	(57.1-71.8)	(4.2-20.1)	(90.3-98.6)	(3.4-11.1)
Total	12	173	185					
Hospital H – Referral:								
Age 12~17								
Triggered	5	6	11			45.5		
Not triggered						(16.7-76.6)		
Age 18~49								
Triggered	67	162	229			29.3		
Not triggered						(23.5-35.6)		
Age 50~69								
Triggered	130	231	361			36		
Not triggered						(31.1-41.2)		
Age 70~79								
Triggered	93	135	228			40.8		
Not triggered						(34.3-47.5)		
Age 80+								

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Triggered	57	74	131			43.5		
Not triggered						(34.9-52.4)		
Hospital I – Referral:								
Age 12~17								
Triggered	3	3	6			50		
						(11.8-88.2)		
Age 18~49								
Triggered	304	152	456			66.7		
						(62.1-71.0)		
Age 50~69								
Triggered	554	254	808			68.6		
						(65.2-71.8)		
Age 70~79								
Triggered	430	220	650			66.2		
						(62.4-69.8)		
Age 80+								
Triggered	278	224	502			55.4		
						(50.9-59.8)		
Hospital K – Follow-up:								
Age 12~17								
Triggered	1			9.1				
Not triggered	10			(0.2-41.3)				
Total	11							
Age 18~49								
Triggered	7	8	15	87.5	87.5	46.7	98.2	11.1
Not triggered	1	56	57	(47.3-99.7)	(76.8-94.4)	(21.3-73.4)	(90.6-100)	(4.9-20.7)
Total	8	64	72					
Age 50~69								
Triggered	6	7	13	75	92.9	46.2	97.8	7.5
Not triggered	2	91	93	(34.9-96.8)	(85.8-97.1)	(19.2-74.9)	(92.4-99.7)	(3.3-14.3)
Total	8	98	106					
Age 70~79								
Triggered	4	9	13	57.1	88	30.8	95.7	8.5
Not triggered	3	66	69	(18.4-90.1)	(78.4-94.4)	(9.1-61.4)	(87.8-99.1)	(3.5-16.8)
Total	7	75	82					
Age 80+								
Triggered	1	5	6	33.3	88.4	16.7	95	6.5
Not triggered	2	38	40	(0.8-90.6)	(74.9-96.1)	(0.4-64.1)	(83.1-99.4)	(1.4-17.9)
Total	3	43	46					
Hospital K – Referral:								
Age 12~17								
Triggered	1	1	2			50		
						(1.3-98.7)		
Age 18~49								
Triggered	2	8	10			20		

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
						(2.5-55.6)		
Age 50~69								
Triggered	8	9	17			47.1		
						(23.0-72.2)		
Age 70~79								
Triggered	7	11	18			38.9		
						(17.3-64.3)		
Age 80+								
Triggered	5	5	10			50		
						(18.7-81.3)		
Hospital L – Follow-up:								
Age 18~49								
Triggered	8	15	23	100	11.8	34.8	100	32
Not triggered	0	2	2	(63.1-100)	(1.5-36.4)	(16.4-57.3)	(15.8-100)	(14.9-53.5)
Total	8	17	25					
Age 50~69								
Triggered	9	17	26	100	15	34.6	100	31
Not triggered	0	3	3	(66.4-100)	(3.2-37.9)	(17.2-55.7)	(29.2-100)	(15.3-50.8)
Total	9	20	29					
Age 70~79								
Triggered	14	14	28	100	12.5	50	100	46.7
Not triggered	0	2	2	(76.8-100)	(1.6-38.3)	(30.6-69.4)	(15.8-100)	(28.3-65.7)
Total	14	16	30					
Age 80+								
Triggered	3	8	11	100	20	27.3	100	23.1
Not triggered	0	2	2	(29.2-100)	(2.5-55.6)	(6.0-61.0)	(15.8-100)	(5.0-53.8)
Total	3	10	13					
Hospital L – Referral:								
Age 12~17								
Triggered	1							
Age 18~49								
Triggered	19	29	48			39.6		
						(25.8-54.7)		
Age 50~69								
Triggered	46	37	83			55.4		
						(44.1-66.3)		
Age 70~79								
Triggered	36	25	61			59		
						(45.7-71.4)		
Age 80+								
Triggered	23	18	41			56.1		
						(39.7-71.5)		
Hospital M – All patients:								
Age 12~17								
Triggered	15	0	15	100		100		100

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Not triggered	0	0	0	(78.2-100)		(78.2-100)		(78.2-100)
Total	15	0	15					
Age 18~49								
Triggered	3	13	16	18.8	97.5	18.8	97.5	3
Not triggered	13	503	516	(4.0-45.6)	(95.7-98.7)	(4.0-45.6)	(95.7-98.7)	(1.7-4.8)
Total	16	516	532					
Age 50~69								
Triggered	14	34	48	21.5	94.3	29.2	91.7	9.9
Not triggered	51	560	611	(12.3-33.5)	(92.1-96.0)	(17.0-44.1)	(89.2-93.7)	(7.7-12.4)
Total	65	594	659					
Age 70~79								
Triggered	15	33	48	17.9	93.1	31.3	86.6	14.9
Not triggered	69	447	516	(10.4-27.7)	(90.5-95.2)	(18.7-46.3)	(83.4-89.4)	(12.1-18.1)
Total	84	480	564					
Age 80+								
Triggered	27	28	55	22.5	93.5	49.1	81.2	21.8
Not triggered	93	402	495	(15.4-31.0)	(90.7-95.6)	(35.4-62.9)	(77.5-84.6)	(18.4-25.5)
Total	120	430	550					
Hospital M – No CCOS:								
Age 12~17								
Triggered	5	0	5	100		100		100
Not triggered	0	0	0	(47.8-100)		(47.8-100)		(47.8-100)
Total	5	0	5					
Age 18~49								
Triggered	0	5	5	0	96.8	0	96.8	3.1
Not triggered	5	149	154	(0.0-52.2)	(92.6-98.9)	(0.0-52.2)	(92.6-98.9)	(1.0-7.2)
Total	5	154	159					
Age 50~69								
Triggered	3	15	18	20	91.1	16.7	92.8	8.2
Not triggered	12	154	166	(4.3-48.1)	(85.8-94.9)	(3.6-41.4)	(87.7-96.2)	(4.6-13.1)
Total	15	169	184					
Age 70~79								
Triggered	9	15	24	40.9	89.4	37.5	90.7	13.4
Not triggered	13	127	140	(20.7-63.6)	(83.2-94.0)	(18.8-59.4)	(84.6-95.0)	(8.6-19.6)
Total	22	142	164					
Age 80+								
Triggered	6	6	12	21.4	94.4	50	82.3	20.6
Not triggered	22	102	124	(8.3-41.0)	(88.3-97.9)	(21.1-78.9)	(74.4-88.5)	(14.1-28.4)
Total	28	108	136					
Hospital M – CCOS:								
Age 12~17								

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Triggered	10	0	10	100		100		100
Not triggered	0	0	0	(69.2-100)		(69.2-100)		(69.2-100)
Total	10	0	10					
Age 18~49								
Triggered	3	8	11	27.3	97.8	27.3	97.8	2.9
Not triggered	8	354	362	(6.0-61.0)	(95.7-99.0)	(6.0-61.0)	(95.7-99.0)	(1.5-5.2)
Total	11	362	373					
Age 50~69								
Triggered	11	19	30	22	95.5	36.7	91.2	10.5
Not triggered	39	406	445	(11.5-36.0)	(93.1-97.3)	(19.9-56.1)	(88.2-93.7)	(7.9-13.6)
Total	50	425	475					
Age 70~79								
Triggered	6	18	24	9.7	94.7	25	85.1	15.5
Not triggered	56	320	376	(3.6-19.9)	(91.7-96.8)	(9.8-46.7)	(81.1-88.5)	(12.1-19.4)
Total	62	338	400					
Age 80+								
Triggered	21	22	43	22.8	93.2	48.8	80.9	22.2
Not triggered	71	300	371	(14.7-32.8)	(89.8-95.7)	(33.3-64.5)	(76.5-84.7)	(18.3-26.5)
Total	92	322	414					
Hospital N – Follow-up:								
Age 12~17								
Triggered	11	0	11	64.7		100	0	100
Not triggered	6	0	6	(38.3-85.8)		(71.5-100)	(0.0-45.9)	(80.5-100)
Total	17	0	17					
Age 18~49								
Triggered	4	45	49	100	51.6	8.2	100	4.1
Not triggered	0	48	48	(39.8-100)	(41.0-62.1)	(2.3-19.6)	(92.6-100)	(1.1-10.2)
Total	4	93	97					
Age 50~69								
Triggered	9	66	75	75	52.5	12	96.1	7.9
Not triggered	3	73	76	(42.8-94.5)	(43.9-61.0)	(5.6-21.6)	(88.9-99.2)	(4.2-13.5)
Total	12	139	151					
Age 70~79								
Triggered	12	62	74	85.7	40.4	16.2	95.5	11.9
Not triggered	2	42	44	(57.2-98.2)	(30.9-50.5)	(8.7-26.6)	(84.5-99.4)	(6.6-19.1)
Total	14	104	118					
Age 80+								
Triggered	11	30	41	84.6	40	26.8	90.9	20.6
Not triggered	2	20	22	(54.6-98.1)	(26.4-54.8)	(14.2-42.9)	(70.8-98.9)	(11.5-32.7)
Total	13	50	63					
Hospital N – Referral:								

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Age 12~17								
Triggered	1	7	8			12.5		
						(0.3-52.7)		
Age 18~49								
Triggered	32	120	152			21.1		
						(14.9-28.4)		
Age 50~69								
Triggered	141	282	423			33.3		
						(28.9-38.0)		
Age 70~79								
Triggered	186	340	526			35.4		
						(31.3-39.6)		
Age 80+								
Triggered	327	470	797			41		
						(37.6-44.5)		
Hospital O – Follow-up:								
Age 18~49								
Triggered	4	7	11	57.1	58.8	36.4	76.9	29.2
Not triggered	3	10	13	(18.4-90.1)	(32.9-81.6)	(10.9-69.2)	(46.2-95.0)	(12.6-51.1)
Total	7	17	24					
Age 50~69								
Triggered	19	21	40	79.2	51.2	47.5	81.5	35.8
Not triggered	5	22	27	(57.8-92.9)	(35.5-66.7)	(31.5-63.9)	(61.9-93.7)	(24.5-48.5)
Total	24	43	67					
Age 70~79								
Triggered	10	22	32	76.9	46.3	31.3	86.4	24.1
Not triggered	3	19	22	(46.2-95.0)	(30.7-62.6)	(16.1-50.0)	(65.1-97.1)	(13.5-37.6)
Total	13	41	54					
Age 80+								
Triggered	13	9	22	86.7	43.8	59.1	77.8	48.4
Not triggered	2	7	9	(59.5-98.3)	(19.8-70.1)	(36.4-79.3)	(40.0-97.2)	(30.2-66.9)
Total	15	16	31					
Hospital O – Referral:								
Age 12~17								
Triggered	1	0	1			100		
						(2.5-100)		
Age 18~49								
Triggered	25	26	51			49		
						(34.8-63.4)		
Age 50~69								
Triggered	70	49	119			58.8		
						(49.4-67.8)		
Age 70~79								
Triggered	77	36	113			68.1		
						(58.7-76.6)		
Age 80+								

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Triggered	73	44	117			62.4		
						(53.0-71.2)		

TT track & trigger warning score(s), DNAR do not attempt resuscitation, CPR cardiopulmonary resuscitation, Composite outcome is defined as a composite of death, admission to critical care, DNAR placed or CPR. For patients with multiple outcomes, the first outcome to occur was used, if the date could be identified, otherwise outcomes were considered to have occurred in the order of CPR, DNAR placed, admission to critical care and death, CI confidence interval, MAU medical admissions unit, CCOS critical care outreach services

Table A3.4: Sensitivity and specificity of TTs by hospital for critical care unit follow-up and referrals from ward by ward (where ward identifiable)

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Hospital E – Follow-up:								
Surgical								
Triggered	24	160	184	36.4	90.6	13	97.3	3.7
Not triggered	42	1535	1577	(24.9-49.1)	(89.1-91.9)	(8.5-18.8)	(96.4-98.1)	(2.9-4.7)
Total	66	1695	1761					
Medical								
Triggered	15	23	38	62.5	89.3	39.5	95.5	10.1
Not triggered	9	191	200	(40.6-81.2)	(84.3-93.1)	(24.0-56.6)	(91.6-97.9)	(6.6-14.6)
Total	24	214	238					
Hospital E - Referral: Surgical								
Triggered	183	311	494			37		
						(32.8-41.5)		
Medical								
Triggered	222	205	427			52		
						(47.1-56.8)		
Hospital I:								
Surgical								
Triggered	511	327	838			61		
						(57.6-64.3)		
Medical								
Triggered	1079	536	1615			66.8		
						(64.5-69.1)		
Hospital K – Follow-up:								
Surgical								
Triggered	9	14	23	69.2	91.9	39.1	97.5	7
Not triggered	4	158	162	(38.6-90.9)	(86.7-95.5)	(19.7-61.5)	(93.8-99.3)	(3.8-11.7)
Total	13	172	185					
Medical								
Triggered	9	16	25	69.2	85.3	36	95.9	10.7
Not triggered	4	93	97	(38.6-90.9)	(77.3-91.4)	(18.0-57.5)	(89.8-98.9)	(5.8-17.5)
Total	13	109	122					
Hospital K – Referral:								
Surgical								
Triggered	14	19	33			42.4		
						(25.5-60.8)		
Medical								
Triggered	8	15	23			34.8		
						(16.4-57.3)		

TT track & trigger warning score(s), DNAR do not attempt resuscitation, CPR cardiopulmonary resuscitation, Composite outcome is defined as a composite of death, admission to critical care, DNAR placed or CPR. For patients with multiple outcomes, the first outcome to occur was used, if the date could be identified, otherwise outcomes were considered to have occurred in the order of CPR, DNAR placed, admission to critical care and death, CI confidence interval

Table A3.5: Sensitivity and specificity of TTs by hospital for critical care unit follow-up and referrals from ward by specialty -- categorised as trauma/orthopaedics, vascular surgery, surgery, medicine, obstetrics/gynaecology and neurosurgery (where specialty recorded in TT dataset)

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Hospital B – Follow-up:								
Trauma/orthopaedics								
Triggered	1	0	1	100	100	100	100	11.1
Not triggered	0	8	8	(2.5-100)	(63.1-100)	(2.5-100)	(63.1-100)	(0.3-48.2)
Total	1	8	9					
Surgery								
Triggered	0	4	4	0	96.1	0	97	2.9
Not triggered	3	98	101	(0.0-70.8)	(90.3-98.9)	(0.0-60.2)	(91.6-99.4)	(0.6-8.1)
Total	3	102	105					
Medicine								
Triggered	5	4	9	55.6	91.3	55.6	91.3	16.4
Not triggered	4	42	46	(21.2-86.3)	(79.2-97.6)	(21.2-86.3)	(79.2-97.6)	(7.8-28.8)
Total	9	46	55					
Obstetrics/gynaecology								
Triggered	2							
Not triggered								
Total	2							
Hospital B - Referral:								
Trauma/orthopaedics								
Triggered	1	6	7			14.3		
						(0.4-57.9)		
Surgery								
Triggered	22	74	96			22.9		
						(15.0-32.6)		
Medicine								
Triggered	57	94	151			37.7		
						(30.0-46.0)		
Obstetrics/gynaecology								
Triggered	1							
Hospital E – Follow-up: Trauma/orthopaedics								
Triggered	9	14	23	69.2	91.9	39.1	97.5	7
Not triggered	4	158	162	(38.6-90.9)	(86.7-95.5)	(19.7-61.5)	(93.8-99.3)	(3.8-11.7)
Total	13	172	185					
Surgery								
Triggered	9	16	25	69.2	85.3	36	95.9	10.7
Not triggered	4	93	97	(38.6-90.9)	(77.3-91.4)	(18.0-57.5)	(89.8-98.9)	(5.8-17.5)
Total	44	1044	1088					
Vascular surgery								

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Triggered	2	37	39	28.6	92.9	5.1	99	1.3
Not triggered	5	481	486	(3.7-71.0)	(90.3-94.9)	(0.6-17.3)	(97.6-99.7)	(0.5-2.7)
Total	7	518	525					
Medicine								
Triggered	19	26	45	55.9	89	42.2	93.4	12.5
Not triggered	15	211	226	(37.9-72.8)	(84.3-92.7)	(27.7-57.8)	(89.3-96.2)	(8.8-17.1)
Total	34	237	271					
Obstetrics/gynaecology								
Triggered	1	4	5	50	90.5	20	97.4	4.5
Not triggered	1	38	39	(1.3-98.7)	(77.4-97.3)	(0.5-71.6)	(86.5-99.9)	(0.6-15.5)
Total	2	42	44					
Hospital E – Referral:								
Trauma/orthopaedics								
Triggered	67	143	210			31.9		
						(25.7-38.7)		
Surgery								
Triggered	102	146	248			41.1		
						(34.9-47.5)		
Vascular surgery								
Triggered	12	22	34			35.3		
						(19.7-53.5)		
Medicine								
Triggered	242	234	476			50.8		
						(46.3-55.4)		
Obstetrics/gynaecology								
Triggered	3	16	19			15.8		
						(3.4-39.6)		
Hospital H – Referral:								
Trauma/orthopaedics								
Triggered	15	28	43			34.9		
						(21.0-50.9)		
Surgery								
Triggered	117	252	369			31.7		
						(27.0-36.7)		
Vascular surgery								
Triggered	15	69	84			17.9		
						(10.4-27.7)		
Medicine								
Triggered	187	229	416			45		
						(40.1-49.9)		
Obstetrics/gynaecology								
Triggered	3	13	16			18.8		
						(4.0-45.6)		
Hospital J – Follow-up:								
Trauma/orthopaedics								
Triggered	2							
Not triggered								

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Total								
Surgery								
Triggered	10	2	12	16.4	99.7	83.3	93.9	7.2
Not triggered	51	786	837	(8.2-28.1)	(99.1-100)	(51.6-97.9)	(92.1-95.4)	(5.5-9.1)
Total	61	788	849					
Medicine								
Triggered	7	5	12	15.9	98.3	58.3	88.7	12.9
Not triggered	37	291	328	(6.6-30.1)	(96.1-99.4)	(27.7-84.8)	(84.8-91.9)	(9.6-17.0)
Total	44	296	340					
Neurosurgery								
Triggered	2	5	7	25	98.2	28.6	97.8	2.9
Not triggered	6	266	272	(3.2-65.1)	(95.7-99.4)	(3.7-71.0)	(95.3-99.2)	(1.2-5.6)
Total	8	271	279					
Obstetrics/gynaecology								
Triggered	3	14	17			17.6		
Not triggered						(3.8-43.4)		
Hospital J – Referral:								
Surgery								
Triggered	60	63	123			48.8		
						(39.7-58.0)		
Medicine								
Triggered	167	118	285			58.6		
						(52.6-64.4)		
Neurosurgery								
Triggered	3					100		
						(29.2-100)		
Obstetrics/gynaecology								
Triggered	1							
Hospital L – Follow-up: Surgery								
Triggered	18	34	52	100	19	34.6	100	30
Not triggered	0	8	8	(81.5-100)	(8.6-34.1)	(22.0-49.1)	(63.1-100)	(18.8-43.2)
Total	18	42	60					
Medicine								
Triggered	14	19	33	100	5	42.4	100	41.2
Not triggered	0	1	1	(76.8-100)	(0.1-24.9)	(25.5-60.8)	(2.5-100)	(24.6-59.3)
Total	14	20	34					
Obstetrics/gynaecology								
Triggered	2	1	3			66.7		
Not triggered						(9.4-99.2)		
Hospital L – Referral:								
Surgery								
Triggered	68	80	148			45.9		
						(37.7-54.3)		

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Medicine								
Triggered	49	30	79			62		
						(50.4-72.7)		
Obstetrics/gynaecology								
Triggered	7	1	8			87.5		
						(47.3-99.7)		
Hospital O – Follow-up:								
Trauma/orthopaedics								
Triggered	8	10	18	72.7	58.3	44.4	82.4	31.4
Not triggered	3	14	17	(39.0-94.0)	(36.6-77.9)	(21.5-69.2)	(56.6-96.2)	(16.9-49.3)
Total	11	24	35					
Surgery								
Triggered	16	29	45	84.2	47.3	35.6	89.7	25.7
Not triggered	3	26	29	(60.4-96.6)	(33.7-61.2)	(21.9-51.2)	(72.6-97.8)	(16.2-37.2)
Total	19	55	74					
Vascular surgery								
Triggered	5	6	11	62.5	53.8	45.5	70	38.1
Not triggered	3	7	10	(24.5-91.5)	(25.1-80.8)	(16.7-76.6)	(34.8-93.3)	(18.1-61.6)
Total	8	13	21					
Medicine								
Triggered	17	12	29	81	52	58.6	76.5	45.7
Not triggered	4	13	17	(58.1-94.6)	(31.3-72.2)	(38.9-76.5)	(50.1-93.2)	(30.9-61.0)
Total	21	25	46					
Hospital O – Referral: Trauma/orthopaedics								
Triggered	43	41	84			51.2		
						(40.0-62.3)		
Surgery								
Triggered	100	62	162			61.7		
						(53.8-69.2)		
Vascular surgery								
Triggered	24	14	38			63.2		
						(46.0-78.2)		
Medicine								
Triggered	77	36	113			68.1		
						(58.7-76.6)		

TT track & trigger warning score(s), DNAR do not attempt resuscitation, CPR cardiopulmonary resuscitation, Composite outcome is defined as a composite of death, admission to critical care, DNAR placed or CPR. For patients with multiple outcomes, the first outcome to occur was used, if the date could be identified, otherwise outcomes were considered to have occurred in the order of CPR, DNAR placed, admission to critical care and death, DNAR or CPR, CI confidence interval

Table A3.6: Sensitivity analyses including multiple visits from CCOS as part of the composite outcome

Summary of outcome events in each TT dataset

Hospital	Patients with outcome n	Composite outcome n (%)	Multiple visits n (%)	CPR n (%)	DNAR n (%)	Critical care n (%)	Death n (%)
B	471	132 (28.0)	70 (14.9)		33 (7.0)	16 (3.4)	13 (2.7)
E	3000	952 (31.7)	576 (19.2)		159 (5.3)	185 (6.2)	32 (1.1)
H	960	693 (72.2)	341 (35.5)		72 (7.5)	230 (24.0)	50 (5.2)
J	1929	556 (28.8)	351 (18.2)	16 (0.8)	86 (4.5)	70 (3.6)	33 (1.7)
K	377	105 (27.9)	81 (21.5)		7 (1.8)	14 (3.7)	3 (0.8)
L	333	206 (61.9)	105 (31.5)		22 (6.6)	74 (22.2)	5 (1.5)
O	582	367 (63.1)	116 (20.0)		88 (15.1)	156 (26.8)	7 (1.2)

CCOS critical care outreach service(s), DNAR do not attempt resuscitation, CPR cardiopulmonary resuscitation, Composite outcome is defined as a composite of multiple visits from CCOS, death, admission to critical care, DNAR placed or CPR. For patients with multiple outcomes, the first outcome to occur was used, if the date could be identified, otherwise outcomes were considered to have occurred in the order of multiple visits, CPR, DNAR placed, admission to critical care and death

Table A3.7: Sensitivity and specificity of TTs by hospital for critical care unit follow-up and referrals from ward including multiple visits from CCOS as part of the composite outcome

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Hospital B – Follow-up:								
Triggered	10	4	14	52.6	97.6	71.4	94.9	10.1
Not triggered	9	166	175	(28.9-75.6)	(94.1-99.4)	(41.9-91.6)	(90.5-97.6)	(6.2-15.3)
Total	19	170	189					
Referral								
Triggered	112	168	280			40		
						(34.2-46.0)		
Hospital E – Follow-up:								
Triggered	121	102	223	70.3	94.5	54.3	97.2	8.5
Not triggered	51	1739	1790	(62.9-77.1)	(93.3-95.5)	(47.5-60.9)	(96.3-97.9)	(7.4-9.9)
Total	172	1841	2013					
Referral								
Triggered	780	207	987			79		
						(76.4-81.5)		
Hospital H – Referral:								
Triggered	693	267	960			72.2	693	267
Not triggered						(69.2-75.0)		
Hospital J – Follow-up:								
Triggered	30	1	31	16.7	99.9	96.8	89.9	11.9
Not triggered	150	1331	1481	(11.5-22.9)	(99.6-100)	(83.3-99.9)	(88.2-91.4)	(10.3-13.6)
Total	180	1332	1512					
Referral								
Triggered	376	41	417			90.2		
						(86.9-92.9)		
Hospital K – Follow-up:								
Triggered	46	3	49	85.2	98.9	93.9	97	16.9
Not triggered	8	263	271	(72.9-93.4)	(96.7-99.8)	(83.1-98.7)	(94.3-98.7)	(12.9-21.4)
Total	54	266	320					
Referral								
Triggered	51	6	57			89.5		
						(78.5-96.0)		
Hospital L – Follow-up: CC follow-up								
Triggered	48	40	88	100	18.4	54.5	100	49.5
Not triggered	0	9	9	(92.6-100)	(8.8-32.0)	(43.6-65.2)	(66.4-100)	(39.2-59.8)
Total	48	49	97					
Hospital L – Referral:								
Triggered	158	78	236			66.9		
						(60.6-72.9)		
Hospital O – Follow-up:								

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Triggered	61	44	105	82.4	57.7	58.1	82.2	41.6
Not triggered	13	60	73	(71.8-90.3)	(47.6-67.3)	(48.1-67.7)	(71.5-90.2)	(34.2-49.2)
Total	74	104	178					
Referral								
Triggered	293	111	404			72.5		
						(67.9-76.8)		

TT track & trigger warning score(s), CCOS critical care outreach service(s), DNAR do not attempt resuscitation, CPR cardiopulmonary resuscitation, Composite outcome is defined as a composite of multiple visits from CCOS, death, admission to critical care, DNAR placed or CPR. For patients with multiple outcomes, the first outcome to occur was used, if the date could be identified, otherwise outcomes were considered to have occurred in the order of multiple visits, CPR, DNAR placed, admission to critical care and death, CI confidence interval

Table A3.8: Sensitivity and specificity of TTs by hospital for critical care unit follow-up and referrals from the ward including multiple visits from CCOS as part of the composite outcome by age (where age recorded in TT dataset)

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Hospital B – Follow-up:								
Age 18~49								
Triggered	1	0	1	50	100	100	96.7	6.5
Not triggered	1	29	30	(1.3-98.7)	(88.1-100)	(2.5-100)	(82.8-99.9)	(0.8-21.4)
Total	2	29	31					
Age 50~69								
Triggered	2	3	5	66.7	95.5	40	98.4	4.3
Not triggered	1	63	64	(9.4-99.2)	(87.3-99.1)	(5.3-85.3)	(91.6-100)	(0.9-12.2)
Total	3	66	69					
Age 70~79								
Triggered	6	1	7	66.7	97.8	85.7	93.8	16.4
Not triggered	3	45	48	(29.9-92.5)	(88.5-99.9)	(42.1-99.6)	(82.8-98.7)	(7.8-28.8)
Total	9	46	55					
Age 80+								
Triggered	1	0	1	20	100	100	87.9	14.7
Not triggered	4	29	33	(0.5-71.6)	(88.1-100)	(2.5-100)	(71.8-96.6)	(5.0-31.1)
Total	5	29	34					
Hospital B – Referral: Age 12~17								
Triggered	1	0	1			100		
						(2.5-100)		
Age 18~49								
Triggered	20	33	53			37.7		
						(24.8-52.1)		
Age 50~69								
Triggered	26	57	83			31.3		
						(21.6-42.4)		
Age 70~79								
Triggered	36	36	72			50		
						(38.0-62.0)		
Age 80+								
Triggered	29	23	52			55.8		
						(41.3-69.5)		
Hospital E – Follow-up:								
Age 12~17								
Triggered	1	1	2	100	87.5	50	100	11.1
Not triggered	0	7	7	(2.5-100)	(47.3-99.7)	(1.3-98.7)	(59.0-100)	(0.3-48.2)
Total	1	8	9					
Age 18~49								
Triggered	12	10	22	70.6	96.6	54.5	98.3	5.5

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Not triggered	5	284	289	(44.0-89.7)	(93.8-98.4)	(32.2-75.6)	(96.0-99.4)	(3.2-8.6)
Total	17	294	311					
Age 50~69								
Triggered	32	37	69	69.6	94.7	46.4	97.9	6.2
Not triggered	14	657	671	(54.2-82.3)	(92.7-96.2)	(34.3-58.8)	(96.5-98.9)	(4.6-8.2)
Total	46	694	740					
Age 70~79								
Triggered	41	27	68	68.3	94.9	60.3	96.4	10.2
Not triggered	19	504	523	(55.0-79.7)	(92.7-96.6)	(47.7-72.0)	(94.4-97.8)	(7.8-12.9)
Total	60	531	591					
Age 80+								
Triggered	23	20	43	74.2	92.2	53.5	96.7	10.7
Not triggered	8	238	246	(55.4-88.1)	(88.3-95.2)	(37.7-68.8)	(93.7-98.6)	(7.4-14.9)
Total	31	258	289					
Hospital E – Referral: Age 12~17								
Triggered	2	0	2			100		
						(15.8-100)		
Age 18~49								
Triggered	74	24	98			75.5		
						(65.8-83.6)		
Age 50~69								
Triggered	196	44	240			81.7		
						(76.2-86.4)		
Age 70~79								
Triggered	222	55	277			80.1		
						(75.0-84.7)		
Age 80+								
Triggered	245	70	315			77.8		
						(72.8-82.2)		
Hospital H – Referral:								
Age 12~17								
Triggered	8	3	11			72.7		
Not triggered						(39.0-94.0)		
Age 18~49								
Triggered	145	84	229			63.3		
Not triggered						(56.7-69.6)		
Age 50~69								
Triggered	266	95	361			73.7		
Not triggered						(68.8-78.2)		
Age 70~79								
Triggered	172	56	228			75.4		
Not triggered						(69.3-80.9)		
Age 80+								

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Triggered	102	29	131			77.9		
Not triggered						(69.8-84.6)		
Hospital K – Follow-up:								
Age 12~17								
Triggered	1	0	1	100	100	100	100	9.1
Not triggered	0	10	10	(2.5-100)	(69.2-100)	(2.5-100)	(69.2-100)	(0.2-41.3)
Total	1	10	11					
Age 18~49								
Triggered	14	1	15	93.3	98.2	93.3	98.2	20.8
Not triggered	1	56	57	(68.1-99.8)	(90.6-100)	(68.1-99.8)	(90.6-100)	(12.2-32.0)
Total	15	57	72					
Age 50~69								
Triggered	13	0	13	86.7	100	100	97.8	14.2
Not triggered	2	91	93	(59.5-98.3)	(96.0-100)	(75.3-100)	(92.4-99.7)	(8.1-22.3)
Total	15	91	106					
Age 70~79								
Triggered	12	1	13	80	98.5	92.3	95.7	18.3
Not triggered	3	66	69	(51.9-95.7)	(92.0-100)	(64.0-99.8)	(87.8-99.1)	(10.6-28.4)
Total	15	67	82					
Age 80+								
Triggered	6	0	6	75	100	100	95	17.4
Not triggered	2	38	40	(34.9-96.8)	(90.7-100)	(54.1-100)	(83.1-99.4)	(7.8-31.4)
Total	8	38	46					
Hospital K – Referral:								
Age 12~17								
Triggered	2	0	0			100		
						(15.8-100)		
Age 18~49								
Triggered	8	2	10			80		
						(44.4-97.5)		
Age 50~69								
Triggered	16	1	17			94.1		
						(71.3-99.9)		
Age 70~79								
Triggered	17	1	18			94.4		
						(72.7-99.9)		
Age 80+								
Triggered	8	2	10			80		
						(44.4-97.5)		
Hospital L – Follow-up:								
Age 18~49								
Triggered	12	11	23	100	15.4	52.2	100	48
Not triggered	0	2	2	(73.5-100)	(1.9-45.4)	(30.6-73.2)	(15.8-100)	(27.8-68.7)
Total	12	13	25					
Age 50~69								

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Triggered	11	15	26	100	16.7	42.3	100	37.9
Not triggered	0	3	3	(71.5-100)	(3.6-41.4)	(23.4-63.1)	(29.2-100)	(20.7-57.7)
Total	11	18	29					
Age 70~79								
Triggered	21	7	28	100	22.2	75	100	70
Not triggered	0	2	2	(83.9-100)	(2.8-60.0)	(55.1-89.3)	(15.8-100)	(50.6-85.3)
Total	21	9	30					
Age 80+								
Triggered	4	7	11	100	22.2	36.4	100	30.8
Not triggered	0	2	2	(39.8-100)	(2.8-60.0)	(10.9-69.2)	(15.8-100)	(9.1-61.4)
Total	4	9	13					
Hospital L – Referral:								
Age 12~17								
Triggered	27	21	48			56.3		
						(41.2-70.5)		
Age 18~49								
Triggered	58	25	83			69.9		
						(58.8-79.5)		
Age 50~69								
Triggered	42	19	61			68.9		
						(55.7-80.1)		
Age 70~79								
Triggered	30	11	41			73.2		
						(57.1-85.8)		
Age 80+								
Triggered	30	11	41			73.2		
						(57.1-85.8)		
Hospital O – Follow-up:								
Age 18~49								
Triggered	7	4	11	70	71.4	63.6	76.9	41.7
Not triggered	3	10	13	(34.8-93.3)	(41.9-91.6)	(30.8-89.1)	(46.2-95.0)	(22.1-63.4)
Total	10	14	24					
Age 50~69								
Triggered	22	18	40	81.5	55	55	81.5	40.3
Not triggered	5	22	27	(61.9-93.7)	(38.5-70.7)	(38.5-70.7)	(61.9-93.7)	(28.5-53.0)
Total	27	40	67					
Age 70~79								
Triggered	17	15	32	85	55.9	53.1	86.4	37
Not triggered	3	19	22	(62.1-96.8)	(37.9-72.8)	(34.7-70.9)	(65.1-97.1)	(24.3-51.3)
Total	20	34	54					
Age 80+								
Triggered	15	7	22	88.2	50	68.2	77.8	54.8
Not triggered	2	7	9	(63.6-98.5)	(23.0-77.0)	(45.1-86.1)	(40.0-97.2)	(36.0-72.7)
Total	17	14	31					
Hospital O – Referral:								

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Age 12~17								
Triggered	1	0	1			100		
						(2.5-100)		
Age 18~49								
Triggered	30	21	51			58.8		
						(44.2-72.4)		
Age 50~69								
Triggered	90	29	119			75.6		
						(66.9-83.0)		
Age 70~79								
Triggered	87	26	113			77		
						(68.1-84.4)		
Age 80+								
Triggered	83	34	117			70.9		
						(61.8-79.0)		

TT track & trigger warning score(s), CCOS critical care outreach service(s), DNAR do not attempt resuscitation, CPR cardiopulmonary resuscitation, Composite outcome is defined as a composite of multiple visits from CCOS, death, admission to critical care, DNAR placed or CPR. For patients with multiple outcomes, the first outcome to occur was used, if the date could be identified, otherwise outcomes were considered to have occurred in the order of multiple visits, CPR, DNAR placed, admission to critical care and death, CI confidence interval

Table A3.9: Sensitivity and specificity of TTs by hospital for critical care unit follow-up and referrals from ward including multiple visits from CCOS as part of the composite outcome by ward (where ward identifiable)

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Hospital E – Follow-up:								
Surgical								
Triggered	92	92	184	68.7	94.3	50	97.3	7.6
Not triggered	42	1535	1577	(60.1-76.4)	(93.1-95.4)	(42.6-57.4)	(96.4-98.1)	(6.4-8.9)
Total	134	1627	1761					
Medical								
Triggered	30	8	38	76.9	96	78.9	95.5	16.4
Not triggered	9	191	200	(60.7-88.9)	(92.2-98.2)	(62.7-90.4)	(91.6-97.9)	(11.9-21.7)
Total	39	199	238					
Hospital E – Referral:								
Surgical								
Triggered	379	115	494			76.7		
						(72.7-80.4)		
Medical								
Triggered	352	75	427			82.4		
						(78.5-85.9)		
Hospital K – Follow-up:								
Surgical								
Triggered	22	1	23	84.6	99.4	95.7	97.5	14.1
Not triggered	4	158	162	(65.1-95.6)	(96.5-100)	(78.1-99.9)	(93.8-99.3)	(9.4-19.9)
Total	26	159	185					
Medical								
Triggered	23	2	25	85.2	97.9	92	95.9	22.1
Not triggered	4	93	97	(66.3-95.8)	(92.6-99.7)	(74.0-99.0)	(89.8-98.9)	(15.1-30.5)
Total	27	95	122					
Hospital K – Referral:								
Surgical								
Triggered	31	2	33			93.9		
						(79.8-99.3)		
Medical								
Triggered	19	4	23			82.6		
						(61.2-95.0)		

TT track & trigger warning score(s), CCOS critical care outreach service(s), DNAR do not attempt resuscitation, CPR cardiopulmonary resuscitation, Composite outcome is defined as a composite of multiple visits from CCOS, death, admission to critical care, DNAR placed or CPR. For patients with multiple outcomes, the first outcome to occur was used, if the date could be identified, otherwise outcomes were considered to have occurred in the order of multiple visits, CPR, DNAR placed, admission to critical care and death, CI confidence interval

Table A3.10: Sensitivity and specificity of TTs by hospital for critical care unit follow-up and referrals from ward including multiple visits from CCOS as part of the composite outcome by specialty -- categorised as trauma/orthopaedics, vascular surgery, surgery, medicine, obstetrics/gynaecology and neurosurgery (where specialty recorded in TT dataset)

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Hospital B – Follow-up:								
Trauma/orthopaedics								
Triggered	1	0	1	100	100	100	100	11.1
Not triggered	0	8	8	(2.5-100)	(63.1-100)	(2.5-100)	(63.1-100)	(0.3-48.2)
Total	1	8	9					
Surgery								
Triggered	3	1	4	42.9	99	75	96	6.7
Not triggered	4	97	101	(9.9-81.6)	(94.4-100)	(19.4-99.4)	(90.2-98.9)	(2.7-13.3)
Total	7	98	105					
Medicine								
Triggered	6	3	9	60	93.3	66.7	91.3	18.2
Not triggered	4	42	46	(26.2-87.8)	(81.7-98.6)	(29.9-92.5)	(79.2-97.6)	(9.1-30.9)
Total	10	45	55					
Obstetrics/gynaecology								
Triggered	2							
Not triggered								
Total								
Hospital B – Referral:								
Trauma/orthopaedics								
Triggered	1	6	7			14.3		
						(0.4-57.9)		
Surgery								
Triggered	37	59	96			38.5		
						(28.8-49.0)		
Medicine								
Triggered	65	86	151			43		
						(35.0-51.3)		
Obstetrics/gynaecology								
Triggered	1							
Hospital E – Follow-up: Trauma/orthopaedics								
Triggered	8	5	13	80	94	61.5	97.5	10.6
Not triggered	2	79	81	(44.4-97.5)	(86.7-98.0)	(31.6-86.1)	(91.4-99.7)	(5.2-18.7)
Total	10	84	94					
Surgery								
Triggered	62	59	121	68.9	94.1	51.2	97.1	8.3
Not triggered	28	933	961	(58.3-78.2)	(92.4-95.4)	(42.0-60.4)	(95.8-98.1)	(6.7-10.1)

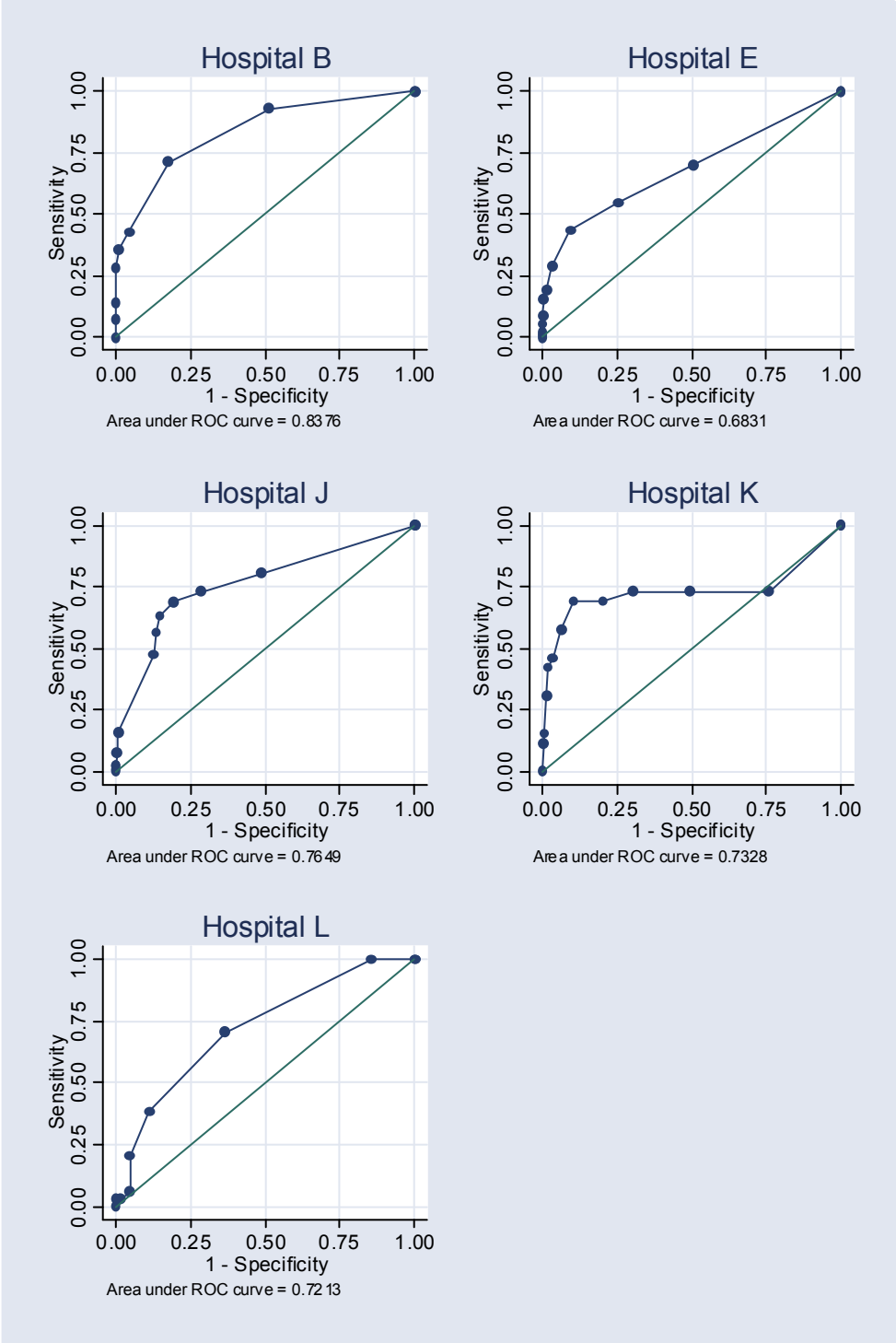
	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Total	90	992	1082					
Vascular surgery								
Triggered	12	27	39	70.6	94.7	30.8	99	3.3
Not triggered	5	478	483	(44.0-89.7)	(92.3-96.4)	(17.0-47.6)	(97.6-99.7)	(1.9-5.2)
Total	17	505	522					
Medicine								
Triggered	36	9	45	70.6	95.9	80	93.4	18.8
Not triggered	15	211	226	(56.2-82.5)	(92.4-98.1)	(65.4-90.4)	(89.3-96.2)	(14.3-24.0)
Total	51	220	271					
Obstetrics/gynaecology								
Triggered	3	2	5	75	95	60	97.4	9.1
Not triggered	1	38	39	(19.4-99.4)	(83.1-99.4)	(14.7-94.7)	(86.5-99.9)	(2.5-21.7)
Total	4	40	44					
Hospital E – Referral: Trauma/orthopaedics								
Triggered	149	61	210			71		
						(64.3-77.0)		
Surgery								
Triggered	198	50	248			79.8		
						(74.3-84.6)		
Vascular surgery								
Triggered	28	6	34			82.4		
						(65.5-93.2)		
Medicine								
Triggered	393	83	476			82.6		
						(78.8-85.9)		
Obstetrics/gynaecology								
Triggered	12	7	19			63.2		
						(38.4-83.7)		
Hospital H – Referral:								
Trauma/orthopaedics								
Triggered	34	9	43			79.1		
						(64.0-90.0)		
Surgery								
Triggered	280	89	369			75.9		
						(71.2-80.2)		
Vascular surgery								
Triggered	47	37	84			56		
						(44.7-66.8)		
Medicine								
Triggered	296	120	416			71.2		
						(66.5-75.5)		
Obstetrics/gynaecology								
Triggered	8	8	16			50		
						(24.7-75.3)		
Hospital J – Follow-up: Trauma/orthopaedics								
Triggered	2							

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Not triggered								
Surgery								
Triggered	12	0	12	13	100	100	90.4	10.8
Not triggered	80	757	837	(6.9-21.7)	(99.5-100)	(73.5-100)	(88.2-92.3)	(8.8-13.1)
Total	92	757	849					
Medicine								
Triggered	11	1	12	16.9	99.6	91.7	83.5	19.1
Not triggered	54	274	328	(8.8-28.3)	(98.0-100)	(61.5-99.8)	(79.1-87.4)	(15.1-23.7)
Total	65	275	340					
Neurosurgery								
Triggered	7	0	7	50	100	100	97.4	5
Not triggered	7	265	272	(23.0-77.0)	(98.6-100)	(59.0-100)	(94.8-99.0)	(2.8-8.3)
Total	14	265	279					
Obstetrics/gynaecology								
Triggered	4	13	17			23.5		
Not triggered						(6.8-49.9)		
Hospital J – Referral:								
Surgery								
Triggered	116	7	123			94.3		
						(88.6-97.7)		
Medicine								
Triggered								
	253	32	285			88.8		
Neurosurgery								
Triggered	1	2	3			33.3		
						(0.8-90.6)		
Obstetrics/gynaecology								
Triggered	2							
Hospital L – Follow-up:								
Surgery								
Triggered	25	27	52	100	22.9	48.1	100	41.7
Not triggered	0	8	8	(86.3-100)	(10.4-40.1)	(34.0-62.4)	(63.1-100)	(29.1-55.1)
Total	25	35	60					
Medicine								
Triggered	21	12	33	100	7.7	63.6	100	61.8
Not triggered	0	1	1	(83.9-100)	(0.2-36.0)	(45.1-79.6)	(2.5-100)	(43.6-77.8)
Total	21	13	34					
Obstetrics/gynaecology								
Triggered	2	1	3			66.7		
Not triggered						(9.4-99.2)		
Hospital L – Referral:								
Surgery								
Triggered	92	56	148			62.2		
						(53.8-70.0)		

	Composite outcome			Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value (95% CI)	Negative predictive value (95% CI)	Prevalence (95% CI)
	Yes	No	Total					
Medicine								
Triggered	58	21	79			73.4		
						(62.3-82.7)		
Obstetrics/gynaecology								
Triggered	8							
Hospital O – Follow-up:								
Trauma/orthopaedics								
Triggered	10	8	18	76.9	63.6	55.6	82.4	37.1
Not triggered	3	14	17	(46.2-95.0)	(40.7-82.8)	(30.8-78.5)	(56.6-96.2)	(21.5-55.1)
Total	13	22	35					
Surgery								
Triggered	25	20	45	89.3	56.5	55.6	89.7	37.8
Not triggered	3	26	29	(71.8-97.7)	(41.1-71.1)	(40.0-70.4)	(72.6-97.8)	(26.8-49.9)
Total	28	46	74					
Vascular surgery								
Triggered	6	5	11	66.7	58.3	54.5	70	42.9
Not triggered	3	7	10	(29.9-92.5)	(27.7-84.8)	(23.4-83.3)	(34.8-93.3)	(21.8-66.0)
Total	9	12	21					
Medicine								
Triggered	19	10	29	82.6	56.5	65.5	76.5	50
Not triggered	4	13	17	(61.2-95.0)	(34.5-76.8)	(45.7-82.1)	(50.1-93.2)	(34.9-65.1)
Total	23	23	46					
Hospital O – Referral:								
Trauma/orthopaedics								
Triggered	53	31	84			63.1		
						(51.9-73.4)		
Surgery								
Triggered	117	45	162			72.2		
						(64.7-79.0)		
Vascular surgery								
Triggered	27	11	38			71.1		
						(54.1-84.6)		
Medicine								
Triggered	92	21	113			81.4		
						(73.0-88.1)		

TT track & trigger warning score(s), CCOS critical care outreach service(s), DNAR do not attempt resuscitation, CPR cardiopulmonary resuscitation, Composite outcome is defined as a composite of multiple visits from CCOS, death, admission to critical care, DNAR placed or CPR. For patients with multiple outcomes, the first outcome to occur was used, if the date could be identified, otherwise outcomes were considered to have occurred in the order of multiple visits, CPR, DNAR placed, admission to critical care and death, CI confidence interval

Figure A3.4: Receiver operator characteristic (ROC) curves for critical care follow-up patients including multiple visits from CCOS as part of the composite outcome



CCOS critical care outreach service, DNAR do not attempt resuscitation, CPR cardiopulmonary resuscitation, Composite outcome is defined as a composite of multiple visits from CCOS, death, admission to critical care, DNAR placed or CPR. For patients with multiple outcomes, the first outcome to occur was used, if the date could be identified, otherwise outcomes were considered to have occurred in the order of multiple visits, CPR, DNAR placed, admission to critical care and death

Figure A3.5: Consent form

Short-title:
Are bedside observations taken in hospital reliable?

Summary:
We are asking you to participate in a study of measurements of blood pressure, heart rate, speed of breathing, level of alertness, temperature and the amount of urine passed. Participation in the study will not affect your treatment in any way.

Background:
Are we identifying sick patients in a reliable manner?

Deterioration of patients in hospital can be detected by sudden drop in blood pressure, a fast beating heart and fast breathing as well as a high fever and confusion. If these signs are recognised early doctors can intervene to find out why the patient is deteriorating and what treatment is needed.

What are you asking me to do?
We are not sure whether different health care professionals (doctors and nurses) will come to the same conclusions about the seriousness of illness of a patient while doing the same observations.

We are asking you therefore to help us:
We would like 2 doctors and 2 nurses check your blood pressure, pulse, temperature and the speed of your breathing. We will check whether they come to similar results or not. This will hopefully help us to design reliable ways to identify sick patients.

Will it alter my treatment?
Whether you agree to participate or not will not affect you treatment in any way. You will not benefit from the study in any way, but others may potentially do so in the future. You are free to change your mind at any time.

What happens to the results of the tests?
The results might help to improve the identification of sick patients in hospital. The results may appear in a scientific paper in a medical journal, but the results would be completely anonymous.

Who is sponsoring the study?
Charitable funds will pay for doing the study.

Thank you for reading this.

Figure A3.6: Data collection sheet

Study number ☐☐☐

Investigator ☐ 1 ☐ 2 ☐ 3 ☐ 4

Blood pressure	☐☐☐/☐☐☐	mmHg
Heart rate	☐☐☐	bpm
Respiratory rate	☐☐☐	per minute
Temperature	☐☐.☐	°C
Neuro 1	☐	Alert
	☐	Responding to Voice
	☐	Responding to Pain
	☐	Unresponsive
Neuro II	☐	Alert and orientated
	☐	Confused or agitated
	☐	Drowsy
	☐	Not rousable or only by nail pressure
Urine output	☐☐	ml/kg/min

EWS 1 ☐
EWS 2 ☐
EWS 3 ☐

Appendix 4

A systematic review of CCOS

Publication:

Esmonde L, McDonnell A, Ball C, Waskett C, Morgan R, Rashidian A, Bray K, Adam S, Harvey S. Investigating the effectiveness of critical care outreach services: a systematic review. Intensive Care Medicine 2006;32:1713-21.

Abstract

Objective

The impact of critical care outreach services (CCOS) on patient and service outcomes was explored to inform development of a typology for CCOS.

Design

Following a sample search of Medline, 15 relevant electronic databases were systematically searched from 1996 to 2004. Searches for publications from nine key authors and citations of eight key articles were performed. Hand-searches of journals, bibliographies of reports and review articles, and conference abstracts were conducted. Relevant experts were contacted. A further two studies published after the review date were also included. Two reviewers assessed studies for inclusion, conducted quality assessment and extracted data. Data was synthesised using narrative techniques.

Measurements and results

Seventeen papers and six brief reports were selected for inclusion from a list of 1760 titles. As anticipated with a relatively new service such as CCOS, there were few controlled trials. There were two randomised controlled trials, 16 uncontrolled before and after studies, three quasi-experimental studies, one controlled before and after study and one post-only controlled study. The most frequent outcomes measured were mortality, length of stay, cardiac arrest rates, unplanned admission rates to critical care and critical care readmission rates.

Conclusions

Although improvements in patient outcomes were found, the evidence in this review is insufficient to demonstrate this conclusively. The many differences in CCOS delivery do not permit identification of service typology. Our findings point to a need for more comprehensive research of this expanding service in a UK context.

Introduction

CCOS were introduced into the NHS in England as an important component of the vision for the future of critical care services, outlined in Comprehensive Critical Care in 2000[38]. These services aimed to avert or ensure timely admission to critical care, to enable discharges from critical care and to share skills with ward and community staff. Critical Care Networks and NHS Trust Critical Care Delivery groups were encouraged to develop their own locally customised service.

In the intervening years, a wide range of services falling under the umbrella of CCOS has been developed, introduced, incrementally implemented and improved over time[1].

CCOS may cover a range of activities undertaken for critically ill patients[26]:

- critical care education and training for general ward staff;
- physiological track and trigger warning systems in general wards;
- telephone 'hotline' advice for ward staff;
- post critical-care discharge follow-up;
- direct bedside clinical support on general wards;
- audit and evaluation of CCOS.

While the need for a new kind of service to intervene earlier in the management of acutely ill patients has been recognised internationally, outreach is likely to mean different things in different countries.
To date, research on the impact of CCOS, or the components that make up CCOS, on patient or service outcomes has been limited. This systematic review sought simultaneously: to explore the impact of the introduction of CCOS on patient and service outcomes and to inform the development of a typology for CCOS.

Methods

Search strategy and data sources
Given that CCOS are a recent development, it was anticipated that some of the relevant literature would not be as full publications in the peer-reviewed, scientific literature. The search strategy was designed to locate both published and unpublished work.

A broad search plan was developed using search terms that reflected the wide variation in terminology used to describe CCOS in an international context. All of the variant terms and synonyms were searched for as free text and, where they existed, relevant keywords were also used including inpatient, hospital, critical care, intensive care, emergency service hospital, patient care team, outreach team, patient emergency team, patient at risk team and medical emergency team.

Fifteen world-wide databases were searched from 1996 to 2004: MEDLINE, EMBASE, CINAHL, PsycINFO, HMIC (Health Management Information Consortium) National Research Register, Dissertation Abstracts, The Cochrane Database of Systematic Reviews, Cochrane Library Central Register of Controlled Trials, The Database of Abstracts of Reviews of Effectiveness (via Cochrane Library), NHS EED (via Cochrane Library), NHS HTA (via Cochrane Library), Citation indexes (Science and Social Sciences), OMNI, TRIP Database. Details of the search strategy for each database are available from the authors.

In addition, the study Steering Group identified nine, international, key authors researching CCOS and a search for papers by these authors on Medline and Web of Science was conducted. Citation searches were performed on Web of Science for eight articles identified as key publications by members of the study Steering Group[2,44,48,81,89-92]. Key journals (Anaesthesia, Critical Care Medicine, Intensive and Critical Care Nursing, Nursing in Critical Care,

Intensive Care Medicine) and conference abstracts from key conferences (British Association of Critical Care Nurses, RCN Critical Care Forum, Intensive Care Society, European Society of Intensive Care Medicine, Society of Critical Care Medicine and National Outreach Forum*)* were hand-searched from 1996 to 2004. Reference lists of key reports were also reviewed[1,38-41] as well as those of eleven review articles[91,93-102]. The National Health Service (NHS) Modernisation Agency website was searched for studies of CCOS and letters sent to the investigator with a request for further information/publications relating to the study. Finally, a list of studies identified for inclusion to date was circulated to experts (n=60) to ascertain completeness of study selection.

Subsequent to completion of the comprehensive searching (above), two papers, published after the 2004 cut-off, were also included in the review due to their relevance and importance.

Study selection and inclusion criteria
All citations were reviewed independently by two reviewers. Only studies in English of adults over 18 years were included. Interventions were the introduction of CCOS or any outreach activity delivered by critical care staff (as defined by the NHS Modernisation Agency and outlined above). Outcomes were any measures of patient health outcomes or professional performance. All study designs which used concurrent or historical controls were included.

Study quality assessment
All studies were assessed independently by two reviewers. The quality assessment instrument selected for use in this review was the tool developed by Thomas - designed to be used with both randomised and non-randomised studies[103]. The tool consists of eight discrete sections assessing selection bias, allocation bias, confounders, blinding, data collection methods, withdrawals and drop-outs, analysis and intervention integrity. Each dimension is rated as strong, moderate or weak.

Data extraction and synthesis
The data extraction form was based on one used in a systematic review of Acute Pain Teams and is available from the authors[104]. All data extraction was checked by a second reviewer.

Results

A total of 1760 discrete citations were identified. After screening by title and abstract, full paper copies were obtained for 110 citations. Of these, 21 studies were eligible for inclusion, of which 15 were published studies. For the remaining six studies, which were originally published in the form of conference abstracts, contact with study authors yielded further data in the form of brief reports or PowerPoint presentations.

The two further studies identified subsequent to the search closure date[50,105] were published papers, making a final total of 23 included studies.

Study design and quality
Of the 23 included studies (of which two reported findings on different aspects of the same original study[46,63]), there were two randomised controlled trials[43,50], three quasi-experimental studies[48,64,106], one controlled before and after study[107], one post-only controlled before and after study[49] and 16 uncontrolled before and after studies[36,43-45,63,65,81,92,108-114]. Overall, study quality was poor, with only nine studies scoring 'strong' on at least three out of six quality criteria. Studies were ranked according to how many strong, moderate and weak scores they were awarded (Table A4.1).

Details of included studies
Fourteen studies were set in England and one in Wales. Of the remaining studies, seven were set in Australia and one in the US. The hospital settings also varied between studies. Although exact classification is difficult due to lack of detail, it is clear that the studies vary in terms of hospital type and size, composition of the outreach team, nature of the service offered e.g. post-discharge follow-up only or all or several elements of outreach clinical intervention, as well as education and training of ward staff or use of track and trigger/early warning systems based on physiological observations. There was also wide variation in operational characteristics of the services, with some offering CCOS around the clock and others during daytime working hours only (Table A4.2).

Study size varied considerably and ranges from intervention groups of 15 patients to 180,000 patients. In 11 studies, the intervention was described as a 'critical care outreach service' and in one study as a 'patient at risk team'. In one, the intervention was the addition of a specialist tracheostomy service in addition to an established CCOS. All these 11 studies were set in English hospitals and, where details of the CCOS were provided, these were all multi-disciplinary including nursing and medical staff. They included both general and specialist nursing staff and different levels of medical staff. Three of these CCOS were nurse led, and one was led by a member of medical staff. Six studies, set in Australia, evaluated the impact of a medical emergency team (MET). These were also multidisciplinary teams.

Of the services which were evaluated, some appeared to focus on a particular element of CCOS e.g. post-critical care discharge follow-up[44,92], while others offered a service which did not appear to include post-discharge follow-up. Some services included many elements e.g. direct bedside clinical support, follow-up, education of ward staff and the introduction of an early warning/physiological track and trigger warning system based on routine physiological observations to detect deteriorating patients on the wards[111,112]. Of the 19 studies which evaluated the introduction of CCOS[43-46,48-50,63,64,81,92,105,107,109-114], 14 of these services included the use of an early warning/physiological track and trigger warning system[43-46,48-50,63,64,81,107,110-112].

It is also important to note that there is variation in terms of the timing of CCOS evaluation. Of the 19 studies which evaluated the introduction of CCOS, eight measured the impact immediately after

introduction[44,48,50,64,92,106,107,111]. In eight there was a 'run-in' period which ranged from 5 months[109] to 28 months[112] and for one study the service was evaluated during the first year and one year after implementation[109]. In two studies[81,107], the timing of evaluation was unclear. The most frequent outcomes measured were mortality (Table A4.3), length of stay (Table A4.4), cardiac arrest rates (Table A4.5), unplanned admission rates to critical care (Table A4.6) and critical care readmission rates (Table A4.7).

Summary of the impact of CCOS:

- on mortality

One RCT demonstrated that a CCOS significantly reduced hospital mortality across a variety of hospital wards in a single non-teaching hospital in England[43]. The highest quality non-randomised study also demonstrated reductions in hospital mortality – in patients discharged from the critical care unit (ICU) using CCOS which appeared to focus heavily on post-critical care unit (ICU) discharge follow-up[44]. Three studies [45,46,63] also found reduced mortality after the introduction of a MET service which responded to physiological/clinical instability rather than conducting routine visits. Findings from the MERIT study however, were equivocal[50] on composite incidence of unexpected deaths cardiac arrests and unplanned critical care unit (ICU) admissions and also on these outcomes measured individually.

Two studies[81,111] demonstrated reduced critical care mortality in critical care readmissions and unplanned admissions from wards covered by the CCOS, respectively. However, both these studies were uncontrolled before and after studies and scored relatively poorly in terms of quality.

- on length of stay

Hospital length of stay (LOS) was significantly reduced in a non-randomised study[63] and a quasi-experimental study[106]. However, in this latter study the intervention was simply the introduction of an EWS for patients admitted to a Medical Admissions Unit over a relatively short period of time, with little consideration of differences in case mix.

Reductions in critical care unit (ICU) LOS for patients' post-cardiac arrest were demonstrated by Bellomo et al[46]. Barnes et al (2003) also showed reduced critical care unit (ICU) LOS in emergency surgical admissions, although again, there is little information provided on differences in case mix[109].

- on cardiac arrest rates

Four studies demonstrated reductions in cardiac arrest rates[45,46,48,65] although the introduction of MET services in the MERIT study did not have a significant effect on cardiac arrest rates[50]. Two studies evaluated the introduction of a MET service that responded to physiological/clinical instability, with a time lag between before and after measurements[45,46]. A third evaluated the impact of calling criteria introduced in a US hospital with an existing MET[65]. All hospital patients were included in the study. In a much smaller study, the impact on

patients admitted to the critical care unit (ICU) was assessed but this study scored relatively poorly for quality[48].

- on unplanned admission rates to critical care
Although the MERIT study did not demonstrate any significant effect on unplanned admission to the critical care unit (ICU) [50], three studies demonstrated reductions in unplanned admissions to the critical care unit (ICU) from the wards[49,63,81]. Two were uncontrolled before and after studies[63,81]. One was a post-only controlled study, which was carried out in three Australian hospitals[49]. In this latter study, the MET service replaced the existing resuscitation service, but was introduced over a long period and was therefore a well-established service.

- on critical care readmission rates
Only two studies[44,81] demonstrated a significant reduction in readmission rates to critical care – one of which scored relatively poorly for study quality[81].

Robustness of the results
The inclusion of six unpublished studies had a negligible impact in terms of the review findings for the main outcomes studied. There were no significant differences for the outcomes mortality, cardiac arrest rates, unplanned critical care admission rates and critical care readmission rates in any of the unpublished studies. Two of the four studies which reported significant differences in LOS were unpublished. Exclusion of these studies would leave only two papers, reporting different aspects of the same study showing significant differences between control and intervention groups.

Discussion
The evidence presented by the primary studies in this review is weak, due to a number of important limitations in study design. There was insufficient robust research to assess the impact of CCOS on patient or service outcomes in a UK context. Only one study[43] that provided Level 1 evidence[115] demonstrated that CCOS activity had a significant positive impact on in-hospital mortality. In addition, two observational studies which scored highly in terms of study quality also demonstrated significant reductions in hospital mortality[44,45]. However, most studies were uncontrolled before and after studies and many were of poor methodological quality. The cluster RCT conducted by the MERIT team found no significant differences in either the primary or secondary outcome measures. However the cardiac arrest teams in control hospitals provided a service that was very similar to the MET service.

Studies which were poorly reported were penalised in terms of their quality scores and this review included six studies which were unpublished. The inclusion of these papers addresses a known publication bias since it has been shown that only half of conference abstracts go on to be published within two years[116]. However, there is a well reported tendency for the results of studies presented at conferences to be revised prior to publication[117]. Although these studies make an important contribution to the content of the review in qualitative terms, their inclusion makes no difference to conclusions made about the impact of CCOS activity on patient outcomes.

No clear typology of CCOS emerges from this review. Across all studies, there was wide variation in terms of service membership, type of CCOS activity and availability of the service. These variations in the delivery of a complex intervention in addition to variability in organisational characteristics of hospitals such as the existence of Do Not Attempt to Resuscitate policies and access to other services and variations in case mix at the patient level all contribute to the heterogeneity of the included studies.

There is also evidence that the aims of CCOSs vary across hospitals. Given this variation in CCOS and study settings, generalisability is difficult to assess and no assumptions should be made regarding the transferability of findings.

The timing of evaluation varies between studies. While having a run-in period may deliver a more realistic picture of the impact of a new service, when studies use a before and after design, a time lag between before and after measurements may result in bias, particularly in outcomes where secular trends are present e.g. LOS.

Implications of the review
Although there is insufficient robust evidence to confirm the effectiveness of CCOS activity on patient or service outcomes, neither has this review demonstrated that CCOS activity is ineffective. There is no basis for suggesting that CCOS should be discontinued or developments halted. Rather, there is a need for a comprehensive evaluation of this expanding service. Ideally, CCOS should be evaluated in a UK context through a cluster RCT. However, given that many hospitals already have some form of CCOS activity, this is not feasible.

Recommendations for further research
A number of recommendations for further research arise from this review:

- further robust research is needed to confirm the relationship between CCOS activity and patient outcomes;
- the relationship between CCOS and service outcomes such as the impact on the performance of ward staff in the management of critically ill patients also requires further investigation;
- the impact of different models of CCOS requires further investigation;
- research using robust designs is required to investigate whether the effects of CCOS are confined to patients who directly receive their service, or whether the impact of CCOS is felt throughout the hospital population;
- evaluations of CCOS should include some assessment of service costs, ideally in relation to patient outcomes in the form of cost-effectiveness studies;
- careful thought should be given to the most appropriate time to evaluate a new service (within the first months of operation, services may be atypical and outcomes may be improved in comparison to an established service or less favourable);

- the choice of outcomes should take into account the aims of the CCOS when first established;
- multi-centre studies are needed in order to explore the impact of CCOS in variety of hospital settings;
- study designs should take into account variations in case mix at patient level;
- study designs should allow for differences at provider level to be taken into account;
- when evaluating CCOS, researchers should consider the use of qualitative methods such as case studies and interviews to capture the experience of patients and staff, as well as the organisational issues associated with the delivery of effective services. Ideally these methods should be used alongside quantitative studies to provide multiple perspectives which may shed light on findings relating to changes in outcome.

Table A4.1: Study design and quality assessment of included studies

Included study	Study design	Selection bias	Allocation bias	Confounders	Blinding	Data collection methods	Withdrawals and dropouts	Strong	Moderate	Weak	N/A	Rank
Priestley G et al. (2004)[43]	RCT	Strong	Strong	Strong	Weak	Strong	Strong	5	0	1	0	1
Hillman K et al. (2005)[50]	RCT	Strong	Strong	Strong	Weak	Strong	Strong	5	0	1	0	1
Ball C et al. (2003)[44]	Uncontrolled before and after	Strong	Weak	Strong	Weak	Strong	Strong	4	0	2	0	3
Buist MD et al. (2002)[45]	Uncontrolled before and after	Strong	Weak	Strong	Weak	Strong	Strong	4	0	2	0	3
Bristow PJ et al. (2000)[49]	Post-only controlled	Strong	Weak	Moderate	Weak	Strong	Strong	3	1	2	0	5
Story DA et al. (2004)[108]	Uncontrolled before and after	Strong	Weak	Strong	Weak	Moderate	Strong	3	1	2	0	5
Subbe CP et al. (2003)[36]	Uncontrolled before and after	Strong	Weak	Strong	Weak	Moderate	Strong	3	1	2	0	5
DeVita MA et al. (2004)[65]	Uncontrolled before and after	Strong	Weak	Weak	Weak	Strong	Strong	3	0	3	0	8
Leary T, Ridley S (2003)[92]	Uncontrolled before and after	Strong	Weak	Weak	Weak	Strong	Strong	3	0	3	0	8
Salamonson Y et al. (2001)[64]	Quasi-experimental	Strong	Moderate	Weak	Weak	Moderate	Strong	2	2	2	0	8
Ingleby S (2002)[106]*	Quasi-experimental	Strong	Moderate	Weak	Weak	Moderate	Strong	2	2	2	0	8
Barnes RJ et al. (2003)[109]*	Uncontrolled before and after	Strong	Weak	Weak	Weak	Moderate	Strong	2	1	3	0	12
Bellomo R et al. (2004)[63]$	Uncontrolled before and after	Strong	Weak	Weak	Weak	Moderate	Strong	2	1	3	0	12

Included study	Study design	Selection bias	Allocation bias	Confounders	Blinding	Data collection methods	Withdrawals and dropouts	Strong	Moderate	Weak	N/A	Rank
Bellomo R et al. (2003)[46]$	Uncontrolled before and after	Strong	Weak	Weak	Weak	Moderate	Strong	2	1	3	0	12
Durham LD (2004)[110]*	Uncontrolled before and after	Strong	Weak	Weak	Weak	Moderate	Strong	2	1	3	0	12
Garcea G et al. (2004)[111]	Uncontrolled before and after	Strong	Weak	Weak	Weak	Moderate	Strong	2	1	3	0	12
Haji-Michael P et al. (2004)[107]*	Before and after	Strong	Weak	Weak	Weak	Moderate	Strong	2	1	3	0	12
Ricketts J, Cox D (2004)[112]*	Uncontrolled before and after	Strong	Weak	Weak	Weak	Moderate	Strong	2	1	3	0	12
Kenward G et al. (2004)[113]	Uncontrolled before and after	Strong	Weak	Weak	Weak	Moderate	Strong	2	1	3	0	12
Norwood MG et al. (2004)[105]	Before and after	Strong	Weak	Weak	Weak	Moderate	Strong	2	1	3	0	12
Mercer M (2004)[114]*	Uncontrolled before and after	Strong	Weak	Weak	Weak	Moderate	Strong	2	0	4	0	21
Pittard AJ (2003)[81]	Uncontrolled before and after	Moderate	Weak	Weak	Weak	Moderate	Strong	1	2	3	0	21
Goldhill DR et al. (1999)[48]	Quasi-experimental	Moderate	Moderate	Moderate	Weak	Moderate	N/A	0	4	1	1	22

N/A not available, RCT randomised controlled trial, * unpublished study, $ reports different aspects of same study

Table A4.2: Details of included studies

Included study	Available details of CCOS and intervention	Available details of setting	Number of patients (C=control, I=intervention)
Priestley G et al. (2004)[43]	CCOS: Led by nurse consultant with team of "experienced nurses" providing 24-hour cover. Critical care medical support available, when required. **Intervention:** CCOS including direct bedside clinical support, education of ward staff and use of PAR score.	England General teaching hospital Beds: 800	C=1,428 I=1,475
Hillman K et al. 2005)[50]	Composition of MET varied between participating centres. At least one doctor and a nurse from the emergency department or critical care unit (ICU). **Intervention:** MET including direct bedside support and single parameter warning system.	Australia 23 public hospitals with critical care unit (ICU) and >20,000 admissions per year	C=11 hospitals I=12 hospitals
Ball C et al. (2003)[44]	CCOS: Five senior critical care nurses led by consultant nurse. 12 hours a day. **Intervention:** CCOS including post-critical care discharge follow-up and use of a single parameter warning system.	England Tertiary referral hospital Beds: 1200	C=201 I=269
Buist MD et al. (2002)[45]	CCOS: Two doctors and one senior critical care unit (ICU) nurse. **Intervention:** MET including direct bedside support, education of ward staff and single parameter warning system.	Australia Metropolitan teaching hospital Beds: 20,000 (5-600 critical care unit (ICU) admissions per year)	C=19,317 I=22,847
Bristow PJ et al. (2000)[49]	CCOS: critical care unit (ICU) registrar, senior nurse and medical registrar in intervention hospital replacing existing arrest team. Compared to control hospitals where arrest team consisted of critical care unit (ICU) registrar, medical registrar and critical care unit (ICU) or coronary care nurse. No information on availability. **Intervention:** MET including direct bedside support and single parameter warning system.	Australia Three public hospitals Beds: 380-530	C 1 (arrest team)=13,059 C 2 (arrest team)=19,545 I (MET)=18,338
Story DA et al. (2004)[108]	CCOS: Critical care nurse in addition to existing MET. Monday-Friday only. **Intervention:** CCOS in addition to existing MET. Included follow-up of all high risk, post-operative patients for the first three days after transfer to general wards from theatre/recovery or from critical care unit (ICU) and staff education.	Australia Large teaching hospital	C=319 I=345
Subbe CP et al. (2003)[36]	CCOS: Introduction of MEWS. **Intervention:** MEWS in Medical Admissions Unit.	Wales District general hospital	C=659 I=1,695
DeVita MA et al. (2004)[65]	CCOS: Eight staff led by critical care unit (ICU) physician including two critical care unit (ICU) nurses, floor nurse, anaesthesia or critical care member, respiratory care member and two physicians. **Intervention:** Introduction of criteria for MET activation increasing MET activity. MET activity included direct bedside support and a single parameter warning system.	US Tertiary teaching hospital Beds: 622 licensed	C=143,776 I=55,248

Included study	Available details of CCOS and intervention	Available details of setting	Number of patients (C=control, I=intervention)
Leary T, Ridley S (2003)[92]	CCOS: "Normal working hours". **Intervention:** CCOS including follow-up of patients discharged from critical care unit (ICU).	England University hospital Trust Beds: 1000, 8 critical care unit (ICU), 6 HDU	C (critical care unit (ICU))=500 C (HDU)=791 I (critical care unit (ICU))=530 I (HDU)=825
Salamonson Y et al. (2001)[64]	CCOS: Intensive care registrar leading team with intensive care/coronary care unit nurse, medical registrar from emergency department and two non-clinical staff. 24-hour. **Intervention:** MET including direct bedside support and single parameter warning system.	Australia Non-teaching hospital Beds: 200, 8 critical care unit (ICU)/CCU	C (Year 1)=58 I (Year 1)=24 C (Year 2)=46 I (Year 2)=34 C (Year 3)=36 I (Year 3)=42
Ingleby S (2002)[106]*	CCOS: Introduction of EWS. **Intervention:** EWS in Medical Admissions Unit.	England Tertiary referral hospital	C=107 I=235
Barnes RJ et al. (2003)[109]*	CCOS: Two senior nurses and nurse consultant, Monday-Friday, 8am-4pm. Out-of-hours cover by the critical care unit (ICU) senior nurse and doctors. **Intervention:** CCOS including direct bedside clinical support and use of modified MEWS scoring system.	England Acute hospital	C=46 I=52
Bellomo R et al. (2004)[63]$	CCOS: Duty intensive care fellow, intensive care nurse and, if available, receiving medical fellow encouraged to attend. Critical care unit (ICU) specialist available from 8am-8pm and, after-hours, would attend within 15-30 minutes, if required. **Intervention:** MET including direct bedside support and single parameter warning system.	Australia Tertiary referral teaching hospital Beds: 400, 21 critical care unit (ICU)	C=1,116 with 1,369 operations I=1,067 with 1,313 operations
Bellomo R et al. (2003)[46]$	CCOS: Duty intensive care fellow, intensive care nurse and, if available, receiving medical fellow encouraged to attend. Critical care unit (ICU) specialist available from 8am-8pm and, after-hours, would attend within 15-30 minutes, if required. **Intervention:** MET including direct bedside support and single parameter warning system.	Australia Tertiary referral teaching hospital Beds: 400, 21 critical care unit (ICU)	C=21,090 I=20,921

Included study	Available details of CCOS and intervention	Available details of setting	Number of patients (C=control, I=intervention)
Durham LD (2004)[110*]	CCOS: Nurse-led, 24 hours, 7 days. **Intervention:** CCOS including education of ward staff, EWS/track and trigger system.	England District general hospital Beds: 850, 8 level 3, 10 level 2	2001: C (medical)=13,602 C (surgical)=9,195 C (elderly)=6,820 2002: I (medical)=15,510 I (surgical)=11,283 I (elderly)=9,888 2003: I (medical)=12,761 I (surgical)=9,919 I (elderly)=9,000
Garcea G et al. (2004)[111]	CCOS: Two senior grade nurses and a consultant nurse specialist with consultant intensivist acting as lead clinician. **Intervention:** CCOS including direct bedside clinical support, education of ward staff, follow-up all discharges from the critical care unit (ICU) and HDU on a daily basis, use of EWS/track and trigger system.	England Teaching hospital	C=547 I=833
Haji-Michael P et al. (2004)[107*]	CCOS: Critical care consultant sessions and a senior critical care nurse. **Intervention:** CCOS including post-critical care unit (ICU) follow-up, direct bedside clinical support, education of ward staff, use of MEWS.	England Oncology hospital Surgical HDU, no critical care unit (ICU)	C (adult leukaemia)=12 I (adult leukaemia)=15 C (general oncology)=10 I (general oncology)=10
Ricketts J, Cox D (2004)[112*]	CCOS: Four senior intensive care nurses, consultant anaesthetist. 7-days from 7am to 3pm. **Intervention:** CCOS including post-critical care unit (ICU) follow-up, direct bedside clinical support, education of ward staff, use of MEWS.	England District general hospital Beds: 400, 9 critical care unit (ICU)	Unclear
Kenward G et al. (2004)[113]	CCOS: 24-hour, 7-days. **Intervention:** CCOS including clinical bedside support.	England District general hospital Beds: 700, 6 critical care unit (ICU), 5 HDU, 4 CCU	Not stated

Included study	Available details of CCOS and intervention	Available details of setting	Number of patients (C=control, I=intervention)
Norwood MG et al. (2004)[105]	CCOS: Team of respiratory physiologist and critical care unit (ICU) sister. Out-of-hours support provided by critical care medical team. **Intervention:** A tracheostomy service including post-critical care unit (ICU) follow-up, education of ward staff.	England Teaching hospital Beds: 8 critical care unit (ICU), 4 HDU, 4 Level 1, 83 acute surgical, 175 acute medical	C=51 I=119
Mercer M (2004)[114]	CCOS: No details given. **Intervention:** CCOS.	England	C=2,843 I=2,742
Pittard AJ (2003)[81]	CCOS: Team of senior critical care nurses and medical staff. Available Monday-Friday, 9am-5pm. **Intervention:** CCOS including direct bedside clinical support, post-critical care follow-up and use of a modification of the MEWS.	England Acute hospital	C=328 I=297
Goldhill DR et al. (1999)[48]	CCOS: Critical care unit (ICU) consultant or deputy, senior critical care unit (ICU) nurse and duty medical or surgical registrar. **Intervention:** PART including direct clinical support and use of multiple parameter warning system.	England Acute hospital described as “not typical” with higher than usual number of emergency, trauma and seriously ill patients	C=28 I=69

CCOS critical care outreach service(s), PAR patient at risk, MET medical emergency team, ICU intensive care unit, MEWS modified early warning score, HDU high dependency unit, CCU coronary care unit, * unpublished study, EWS early warning score, $ report different aspects of same study, PART patient at risk team

Table A4.3: Summary of evidence for impact on mortality

Studies showing a statistically significant effect		Summary of findings as reported (C=control, I=intervention)
Priestley G et al. (2004)[43]	Hospital mortality	Reduction in hospital mortality at patient level - odds ratio (95% CI) 0.56 (0.38-0.82) and cluster level 0.52 (0.32-0.85)
Ball C et al. (2003)[44]	Hospital mortality post-critical care unit (ICU) discharge	Improved survival to hospital discharge after discharge from critical care unit (ICU) C 161/201 (81%), I 235/269 (87%); risk ratio – 1.08 (95% CI 1.00-1.18)
Buist MD et al. (2002)[45]	Hospital mortality and cardiac arrest mortality	Reduced hospital deaths n (rate/1000) C 380 (19.7), I 393 (17.2) p<0.001 Reduced cardiac arrests n (rate/1000) C 73 (3.8), I 47 (2.1) p<0.001) Reduced cardiac arrest deaths n (rate/1000) C 56 (76.7), I 26 (55.3) p<0.001
Bellomo R et al. (2003)[46]	Hospital mortality and cardiac arrest mortality	Reduction in hospital deaths related to cardiac arrest C 37, I 16 - relative risk reduction (95% CI) 0.43 (0.26-0.70) Reduction in hospital deaths C 302, I 222 – relative risk reduction 0.74 (0.74-0.79)
Bellomo R et al. (2004)[63]	Hospital mortality	Incidence of in-hospital deaths C 73, I 45 - relative risk reduction 36.6%, p=0.0178
Garcea G et al. (2004)[111]	Critical care readmission mortality	Reduced critical care mortality in readmissions C 36.7%, I 22.8% (95% CI) -2.4-30.3
Pittard AJ (2003)[81]	Critical care unit (ICU) mortality for unplanned admissions from pilot wards	Reduction in critical care unit (ICU) mortality for unplanned admissions from pilot wards C 28.6%, I 23.5% (p=0.05)
Norwood MG et al. (2004)[105]	Critical care unit (ICU) mortality	Reduction in critical care unit (ICU) deaths with tracheostomy tube in situ C 43% (n=22), I 16% (n=19)
Studies <u>not</u> showing a statistically significant effect		Summary of findings as reported (C=control, I=intervention)
Hillman K et al. 2005)[50]	Primary outcome: composite incidence of unexpected death, cardiac arrest and unplanned critical care unit (ICU) admission. Secondary outcomes: cardiac arrest, unplanned critical care unit (ICU) admission, unexpected death	Composite incidence of unexpected deaths, cardiac arrests and unplanned critical care unit (ICU) admissions per 1000 admissions C 5.86, I 5.31- adjusted p=0.64, adjusted odds ratio (95%CI) 0.98 (0.83-0.16) Cardiac arrest per 1000 admissions C 1.64, I 1.31 - adjusted p=0.736, adjusted odds ratio (95% CI) 0.94 (0.79-1.13) Unplanned critical care unit (ICU) admission per 1000 admissions C 4.68, I 4.19 - adjusted p=0.599, adjusted odds ratio (95% CI) 1.04 (0.89-1.21) Unexpected death per 1000 admissions C 1.18, I 1.06 - adjusted p=0.752, adjusted odds ratio (95% CI) 1.03 (0.84-1.28)

Studies not showing a statistically significant effect		Summary of findings as reported (C=control, I=intervention)
Bristow PJ et al. (2000)[49]	Hospital mortality and non-DNAR mortality	Mortality n (rate/1,000) I 243 (133) adjusted odds ratio=1, C1 240 (184) adjusted odds ratio (95%)=1.08 (0.89-1.30), C2 295 (151) adjusted odds ratio (95% CI)=0.83 (0.70-1.00) Non-DNAR death n (rate/1,000) I 55 (30) adjusted odds ratio=1, C1 86 (66) adjusted odds ratio (95% CI)=1.68 (1.19-2.36), C2 88 (45) adjusted odds ratio (95% CI)=0.94 (0.67-1.33)
Story DA et al. (2004)[108]	30-day mortality	30-day mortality (per 100 patients) C 29 (9.1), I 24 (7.0)
Subbe CP et al. (2003)[36]	Hospital mortality and critical care unit (ICU) mortality	Hospital mortality n (%) C 53 (8%), I 166 (9.7%), critical care unit (ICU) mortality C 67%, I 33%
DeVita MA et al. (2004)[65]	Cardiac arrest mortality	Proportion of deaths on day of cardiac arrest C 3.3%, I 33.3% Proportion of in-hospital deaths post cardiac arrest C 55.2%, I 58%
Leary T, Ridley S (2003)[92]	Mortality in critical care readmissions	Re-admitted patient in critical care death C 6 (12.2%), I 10 (19.6%)
Salamonson Y et al. (2001)[64]	Hospital mortality	Hospital survival Year 1 C=44 (76%), I=17 (71%), Year 2 C=35 (79%), I=27 (79%), Year 3 C=26 (72%), I=31 (74%)
Ingleby S (2002)[106]	Hospital mortality and mortality in DNARs	Mortality C 10%, I 11% Mortality in DNARs C 73.7%, I 46.2%
Barnes RJ et al. (2003)[109]	Critical care unit (ICU) mortality, post-critical care unit (ICU) discharge and hospital mortality	Critical care unit (ICU) mortality C 14 (30%), I 20 (38%) Deaths after discharge from critical care unit (ICU) C 6 (13%), I 5 (10%) Hospital mortality C 26 (57%), I 27 (52%)
Haji-Michael P et al. (2004)[107]	Hospital mortality	Hospital mortality – adult leukaemia C 75%, I 40%, general oncology C 60%, I 50% Mean risk of hospital death – adult leukaemia C 56%, I 50%, general oncology C 33%, I 45%
Ricketts J, Cox D (2004)[112]	Critical care unit (ICU) mortality	Critical care unit (ICU) mortality rate C=27%, I=13%
Kenward G et al. (2004)[113]	Hospital mortality	Deaths per 1000 admissions C 20 (2%), I 19.7 (1.97%)
Mercer M (2004)[114]	Hospital mortality	Number of deaths/month (as % of total admissions) in hospital C 83.7(2.94), I 94.8 (3.5) Number of deaths/month (as % of total admissions) in outreach wards C 18.8 (3.1), I 19.3 (3.1)
Goldhill DR et al. (1999)[48]	Critical care unit (ICU) mortality in unplanned admissions from wards	Number (%) who died in the critical care unit (ICU) C 31 (44.9), I 7 (25%)

ICU intensive care unit, DNAR do not attempt resuscitation

Table A4.4: Summary of evidence for impact on length of stay

Studies showing a statistically significant effect		Summary of findings as reported (C=control, I=intervention)
Bellomo R et al. (2003)[46]	Critical care unit (ICU) LOS post- cardiac arrest	Reduction in critical care unit (ICU) bed days post-cardiac arrest C 163, I 33 – relative risk reduction (95% CI) 0.20 (0.13 to 0.33) Reduction in hospital bed days post-cardiac arrest C 1353, I 159 – relative risk reduction (95% CI) 0.11 (0.09 to 0.13)
Bellomo R et al. (2004)[63]	Hospital LOS	Reduction in mean hospital stay C 23.8 +/- 56.5 days, I 18.9 +/- 35.3 days (p=.0092)
Ingleby S (2002)[106]	Hospital LOS	Reduction in median (mean) hospital LOS C 8 days (12.3), I 6 days (10.5) (p<0.01)
Barnes RJ et al. (2003)[109]	Critical care unit (ICU) LOS	Increased median critical care unit (ICU) LOS C 2.5 days, I 6.4 days p=0.004
Studies not showing a statistically significant effect		Summary of findings as reported (C=control, I=intervention)
Priestley G et al. (2004)[43]	Hospital LOS	Findings on LOS equivocal
Subbe CP et al. (2003)[36]	Critical care unit (ICU) LOS	Median (IQR) LOS in critical care unit (ICU) C 4 days (1-8), I 2 days (1-30)
Leary T, Ridley S (2003)[92]	Critical care unit (ICU) LOS and days to critical care unit (ICU) readmission	Median (IQR) critical care unit (ICU) LOS (first admission) C 1.68 days (0.96-3.18), I 1.80 days (0.96-4.03) Median (IQR) days to critical care unit (ICU) readmission C 2.93 days (1.32-6.05), I 2.25 days (1.06-6.32) Median (IQR) critical care unit (ICU) LOS (second admission) C 2.68 days (0.94-5.79), I 2.02 days (0.91-6.32)
Haji-Michael P et al. (2004)[107]	Critical care unit (ICU) LOS	Median (IQR) critical care unit (ICU) LOS – adult leukaemia C 4.0 (5.7), I 3.0 (7.9) – general oncology C 2.5 (1.7), I 4.2 (7.9)
Ricketts J, Cox D (2004)[112]	Critical care unit (ICU) LOS	Critical care unit (ICU) LOS C <7% exceeding 21 days, I 4.5% exceeding 21 days
Pittard AJ (2003)[81]	Critical care unit (ICU) LOS	Mean critical care unit (ICU) LOS for all admissions C 3.4 days, I 3.7 days Mean critical care unit (ICU) LOS for unplanned admissions from pilot wards C 7.4 days, I 4.8 days
Goldhill DR et al. (1999)[48]	Hospital LOS and critical care unit (ICU) LOS	Median (IQR) hospital LOS C 6 days (1-16), I 5.5 days (1-17.5) Median (IQR) critical care unit (ICU) LOS C 2 (1-6), I 5.5 (1-9.25)

ICU intensive care unit, LOS length of stay, IQR interquartile range

Table A4.5: Summary of evidence for impact on cardiac arrest

Studies showing a statistically significant effect	Summary of findings as reported (C=control, I=intervention)
Buist MD et al. (2002)[45]	Reduced number of cardiac arrests n (rate/1000) C 73 (3.77), I 47 (2.05) p<0.001
DeVita MA et al. (2004)[65]	Reduced mean monthly incidence of cardiopulmonary arrest per 1000 admissions C 6.5, I 5.4, p=0.016
Bellomo R et al. (2003)[46]	Reduction in cardiac arrests C 63, I 22 relative risk reduction (95% CI) 0.35 (0.22-0.57)
Goldhill DR et al. (1999)[48]	Reduction in number (%) having CPR before critical care unit (ICU) admission C 21 (30.4), I 1 (3.6%), p< 0.005
Durham LD (2004)[110]	Number of cardiac arrests n (% total admissions) 2001 C medical wards 110 (0.81), C surgical wards 29 (0.32), C elderly wards 160 (2.35) 2002 (during) I elderly wards 173 (1.75) p=0.008 2003 (after) I medical wards 76 (0.60) p=0.038, I elderly wards 135 (1.5) p <0.001
Studies <u>not</u> showing a statistically significant effect	Summary of findings as reported (C=control, I=intervention)
Hillman K et al. 2005)[50]	Cardiac arrest rates per 1000 admissions C=1.64, I=1.31, adjusted p=0.736, adjusted odds ratio (95% CI) 0.94 (0.79-1.13)
Bristow PJ et al (2000)[49]	Cardiac arrest n (rate/1000) I 69 (38) adjusted odds ratio=1, C1 66 (51) adjusted odds ratio (95% CI) 1.14 (0.81-1.61), C2 99 (51) adjusted odds ratio (95% CI) 1.00 (0.73-1.37)
Subbe CP et al. (2003)[36]	Cardiopulmonary arrests C 4 (0.6%), I 40 (2.3%)
Ingleby S (2002)[106]	Cardiac arrests C 9%, I 10%
Durham LD (2004)[110]	Number of cardiac arrests n (% total admissions) 2001 C medical wards 110 (0.81), C surgical wards 29 (0.32), C elderly wards 160 (2.35) 2002 (during) I medical wards 113 (0.73), I surgical wards 36 (0.32) 2003 (after) I surgical wards 22 (0.22)
Ricketts J, Cox D (2004)[112]	Cardiac arrest calls - numbers unclear
Kenward G et al. (2004)[113]	Unexpected cardiac arrest rate per 1000 admissions C 2.6%, I 2.4%
Mercer M (2004)[114]	Cardiac arrests/month in hospital C 28, I 22.3 Cardiac arrests/month in outreach wards C 8.6, I 6.6

CPR cardiopulmonary resuscitation, ICU intensive care unit

Table A4.6: Summary of evidence for impact on unplanned admissions to critical care

Studies showing a statistically significant effect	Summary of findings as reported (C=control, I=intervention)
Bristow PJ et al. (2000)[49]	Reduction in unanticipated critical care unit (ICU/HDU) admission n (rate/1,000) I 18 (64) adjusted odds ratio=1, C1 146 (112) adjusted odds ratio (95% CI) 1.59 (1.24-2.04), C2 234 (120) adjusted odds ratio (95% CI)=1.73 (1.37-2.16)
Bellomo R et al. (2004)[63]	Reduced unplanned critical care unit (ICU) admissions C 89, I 48, relative risk reduction 44.4%, p=0.001
Pittard AJ (2003)[81]	Reduction in unplanned critical care unit (ICU) admission rate from pilot wards only C 58%, I 43%, p=0.05
Studies not showing a statistically significant effect	Summary of findings as reported (C=control, I=intervention)
Hillman K et al. 2005)[50]	Unplanned critical care unit (ICU) admission per 1000 admissions C 4.68, I 4.19, adjusted p=0.599, adjusted odds ratio (95% CI) 1.04 (0.89-1.21)
Buist MD et al. (2002)[45]	Number of unplanned admissions to the critical care unit (ICU) n (rate/1000) C 45 (2.3) - of these 15 (33.3%) died, I 78 (3.4) - of these 23 (29.5%) died
Subbe CP et al. (2003)[36]	Number admitted to the critical care unit (ICU/HDU) C 6 (0.9%), I critical care unit (ICU) 9 (0.5%), HDU 79 (4.6%)
Haji-Michael P et al. (2004)[107]	Number of critical care unit (ICU) admissions - adult leukaemia C 12, I 15 - general oncology C 10, I 10
Mercer M (2004)[114]	Number (%) unplanned CCU admissions C 218 (87%) 36.3/month, I 572 (88%) 47.6/month Number (%) unplanned CCU admissions from outreach wards C 55 (90%) 9.2/month, I 143 (97%) 11.9/month

ICU intensive care unit, HDU high dependency unit, CCU coronary care unit

Table A4.7: Summary of evidence for impact on readmissions to critical care

Studies showing a statistically significant effect	Summary of findings as reported (C=control, I=intervention)
Ball C et al. (2003)[44]	Reduced critical care unit (ICU) readmission rate C 25/201 (12%), I 16/269 (6%), risk ratio (95% CI) 0.48 (0.26-0.87)
Pittard AJ (2003)[81]	Reduction in number of patients readmitted to the critical care unit (ICU) all admissions C=15 (5.1%), I 11 (3.3%), p=0.05
Studies not showing a statistically significant effect	Summary of findings as reported (C=control, I=intervention)
Leary T, Ridley S (2003)[92]	Readmission to critical care C 49/1291, I 51/1355
Bellomo R et al. (2004)[63]	Critical care unit (ICU) readmission C 2.9% (33), I 1.8% (20)
Garcea G et al. (2004)[111]	Readmission rate to critical care C 9.0%, I 9.5%
Ricketts J, Cox D (2004)[112]	Readmission rate C=7%, I=6%

ICU intensive care unit

Appendix 5

Additional results for quantitative evaluation of CCOS

Table A5.1: Effects of formal CCOS on outcomes

Primary exposure variable	Effect estimate (95% CI) compared with no CCOS	P-value
Model1a: Admissions from ward	Odds ratio	0.687a
CCOS month 1	1.03 (0.89, 1.19)	0.682
CCOS month 2	0.97 (0.83, 1.12)	0.641
CCOS month 3 and following	0.94 (0.84, 1.06)	0.316
Model2a: CPR 24 hours prior to admission	Odds ratio	0.049a
CCOS month 1	0.95 (0.67, 1.35)	0.787
CCOS month 2	0.75 (0.51, 1.10)	0.142
CCOS month 3 and following	0.84 (0.73, 0.96)	0.012
Model2b: Admission out-of-hours	Odds ratio	0.039a
CCOS month 1	1.00 (0.81, 1.24)	0.996
CCOS month 2	0.95 (0.81, 1.12)	0.534
CCOS month 3 and following	0.91 (0.84, 0.97)	0.005
Model2c: ICNARC physiology score	Change in mean	0.049a
CCOS month 1	−1.15 (−2.57, 0.26)	0.109
CCOS month 2	−1.35 (−3.04, 0.34)	0.118
CCOS month 3 and following	−1.22 (−2.12, −0.31)	0.008
Model2c: ICNARC physiology score	Change in SD	0.870a
CCOS month 1	0.023 (−0.056, 0.102)	0.568
CCOS month 2	0.001 (−0.130, 0.132)	0.988
CCOS month 3 and following	−0.010 (−0.050, 0.030)	0.638
Model2d: All active treatment withdrawn	Odds ratio	0.739a
CCOS month 1	1.12 (0.84, 1.48)	0.440
CCOS month 2	0.91 (0.68, 1.21)	0.510
CCOS month 3 and following	1.00 (0.82, 1.21)	0.992
Model2e: Unit mortality	Odds ratio	0.757a
CCOS month 1	1.00 (0.81, 1.24)	0.993
CCOS month 2	1.06 (0.89, 1.25)	0.537
CCOS month 3 and following	0.97 (0.87, 1.08)	0.628
Model3a: Discharge out-of-hours	Odds ratio	0.003a
CCOS month 1	1.57 (1.19, 2.07)	0.001
CCOS month 2	1.01 (0.69, 1.46)	0.977
CCOS month 3 and following	1.08 (0.89, 1.31)	0.453
Model3b: Early discharge due to shortage of beds	Odds ratio	0.310a
CCOS month 1	1.30 (0.84, 2.01)	0.242
CCOS month 2	1.08 (0.72, 1.61)	0.708
CCOS month 3 and following	0.86 (0.64, 1.15)	0.304
Model3c: Readmission within 48 hours	Odds ratio	0.944a
CCOS month 1	1.09 (0.73, 1.64)	0.676
CCOS month 2	1.02 (0.64, 1.62)	0.932
CCOS month 3 and following	1.03 (0.90, 1.19)	0.649
Model3d: Hospital mortality	Odds ratio	0.069a
CCOS month 1	1.28 (1.05, 1.57)	0.016
CCOS month 2	0.94 (0.76, 1.17)	0.578
CCOS month 3 and following	1.05 (0.96, 1.15)	0.277

CCOS critical care outreach service(s), CI confidence interval, a P-value for overall effect of CCOS, CPR cardiopulmonary resuscitation, ICNARC Intensive Care National Audit & Research Centre, SD standard deviation

Table A5.2: Effects of CCOS activities on outcomes

Secondary exposure variable	Effect estimate (95% CI) compared with no CCOS	P-value
Model1a: Admissions from ward	Odds ratio	0.603a
Ward follow-up	0.89 (0.75, 1.06)	0.190
Outpatient follow-up	1.12 (0.99, 1.28)	0.073
Telephone advice	1.01 (0.87, 1.18)	0.859
Direct bedside clinical support	0.97 (0.75, 1.25)	0.815
Informal bedside teaching	1.07 (0.84, 1.37)	0.563
Formal educational courses	0.96 (0.86, 1.07)	0.466
Use of early warning/track & trigger	1.07 (0.93, 1.22)	0.338
Audit and evaluation of CCOS activity	1.04 (0.89, 1.21)	0.599
Model2a: CPR 24 hours prior to admission	Odds ratio	0.111a
Ward follow-up	1.24 (0.97, 1.57)	0.081
Outpatient follow-up	1.00 (0.85, 1.19)	0.977
Telephone advice	0.99 (0.85, 1.15)	0.911
Direct bedside clinical support	0.90 (0.67, 1.21)	0.500
Informal bedside teaching	1.00 (0.65, 1.54)	0.994
Formal educational courses	0.89 (0.73, 1.07)	0.205
Use of early warning/track & trigger	0.84 (0.72, 0.98)	0.029
Audit and evaluation of CCOS activity	0.92 (0.76, 1.10)	0.346
Model2b: Admission out-of-hours	Odds ratio	0.152a
Ward follow-up	0.97 (0.89, 1.07)	0.586
Outpatient follow-up	0.99 (0.92, 1.06)	0.734
Telephone advice	1.08 (1.01, 1.15)	0.017
Direct bedside clinical support	0.97 (0.88, 1.07)	0.565
Informal bedside teaching	1.05 (0.96, 1.15)	0.268
Formal educational courses	0.97 (0.90, 1.04)	0.363
Use of early warning/track & trigger	1.01 (0.93, 1.10)	0.746
Audit and evaluation of CCOS activity	0.92 (0.82, 1.02)	0.096
Model2c: ICNARC physiology score	Change in mean	0.402a
Ward follow-up	0.99 (−0.57, 2.55)	0.213
Outpatient follow-up	0.33 (−0.67, 1.33)	0.518
Telephone advice	−0.13 (−1.04, 0.77)	0.772
Direct bedside clinical support	−1.00 (−3.29, 1.28)	0.387
Informal bedside teaching	0.20 (−2.08, 2.48)	0.863
Formal educational courses	0.10 (−0.96, 1.16)	0.854
Use of early warning/track & trigger	−0.83 (−1.91, 0.25)	0.130
Audit and evaluation of CCOS activity	−0.13 (−1.28, 1.02)	0.824
Model2c: ICNARC physiology score	Change in SD	0.098a
Ward follow-up	−0.042 (−0.093, 0.010)	0.111
Outpatient follow-up	−0.011 (−0.044, 0.023)	0.536
Telephone advice	0.014 (−0.021, 0.048)	0.442
Direct bedside clinical support	0.017 (−0.030, 0.063)	0.487
Informal bedside teaching	0.037 (−0.022, 0.095)	0.220
Formal educational courses	0.022 (−0.016, 0.059)	0.261
Use of early warning/track & trigger	−0.058 (−0.103, −0.014)	0.010
Audit and evaluation of CCOS activity	0.011 (−0.049, 0.071)	0.716
Model2d: All active treatment withdrawn	Odds ratio	0.006a
Ward follow-up	1.04 (0.83, 1.31)	0.740
Outpatient follow-up	1.27 (1.09, 1.47)	0.002
Telephone advice	0.80 (0.67, 0.97)	0.021
Direct bedside clinical support	1.03 (0.79, 1.35)	0.815
Informal bedside teaching	0.92 (0.65, 1.31)	0.653
Formal educational courses	1.15 (0.93, 1.41)	0.201

Secondary exposure variable	Effect estimate (95% CI) compared with no CCOS	P-value
Use of early warning/track & trigger	0.86 (0.67, 1.11)	0.249
Audit and evaluation of CCOS activity	1.15 (0.89, 1.47)	0.281
Model2e: Unit mortality	Odds ratio	0.655a
Ward follow-up	1.01 (0.89, 1.16)	0.838
Outpatient follow-up	0.92 (0.83, 1.01)	0.087
Telephone advice	0.96 (0.87, 1.06)	0.448
Direct bedside clinical support	0.97 (0.85, 1.10)	0.640
Informal bedside teaching	1.03 (0.90, 1.18)	0.706
Formal educational courses	0.96 (0.86, 1.07)	0.468
Use of early warning/track & trigger	0.99 (0.89, 1.11)	0.905
Audit and evaluation of CCOS activity	1.01 (0.88, 1.16)	0.855
Model3a: Discharge out-of-hours	Odds ratio	0.027a
Ward follow-up	0.95 (0.76, 1.20)	0.688
Outpatient follow-up	1.10 (0.92, 1.31)	0.309
Telephone advice	1.13 (0.95, 1.35)	0.160
Direct bedside clinical support	0.72 (0.55, 0.94)	0.014
Informal bedside teaching	1.23 (0.99, 1.52)	0.061
Formal educational courses	1.00 (0.83, 1.20)	0.994
Use of early warning/track & trigger	1.02 (0.72, 1.44)	0.906
Audit and evaluation of CCOS activity	1.23 (1.01, 1.50)	0.038
Model3b: Early discharge due to shortage of beds	Odds ratio	0.710a
Ward follow-up	0.91 (0.63, 1.30)	0.598
Outpatient follow-up	0.88 (0.66, 1.17)	0.380
Telephone advice	1.04 (0.79, 1.36)	0.785
Direct bedside clinical support	1.05 (0.70, 1.57)	0.805
Informal bedside teaching	0.97 (0.71, 1.33)	0.870
Formal educational courses	0.95 (0.73, 1.26)	0.740
Use of early warning/track & trigger	1.29 (0.93, 1.80)	0.132
Audit and evaluation of CCOS activity	0.84 (0.56, 1.26)	0.391
Model3c: Readmission within 48 hours	Odds ratio	0.411a
Ward follow-up	1.00 (0.80, 1.25)	0.972
Outpatient follow-up	0.98 (0.86, 1.11)	0.739
Telephone advice	1.01 (0.84, 1.21)	0.904
Direct bedside clinical support	0.97 (0.76, 1.23)	0.781
Informal bedside teaching	1.17 (0.96, 1.42)	0.123
Formal educational courses	1.00 (0.86, 1.15)	0.950
Use of early warning/track & trigger	0.88 (0.70, 1.09)	0.247
Audit and evaluation of CCOS activity	1.08 (0.83, 1.40)	0.564
Model3d: Hospital mortality	Odds ratio	0.114a
Ward follow-up	0.98 (0.82, 1.18)	0.862
Outpatient follow-up	0.94 (0.85, 1.03)	0.193
Telephone advice	1.09 (0.96, 1.23)	0.169
Direct bedside clinical support	0.79 (0.64, 0.96)	0.020
Informal bedside teaching	1.15 (1.01, 1.32)	0.037
Formal educational courses	1.03 (0.94, 1.12)	0.530
Use of early warning/track & trigger	1.05 (0.94, 1.16)	0.409
Audit and evaluation of CCOS activity	1.07 (0.92, 1.23)	0.381

CCOS critical care outreach service(s), CI confidence interval, a P-value for overall effect of CCOS activities, CPR cardiopulmonary resuscitation, ICNARC Intensive Care National Audit & Research Centre, SD standard deviation

Table A5.3: Effects of CCOS coverage on outcomes

Secondary exposure variable	Effect estimate (95% CI) compared with no CCOS	P-value
Model1a: Admissions from ward	Odds ratio	0.438a, 0.330b
24 hours 7 days a week, 100% ward coverage	0.93 (0.77, 1.12)	0.423
12-23 hours 7 days, 100% ward coverage	1.20 (0.87, 1.65)	0.260
<12 hours 7 days, 100% ward coverage	0.95 (0.79, 1.13)	0.549
Selected days, 100% ward coverage	0.88 (0.76, 1.01)	0.068
24 hours 7 days, <100% ward coverage	0.93 (0.75, 1.15)	0.496
12-23 hours 7 days, <100% ward coverage	1.20 (0.87, 1.67)	0.272
<12 hours 7 days, <100% ward coverage	0.95 (0.80, 1.13)	0.556
Selected days, <100% ward coverage	0.88 (0.76, 1.02)	0.092
Model2a: CPR 24 hours prior to admission	Odds ratio	0.215a, 0.015b
24 hours 7 days a week, 100% ward coverage	0.67 (0.50, 0.89)	0.005
12-23 hours 7 days, 100% ward coverage	0.96 (0.66, 1.40)	0.838
<12 hours 7 days, 100% ward coverage	0.84 (0.68, 1.04)	0.105
Selected days, 100% ward coverage	0.76 (0.63, 0.91)	0.004
24 hours 7 days, <100% ward coverage	0.80 (0.61, 1.05)	0.103
12-23 hours 7 days, <100% ward coverage	1.15 (0.75, 1.74)	0.526
<12 hours 7 days, <100% ward coverage	1.00 (0.80, 1.25)	0.979
Selected days, <100% ward coverage	0.90 (0.73, 1.11)	0.329
Model2b: Admission out-of-hours	Odds ratio	0.456a, 0.085b
24 hours 7 days a week, 100% ward coverage	0.95 (0.87, 1.03)	0.220
12-23 hours 7 days, 100% ward coverage	0.97 (0.85, 1.10)	0.581
<12 hours 7 days, 100% ward coverage	0.90 (0.81, 1.00)	0.055
Selected days, 100% ward coverage	0.89 (0.79, 1.00)	0.045
24 hours 7 days, <100% ward coverage	0.93 (0.83, 1.03)	0.171
12-23 hours 7 days, <100% ward coverage	0.94 (0.81, 1.10)	0.455
<12 hours 7 days, <100% ward coverage	0.88 (0.80, 0.98)	0.015
Selected days, <100% ward coverage	0.87 (0.77, 0.97)	0.016
Model2c: ICNARC physiology score	Change in mean	0.013a, 0.001b
24 hours 7 days a week, 100% ward coverage	−1.49 (−3.12, 0.14)	0.072
12-23 hours 7 days, 100% ward coverage	0.38 (−1.17, 1.94)	0.629
<12 hours 7 days, 100% ward coverage	−1.19 (−2.42, 0.04)	0.058
Selected days, 100% ward coverage	−2.51 (−3.72, −1.30)	<0.001
24 hours 7 days, <100% ward coverage	−0.43 (−2.12, 1.26)	0.621
12-23 hours 7 days, <100% ward coverage	1.45 (−0.40, 3.29)	0.124
<12 hours 7 days, <100% ward coverage	−0.12 (−1.62, 1.38)	0.872
Selected days, <100% ward coverage	−1.44 (−2.62, −0.27)	0.016
Model2c: ICNARC physiology score	Change in SD	0.434a, 0.565b
24 hours 7 days a week, 100% ward coverage	−0.036 (−0.101, 0.030)	0.285
12-23 hours 7 days, 100% ward coverage	−0.006 (−0.074, 0.062)	0.865
<12 hours 7 days, 100% ward coverage	−0.034 (−0.089, 0.021)	0.221
Selected days, 100% ward coverage	−0.004 (−0.061, 0.052)	0.882
24 hours 7 days, <100% ward coverage	−0.004 (−0.078, 0.070)	0.917
12-23 hours 7 days, <100% ward coverage	0.026 (−0.057, 0.108)	0.540
<12 hours 7 days, <100% ward coverage	−0.003 (−0.068, 0.063)	0.939
Selected days, <100% ward coverage	0.027 (−0.026, 0.080)	0.310
Model2d: All active treatment withdrawn	Odds ratio	0.004a, 0.008b
24 hours 7 days a week, 100% ward coverage	1.10 (0.84, 1.46)	0.479
12-23 hours 7 days, 100% ward coverage	1.52 (1.13, 2.05)	0.006
<12 hours 7 days, 100% ward coverage	1.12 (0.88, 1.42)	0.373
Selected days, 100% ward coverage	0.79 (0.61, 1.03)	0.083
24 hours 7 days, <100% ward coverage	1.00 (0.76, 1.31)	0.985
12-23 hours 7 days, <100% ward coverage	1.37 (0.94, 2.01)	0.102

Secondary exposure variable	Effect estimate (95% CI) compared with no CCOS	P-value
<12 hours 7 days, <100% ward coverage	1.01 (0.75, 1.35)	0.956
Selected days, <100% ward coverage	0.72 (0.53, 0.96)	0.027
Model2e: Unit mortality	Odds ratio	0.860a, 0.924b
24 hours 7 days a week, 100% ward coverage	0.98 (0.83, 1.16)	0.805
12-23 hours 7 days, 100% ward coverage	0.98 (0.86, 1.12)	0.821
<12 hours 7 days, 100% ward coverage	1.04 (0.88, 1.22)	0.653
Selected days, 100% ward coverage	0.93 (0.79, 1.10)	0.401
24 hours 7 days, <100% ward coverage	0.99 (0.82, 1.18)	0.873
12-23 hours 7 days, <100% ward coverage	0.99 (0.82, 1.20)	0.927
<12 hours 7 days, <100% ward coverage	1.04 (0.88, 1.24)	0.631
Selected days, <100% ward coverage	0.94 (0.79, 1.12)	0.466
Model3a: Discharge out-of-hours	Odds ratio	0.683a, 0.733b
24 hours 7 days a week, 100% ward coverage	1.05 (0.85, 1.29)	0.640
12-23 hours 7 days, 100% ward coverage	1.42 (0.86, 2.37)	0.174
<12 hours 7 days, 100% ward coverage	0.98 (0.77, 1.23)	0.840
Selected days, 100% ward coverage	1.09 (0.87, 1.36)	0.466
24 hours 7 days, <100% ward coverage	1.03 (0.81, 1.29)	0.824
12-23 hours 7 days, <100% ward coverage	1.39 (0.82, 2.36)	0.222
<12 hours 7 days, <100% ward coverage	0.95 (0.71, 1.28)	0.751
Selected days, <100% ward coverage	1.06 (0.86, 1.31)	0.572
Model3b: Early discharge due to shortage of beds	Odds ratio	0.037a, 0.066b
24 hours 7 days a week, 100% ward coverage	0.58 (0.27, 1.24)	0.159
12-23 hours 7 days, 100% ward coverage	0.63 (0.37, 1.09)	0.099
<12 hours 7 days, 100% ward coverage	0.77 (0.54, 1.11)	0.164
Selected days, 100% ward coverage	1.22 (0.88, 1.68)	0.236
24 hours 7 days, <100% ward coverage	0.60 (0.30, 1.20)	0.147
12-23 hours 7 days, <100% ward coverage	0.65 (0.35, 1.19)	0.163
<12 hours 7 days, <100% ward coverage	0.80 (0.52, 1.22)	0.295
Selected days, <100% ward coverage	1.25 (0.83, 1.88)	0.278
Model3c: Readmission within 48 hours	Odds ratio	0.257a, 0.341b
24 hours 7 days a week, 100% ward coverage	1.02 (0.74, 1.40)	0.927
12-23 hours 7 days, 100% ward coverage	1.13 (0.95, 1.34)	0.154
<12 hours 7 days, 100% ward coverage	0.93 (0.78, 1.11)	0.411
Selected days, 100% ward coverage	1.10 (0.92, 1.31)	0.305
24 hours 7 days, <100% ward coverage	0.99 (0.72, 1.36)	0.941
12-23 hours 7 days, <100% ward coverage	1.10 (0.89, 1.37)	0.378
<12 hours 7 days, <100% ward coverage	0.90 (0.75, 1.10)	0.306
Selected days, <100% ward coverage	1.07 (0.88, 1.30)	0.507
Model3d: Hospital mortality	Odds ratio	0.089a, 0.086b
24 hours 7 days a week, 100% ward coverage	1.09 (0.94, 1.28)	0.259
12-23 hours 7 days, 100% ward coverage	1.16 (1.04, 1.30)	0.009
<12 hours 7 days, 100% ward coverage	1.00 (0.87, 1.15)	0.991
Selected days, 100% ward coverage	1.03 (0.92, 1.15)	0.613
24 hours 7 days, <100% ward coverage	1.10 (0.97, 1.26)	0.131
12-23 hours 7 days, <100% ward coverage	1.17 (1.02, 1.35)	0.025
<12 hours 7 days, <100% ward coverage	1.01 (0.90, 1.14)	0.872
Selected days, <100% ward coverage	1.04 (0.94, 1.15)	0.434

CCOS critical care outreach service(s), CI confidence interval, a P-value for difference among the secondary exposure categories, b P-value for overall effect of CCOS, CPR cardiopulmonary resuscitation, ICNARC Intensive Care National Audit & Research Centre, SD standard deviation

Table A5.4: Effects of CCOS staffing on outcomes

Secondary exposure variable	Effect estimate (95% CI) compared with no CCOS	P-value
Model1a: Admission from ward	Odds ratio	0.079a, 0.070b
Medical team	1.07 (0.88, 1.30)	0.500
Large team	1.18 (1.02, 1.35)	0.025
Model2a: CPR 24 hours prior to admission	Odds ratio	0.374a, 0.029b
Medical team	0.87 (0.71, 1.08)	0.222
Large team	0.93 (0.77, 1.13)	0.485
Model2b: Admission out-of-hours	Odds ratio	0.090a, 0.003b
Medical team	0.92 (0.84, 1.00)	0.046
Large team	0.99 (0.91, 1.07)	0.809
Model2c: ICNARC physiology score	Change in mean	1.000a, 0.054b
Medical team	0.02 (−1.36, 1.40)	0.978
Large team	0.01 (−1.12, 1.14)	0.988
Model2c: ICNARC physiology score	Change in SD	0.360a, 0.502b
Medical team	−0.006 (−0.072, 0.060)	0.862
Large team	−0.033 (−0.079, 0.013)	0.157
Model2d: All active treatment withdrawn	Odds ratio	0.006a, 0.015b
Medical team	0.76 (0.59, 0.97)	0.026
Large team	1.29 (1.02, 1.64)	0.033
Model2e: Unit mortality	Odds ratio	0.276a, 0.390b
Medical team	0.91 (0.81, 1.03)	0.123
Large team	0.99 (0.88, 1.10)	0.812
Model3a: Discharge out-of-hours	Odds ratio	0.297a, 0.342b
Medical team	0.84 (0.65, 1.09)	0.192
Large team	1.02 (0.76, 1.36)	0.909
Model3b: Early discharge due to shortage of beds	Odds ratio	0.153a, 0.249b
Medical team	0.84 (0.55, 1.27)	0.404
Large team	0.78 (0.54, 1.12)	0.177
Model3c: Readmission within 48 hours	Odds ratio	0.634a, 0.750b
Medical team	1.06 (0.87, 1.30)	0.535
Large team	1.05 (0.89, 1.24)	0.587
Model3d: Hospital mortality	Odds ratio	0.062a, 0.051b
Medical team	1.01 (0.93, 1.10)	0.801
Large team	1.11 (1.02, 1.21)	0.020

CCOS critical care outreach service(s), CI confidence interval, a P-value for difference among the secondary exposure categories, b P-value for overall effect of CCOS, CPR cardiopulmonary resuscitation, ICNARC Intensive Care National Audit & Research Centre, SD standard deviation

Table A5.5: Results of sensitivity analyses

Primary exposure variable	Effect estimate (95% CI) compared with no CCOS	P-value
Model2a: CPR 24 hours prior to admission b	Odds ratio	0.086a
CCOS month 1	0.81 (0.51, 1.29)	0.371
CCOS month 2	0.92 (0.57, 1.49)	0.736
CCOS month 3 and following	0.82 (0.70, 0.96)	0.015
Model2d: All active treatment withdrawn c	Odds ratio	0.965a
CCOS month 1	0.92 (0.55, 1.52)	0.740
CCOS month 2	0.92 (0.62, 1.38)	0.695
CCOS month 3 and following	0.97 (0.77, 1.22)	0.782

CI confidence interval, CCOS critical care outreach service, CPR cardiopulmonary resuscitation, b restricted to admissions in hospital for at least 24 hours prior to critical care unit (ICU) admission, a P-value for overall effect of CCOS, c restricted to all active treatment withdrawal occurring within 48 hours of critical care unit (ICU) admission

Matched cohort analysis at the critical care patient level - contemporaneous match

A contemporaneous match was an admission to the same critical care unit during the study period but not seen by the CCOS. This matching was known to be subject to severe selection bias, but was included for completeness and comparison.

Table A5.6: Comparison of matched and unmatched cases for CCOS visits prior to admission (contemporaneous matching)

	Matched	Unmatched
Patients, n (%)	1,288 (59.4)	882 (40.7)
Age, mean (SD)	63.7 (15.4)	58.3 (18.3)
Sex (male), n (%)	737 (57.2)	467 (53.0)
Severe past medical history, n (%)	198 (15.4)	284 (32.2)
ICNARC physiology score, mean (SD)	22.0 (10.0)	21.6 (10.4)
Ultimate hospital mortality, n (%)	559 (45.1)	398 (48.0)

CCOS critical care outreach service(s), SD standard deviation, ICNARC intensive care national audit & research centre

Table A5.7: Contemporaneous matched results for CCOS visits prior to admission

Primary analysis: ICNARC physiology score				
Match	Mean (SD)		Difference in means	
	Case	Control	Δ (95% CI)	P-value
	22.2 (10.1)	21.8 (10.4)	0.35 (−0.36, 1.06)	0.34
S	23.5 (10.1)	22.8 (10.4)	0.62 (−0.46, 1.70)	0.26
Secondary analysis: prior hospital length of stay				
Match	Median (IQR)		Ratio of geometric means	
	Case	Control	Ratio (95% CI)	P-value
	3 (1–10)	2 (1–9)	1.19 (1.09, 1.30)	<0.001
S	3 (1–10)	2 (1–9)	1.14 (0.98, 1.33)	0.087
Secondary analysis: CPR within 24 hours prior to admission				
Match	Number (percentage)		Matched pairs risk ratio	
	Case	Control	RR (95% CI)	P-value
	57 (4.6)	85 (6.8)	0.67 (0.51, 0.89)	0.007
S	23 (3.9)	44 (7.5)	0.52 (0.33, 0.84)	0.009
Secondary analysis: number of organ dysfunctions				
Match	Mean (SD)		Difference in means	
	Case	Control	Δ (95% CI)	P-value
	2.3 (1.2)	2.3 (1.2)	0.07 (−0.02, 0.15)	0.14
S	2.4 (1.2)	2.4 (1.2)	0.01 (−0.12, 0.15)	0.84
Secondary analysis: unit mortality				
Match	Deaths (percentage)		Matched pairs risk ratio	
	Case	Control	RR (95% CI)	P-value
	422 (33.7)	369 (29.6)	1.14 (1.02, 1.27)	0.021
S	224 (38.3)	197 (33.9)	1.13 (0.98, 1.31)	0.11
Secondary analysis: hospital mortality				
Match	Deaths (percentage)		Matched pairs risk ratio	

	Case	Control	RR (95% CI)	P-value
	568 (46.9)	517 (43.4)	1.08 (1.00, 1.17)	0.066
S	279 (49.6)	268 (48.6)	1.03 (0.92, 1.16)	0.66
Secondary analysis: unit length of stay				
Match	Median (IQR)		Ratio of geometric means	
	Case	Control	Ratio (95% CI)	P-value
	3.4 (1.4–8.9)	3.1 (1.2–7.9)	1.08 (0.98, 1.12)	0.12
S	3.7 (1.4–9.3)	3.4 (1.4–8.1)	1.08 (0.92, 1.26)	0.33

CCOS critical care outreach service(s), ICNARC intensive care national audit & research centre, SD standard deviation, CI confidence interval, S sensitivity analysis, IQR interquartile range, CPR cardiopulmonary resuscitation, RR risk ratio

Table A5.8: Contemporaneous matched results for CCOS prior to admission - subgroup analysis where last visit scheduled

	Effect estimate (95% CI) [P-value]
ICNARC physiology score, difference in means	−0.44 (−1.89, 1.01) [0.55]
Prior hospital LOS, ratio of geometric means	1.29 (1.07, 1.55) [0.007]
CPR prior to admission, matched pairs risk ratio	0.67 (0.34, 1.34) [0.26]
Organ dysfunctions, difference in means	−0.07 (−0.25, 0.11) [0.43]
Unit mortality, matched pairs risk ratio	0.97 (0.77, 1.22) [0.81]
Hospital mortality, matched pairs risk ratio	0.97 (0.81, 1.15) [0.72]
Unit LOS, ratio of geometric means	0.15 (0.85, 1.29) [0.65]

CCOS critical care outreach service, Values are difference in effect of CCOS (interaction) associated with the last CCOS visit being scheduled, CI confidence interval, ICNARC intensive care national audit & research centre, LOS length of stay, CPR cardiopulmonary resuscitation

Table A5.9: Comparison of matched and unmatched cases for CCOS visits prior to admission (contemporaneous propensity matching)

	Matched	Unmatched
Patients, n (%)	2,129 (97.7)	50 (2.3)
Age, mean (SD)	61.2 (16.9)	65.1 (14.6)
Sex (male), n (%)	1,167 (54.8)	30 (60.0)
Severe past medical history, n (%)	470 (22.1)	22 (44.0)
ICNARC physiology score, mean (SD)	21.7 (10.2)	25.2 (9.8)
Ultimate hospital mortality, n (%)	942 (46.4)	29 (61.7)

CCOS critical care outreach service(s), SD standard deviation, ICNARC intensive care national audit & research centre

Table A5.10: Balance between cases and contemporaneous propensity matched controls for CCOS visits prior to admission

Factor	Case	Control
Age, mean (SD)	61.2 (16.9)	62.2 (16.2)

Severe past medical history, n (%)	470 (22.1)	456 (21.4)
Source of admission, n (%)		
Ward	1,441 (67.7)	1,425 (66.9)
Critical care unit (ICU or HDU)	129 (6.1)	134 (6.3)
Theatre (elective)	115 (5.4)	132 (6.2)
Theatre (emergency)	268 (12.6)	288 (13.5)
A&E/other hospital/clinic or home	176 (8.3)	150 (7.0)
Reason for admission, n (%)		
Respiratory	758 (35.6)	728 (34.2)
Cardiovascular	406 (19.1)	425 (20.0)
Gastrointestinal	426 (20.0)	466 (21.9)
Neurological	162 (7.8)	156 (7.3)
Other	377 (17.7)	354 (16.6)

CCOS critical care outreach service(s), SD standard deviation, ICU intensive care unit, HDU high dependency unit, A&E accident & emergency department

Table A5.11: Contemporaneous propensity matched results for CCOS visits prior to admission

Primary analysis: ICNARC physiology score				
Match	Mean (SD)		Difference in means	
	Case	Control	Δ (95% CI)	P-value
	21.7 (10.2)	21.3 (10.5)	0.42 (−0.15, 1.00)	0.15
S	22.9 (10.3)	22.7 (10.7)	0.13 (−0.78, 1.04)	0.78
Secondary analysis: prior hospital length of stay				
Match	Median (IQR)		Ratio of geometric means	
	Case	Control	Ratio (95% CI)	P-value
	3 (1-11)	2 (1-9)	1.24 (1.15, 1.33)	<0.001
S	3 (1-9)	2 (1-8)	1.18 (1.04, 1.34)	0.008
Secondary analysis: CPR within 24 hours				
Match	Number (percentage)		Matched pairs risk ratio	
	Case	Control	RR (95% CI)	P-value
	119 (5.6)	155 (7.3)	0.77 (0.62, 0.96)	0.021
S	50 (5.3)	67 (7.2)	0.73 (0.52, 1.03)	0.092
Secondary analysis: number of organ dysfunctions				
Match	Mean (SD)		Difference in means	
	Case	Control	Δ (95% CI)	P-value
	2.3 (1.2)	2.2 (1.2)	0.07 (0.00, 0.14)	0.044
S	2.4 (1.2)	2.3 (1.2)	0.07 (−0.04, 0.17)	0.21
Secondary analysis: Unit mortality				
Match	Deaths (percentage)		Matched pairs risk ratio	
	Case	Control	RR (95% CI)	P-value
	701 (32.9)	602 (28.4)	1.16 (1.06, 1.27)	0.001
S	350 (37.0)	299 (32.2)	1.14 (1.00, 1.29)	0.047
Secondary analysis: hospital mortality				
Match	Deaths (percentage)		Matched pairs risk ratio	

	Case	Control	RR (95% CI)	P-value
	942 (46.4)	871 (43.1)	1.06 (1.00, 1.14)	0.067
S	442 (49.2)	412 (46.6)	1.02 (0.93, 1.13)	0.68
Secondary analysis: unit length of stay				
Match	Median (IQR)		Ratio of geometric means	
	Case	Control	Ratio (95% CI)	P-value
	3.3 (1.3-8.5)	2.9 (1.1-6.7)	1.15 (1.06, 1.24)	0.001
S	3.2 (1.3-8.6)	3.1 (1.2-7.5)	1.10 (0.97, 1.25)	0.15

CCOS critical care outreach service(s), ICNARC intensive care national audit & research centre, SD standard deviation, CI confidence interval, S sensitivity analysis, IQR interquartile range, CPR cardiopulmonary resuscitation, RR risk ratio

Table A5.12: Contemporaneous propensity matched results for CCOS visits prior to admission- subgroup analyses where last visit scheduled

	Effect estimate (95% CI) [P-value]
ICNARC physiology score, difference in means	−1.56 (−2.72, −0.40) [0.009]
Prior hospital LOS, ratio of geometric means	1.42 (1.23, 1.64) [<0.001]
CPR prior to admission, matched pairs risk ratio	0.44 (0.27, 0.71) [0.001]
Organ dysfunctions, difference in means	−0.19 (−0.33, −0.05) [0.008]
Unit mortality, matched pairs risk ratio	0.86 (0.71, 1.03) [0.099]
Hospital mortality, matched pairs risk ratio	0.88 (0.77, 1.01) [0.063]
Unit LOS, ratio of geometric means	1.25 (1.06, 1.47) [0.007]

CCOS critical care outreach service(s), Values are difference in effect of CCOS (interaction) associated with the last CCOS visit being scheduled, CI confidence interval, ICNARC intensive care national audit & research centre, LOS length of stay, CPR cardiopulmonary resuscitation

Table A5.13: Comparison of matched and unmatched cases for CCOS visits following discharge (contemporaneous matching)

	Matched	Unmatched
Patients, n (%)	1,792 (30.4)	4,095 (69.6)
Age, mean (SD)	62.2 (16.4)	58.4 (18.3)
Sex (male), n (%)	1,306 (57.8)	2,277 (55.6)
Severe past medical history, n (%)	227 (12.7)	718 (17.5)
ICNARC physiology score, mean (SD)	13.9 (7.0)	16.1 (8.2)
Ultimate hospital mortality, n (%)	156 (8.9)	440 (11.2)

CCOS critical care outreach service(s), SD standard deviation, ICNARC intensive care national audit & research centre

Table A5.14: Contemporaneous matched results for CCOS visits following discharge

Primary analysis: hospital mortality				
Match	Deaths (percentage)		Matched pairs risk ratio	
	Case	Control	RR (95% CI)	P-value
	156 (8.9)	158 (9.0)	1.01 (0.82, 1.25)	0.90
S	103 (7.4)	127 (9.2)	0.83 (0.64, 1.06)	0.14
Secondary analysis: readmission within 48 hours				
Match	Deaths (percentage)		Matched pairs risk ratio	
	Case	Control	RR (95% CI)	P-value
	31 (1.7)	26 (1.5)	1.17 (0.67, 2.02)	0.59
S	12 (0.8)	14 (1.0)	0.86 (0.37, 2.02)	0.73
Secondary analysis: readmission within 48 hours not from HDU				
Match	Deaths (percentage)		Matched pairs risk ratio	
	Case	Control	RR (95% CI)	P-value
	27 (1.5)	23 (1.3)	1.16 (0.64, 2.12)	0.63
S	12 (0.8)	14 (1.0)	0.86 (0.37, 2.02)	0.73
Secondary analysis: post-discharge hospital length of stay				
Match	Median (IQR)		Ratio of geometric means	
	Case	Control	Ratio (95% CI)	P-value
	10 (6–20)	11 (6–21)	0.98 (0.93, 1.04)	0.59
S	10 (5–18)	10 (5–20)	0.99 (0.93, 1.06)	0.75

CCOS critical care outreach service(s), CI confidence interval, HDU high dependency unit, IQR interquartile range

Table A5.15: Contemporaneous matched results for CCOS visits following discharge - subgroup analyses where CCOS visit prior to admission in addition

	Effect estimate (95% CI) [P-value]
Hospital mortality, matched pairs risk ratio	0.91 (0.53, 1.58) [0.75]
Readmissions within 48 hours, matched pairs risk ratio	0.29 (0.00, 163.3) [0.70]
Readmissions within 48 hours not from HDU, matched pairs risk ratio	0.18 (not estimable) [1.00]
Post-discharge hospital LOS, ratio of geometric means	1.05 (0.88, 1.26) [0.58]

CCOS critical care outreach service(s), Values are difference in effect of CCOS (interaction) associated with receiving CCOS visits prior to admission in addition to following discharge, CI confidence interval, HDU high dependency unit, LOS length of stay

Table A5.16: Comparison of matched and unmatched cases for CCOS visits following discharge (contemporaneous propensity matching)

	Matched	Unmatched
Patients, n (%)	4,468 (77.8)	1,275 (22.2)
Age, mean (SD)	59.5 (18.0)	59.6 (17.5)
Sex (male), n (%)	2,502 (56.0)	740 (58.0)
Severe past medical history, n (%)	649 (14.5)	263 (20.6)
ICNARC physiology score, mean (SD)	15.4 (7.9)	15.4 (7.8)
Ultimate hospital mortality, n (%)	480 (11.0)	115 (9.2)

CCOS critical care outreach service(s), SD standard deviation, ICNARC intensive care national audit & research centre

Table A5.17: Balance between cases and contemporaneous propensity matched controls for CCOS visits following discharge

Factor	Case	Control
Age, mean (SD)	59.5 (18.0)	59.3 (18.1)
ICNARC physiology score, mean (SD)	15.4 (7.9)	15.3 (7.9)
Source of admission, n (%)		
Ward	1,030 (23.1)	1,152 (25.8)
Critical care unit (ICU or HDU)	221 (4.9)	224 (5.0)
Theatre (elective)	1,398 (31.3)	1,318 (29.5)
Theatre (emergency)	978 (21.9)	944 (21.1)
A&E/other hospital/clinic or home	841 (18.8)	830 (18.6)
Destination following discharge, n (%)		
Ward	3,833 (85.8)	3,804 (85.1)
Intermediate care	156 (3.5)	153 (3.4)
HDU	461 (10.3)	492 (11.0)
Critical care unit (ICU)	11 (0.2)	14 (0.3)
Recovery	7 (0.2)	5 (0.1)

CCOS critical care outreach service(s), SD standard deviation, ICNARC intensive care national audit & research centre, ICU intensive care unit, HDU high dependency unit, A&E accident and emergency department

Table A5.18: Contemporaneous propensity matched results for CCOS visits following discharge

Primary analysis: hospital mortality				
Match	Deaths (percentage)		Matched pairs risk ratio	
	Case	Control	RR (95% CI)	P-value
	480 (11.0)	524 (12.0)	1.04 (0.91, 1.19)	0.54
S	302 (9.4)	383 (12.3)	0.86 (0.73, 1.02)	0.093
Secondary analysis: readmissions within 48 hours				
Match	Deaths (percentage)		Matched pairs risk ratio	
	Case	Control	RR (95% CI)	P-value
	100 (2.2)	71 (1.6)	1.43 (1.04, 1.96)	0.027
S	31 (0.9)	48 (1.5)	0.57 (0.34, 0.94)	0.028
Secondary analysis: readmissions within 48 hours not from HDU				
Match	Deaths (percentage)		Matched pairs risk ratio	
	Case	Control	RR (95% CI)	P-value
	84 (1.9)	63 (1.4)	1.33 (0.96, 1.85)	0.086
S	28 (0.9)	48 (1.6)	0.57 (0.34, 0.94)	0.028
Secondary analysis: post-discharge hospital length of stay				
Match	Median (IQR)		Ratio of geometric means	
	Case	Control	Ratio (95% CI)	P-value
	11 (6-22)	11 (6-23)	1.02 (0.98, 1.06)	0.40
S	10 (5-19)	9 (5-20)	1.03 (0.98, 1.09)	0.27

CCOS critical care outreach service(s), RR risk ratio, CI confidence interval, S sensitivity analysis, HDU high dependency unit, IQR interquartile range

Table A5.19: Contemporaneous matched results for CCOS visits following discharge - subgroup analyses where CCOS visit prior to admission in addition

	Effect estimate (95% CI) [P-value]
Hospital mortality, matched pairs risk ratio	1.52 (1.04, 2.22) [0.033]
Readmissions within 48 hours, matched pairs risk ratio	1.32 (0.00, 6083) [0.95]
Readmissions within 48 hours not from HDU, matched pairs risk ratio	1.32 (0.00, 2303) [0.94]
Post-discharge hospital LOS, ratio of geometric means	1.09 (0.93, 1.30) [0.29]

CCOS critical care outreach services, Values are difference in effect of CCOS (interaction) associated with receiving CCOS visits prior to admission in addition to following discharge, CI confidence interval, HDU high dependency unit, LOS length of stay

Economic evaluation – contemporaneous match

Table A5.20: Breakdown of costing data – contemporaneous match

Mean CCOS visits		Mean Critical care unit (ICU) days		Mean hospital days	
Case	Control	Case	Control	Case	Control
2.64	0	0.77	0.63	17.0	17.7

CCOS critical care outreach service(s), ICU intensive care unit

Table A5.21: Breakdown of mean cost per patient – contemporaneous match

CCOS visits		Critical care unit (ICU) days		Hospital days	
Case	Control	Case	Control	Case	Control
£199	£0	£1323	£1089	£3729	£3888

CCOS critical care outreach service(s), ICU intensive care unit

Table A5.22: Difference in mean cost per patient – contemporaneous match

Cost per patient, mean (SD)		Difference in costs (Case – Control)	
Case	Control	Δ (95% CI)	P-value
£5252 (9539)	£4977 (8575)	£275 (−£305, £854)	0.35

SD standard deviation, CI confidence interval

Figure A5.1: Cost-effectiveness plane (10,000 bootstrap samples) for contemporaneous match

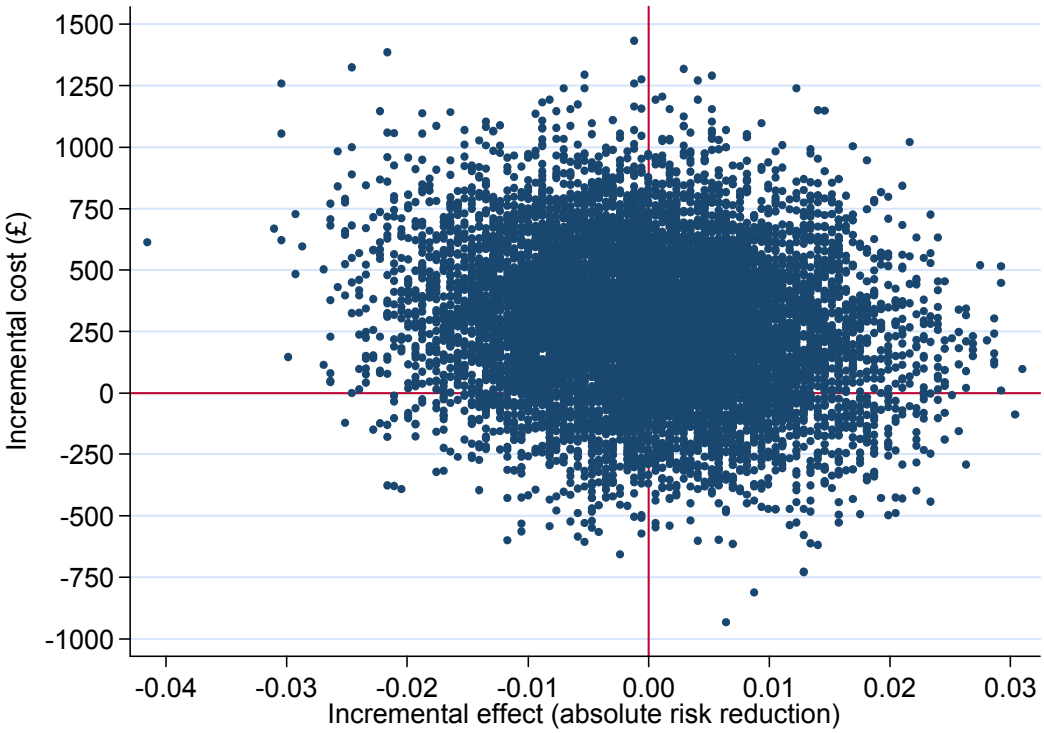


Figure A5.2: Cost-effectiveness acceptability curve for contemporaneous match

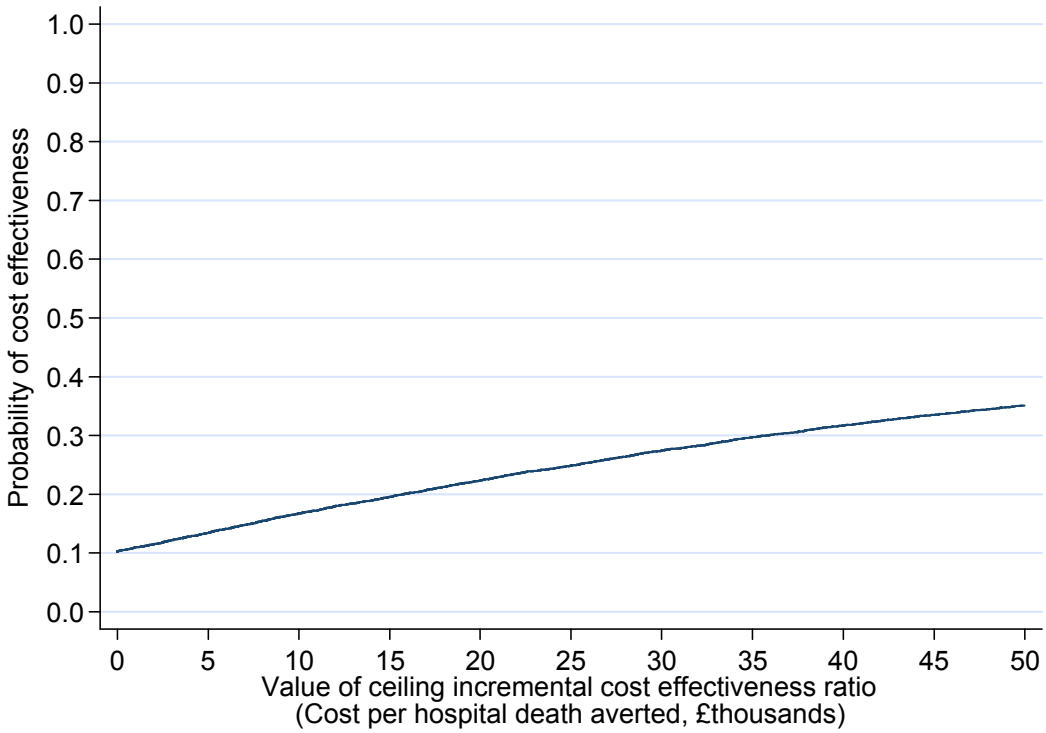


Figure A5.3: Cost-effectiveness acceptability curves from sensitivity ` analyses for contemporaneous match

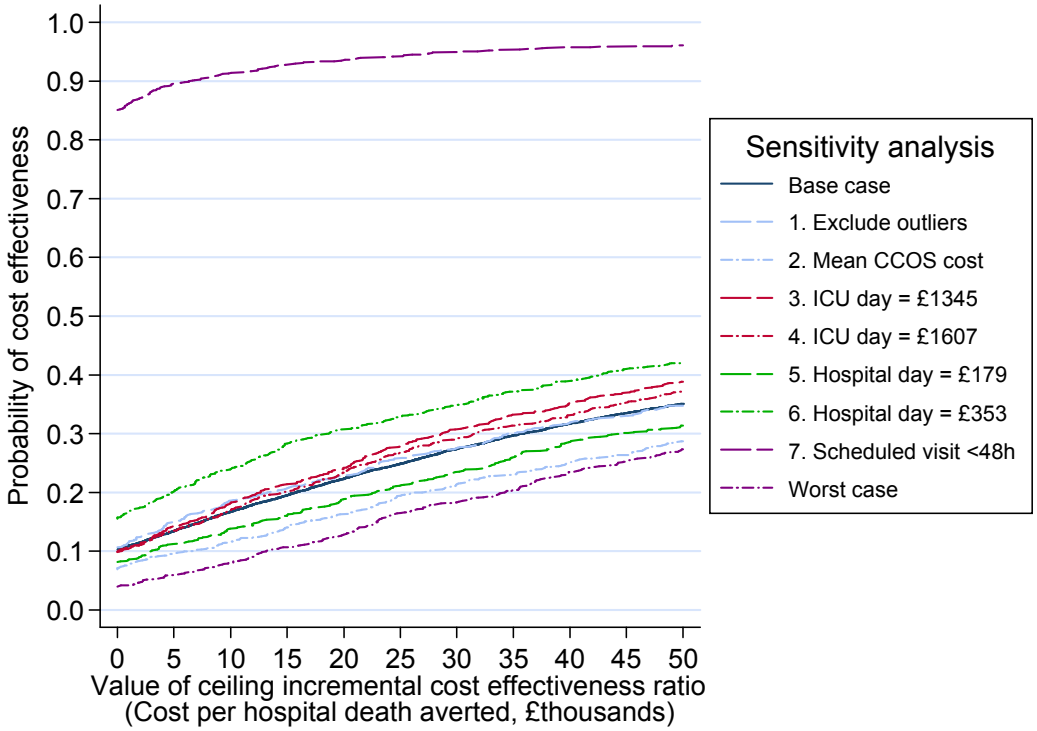


Table A5.23: Breakdown of costing data – contemporaneous propensity match

Mean CCOS visits		Mean Critical care unit (ICU) days		Mean hospital days	
Case	Control	Case	Control	Case	Control
2.76	0	0.86	0.64	18.1	18.6

CCOS critical care outreach service(s), ICU intensive care unit

Table A5.24: Breakdown of mean cost per patient – contemporaneous propensity match

CCOS visits		Critical care unit (ICU) days		Hospital days	
Case	Control	Case	Control	Case	Control
£222	£0	£1479	£1100	£3975	£4102

CCOS critical care outreach service(s), ICU intensive care unit

Table A5.25: Difference in mean total cost per patient – contemporaneous propensity match

Cost per patient, mean (SD)		Difference in costs (Case-Control)	
Case	Control	Δ (95% CI)	P-value
£5677 (9937)	£5202 (9425)	£475 (£82, £868)	0.018

SD standard deviation, CI confidence interval

Figure A5.4: Cost-effectiveness plane (10,000 bootstrap samples) for contemporaneous propensity match

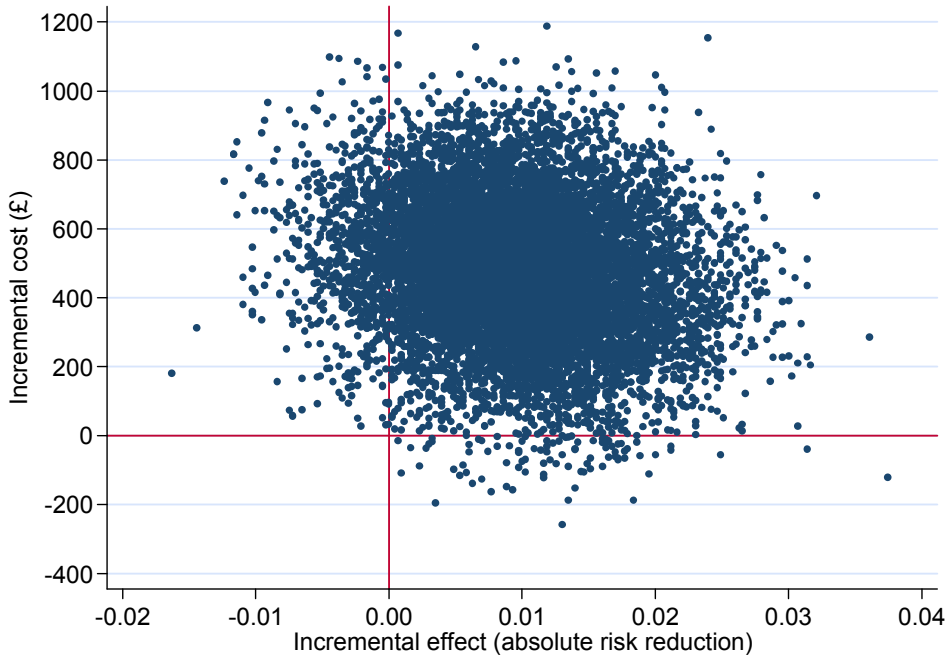
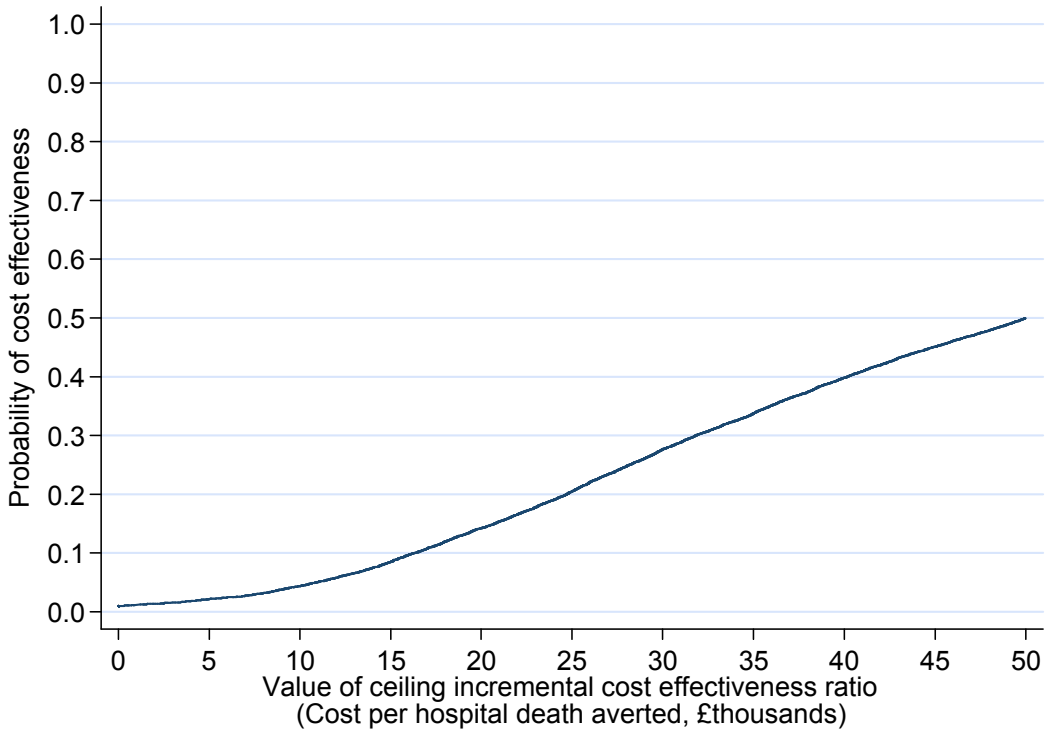


Figure A5.5: Cost-effectiveness acceptability curve for contemporaneous propensity match



Propensity model – CCOS visits prior to admission to the critical care unit

The propensity model was fitted on 21,794 critical care unit admissions with complete data for all factors included in the model, including 2,179 cases receiving one or more visits from the CCOS prior to admission to the critical care unit (representing 99.4% of all cases). The results of the propensity model are shown in Table A5.26.

Table A5.26: Propensity model for CCOS visits prior to admission

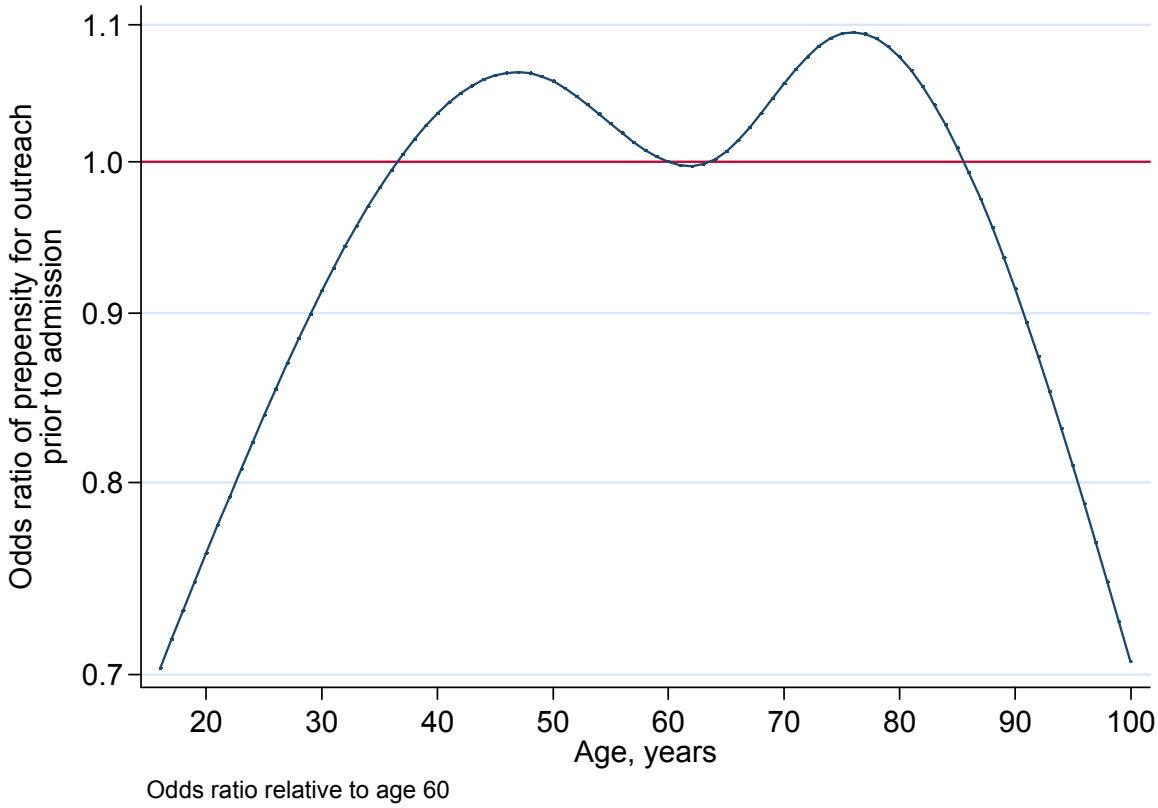
Factor	Odds ratio (95% CI)	P-value
Age	See Figure **A5.6**	0.049
Severe past medical history	1.27 (1.13, 1.43)	<0.001
Source of admission:		<0.001
Ward	1.00	
Critical care unit (ICU or HDU)	0.30 (0.25, 0.37)	
Theatre (elective)	0.13 (0.10, 0.16)	
Theatre (emergency)	0.28 (0.24, 0.33)	
A&E/other hospital/clinic or home	0.14 (0.11, 0.16)	
Reason for admission:		<0.001
Respiratory, infection	1.00	
Respiratory, obstruction	0.78 (0.61, 1.00)	
Respiratory, oedema	0.92 (0.72, 1.18)	
Respiratory, collapse	1.08 (0.69, 1.70)	
Respiratory, other	0.89 (0.68, 1.16)	
Cardiovascular, failure	0.52 (0.34, 0.78)	
Cardiovascular, obstruction	0.47 (0.33, 0.66)	
Cardiovascular, over-activity	0.66 (0.45, 0.97)	
Cardiovascular, shock/hypotension	1.16 (0.97, 1.39)	
Cardiovascular, other	0.40 (0.30, 0.53)	
Gastrointestinal, haemorrhage	0.63 (0.48, 0.83)	

Factor	Odds ratio (95% CI)	P-value
Gastrointestinal, infection	0.73 (0.54, 0.99)	
Gastrointestinal, inflammation	0.69 (0.54, 0.89)	
Gastrointestinal, obstruction	0.53 (0.38, 0.74)	
Gastrointestinal, trauma	0.85 (0.66, 1.09)	
Gastrointestinal, tumour	0.24 (0.16, 0.35)	
Gastrointestinal, other	0.34 (0.21, 0.56)	
Neurological, haemorrhage	0.48 (0.33, 0.70)	
Neurological, infection	0.80 (0.51, 1.26)	
Neurological, seizure	0.57 (0.38, 0.84)	
Neurological, coma/encephalopathy	0.81 (0.56, 1.16)	
Neurological, other	0.35 (0.24, 0.50)	
Genitourinary, failure	0.69 (0.55, 0.86)	
Genitourinary, other	0.35 (0.25, 0.50)	
Endocrine, diabetes	1.07 (0.68, 1.69)	
Endocrine, other	0.52 (0.39, 0.71)	
Haematological, infection	0.79 (0.59, 1.04)	
Haematological, other	0.85 (0.49, 1.45)	
Musculoskeletal	0.40 (0.27, 0.60)	
Dermatological	0.57 (0.29, 1.12)	

CCOS critical care outreach service(s), CI confidence interval, The relationship between age and propensity for receiving CCOS visits prior to admission (fitted using restricted cubic splines with 4 degrees of freedom) is illustrated in

Figure **A5.6**, ICU intensive care unit, HDU high dependency unit, A&E accident & emergency department

Figure A5.6: Propensity for CCOS prior to admission by age



The propensity model had an area under the Receiver Operating Characteristic (ROC) curve of 0.785 (95% confidence interval 0.775-0.794) indicating acceptable discrimination of cases. However, the measures of explained variation were R^2_{SS} = 0.11 and R^2_E = 0.15 indicating that a relatively small proportion of the variation was explained by the model

Propensity model – CCOS visits following discharge from the critical care unit

The propensity model was fitted on 15,562 patients discharged alive from the critical care unit to any location in the same hospital, and with complete data for all factors included in the model. These included 5,743 cases receiving one or more CCOS visits post-discharge (representing 97.6% of all cases). The results of the propensity model are shown in Table A5.27.

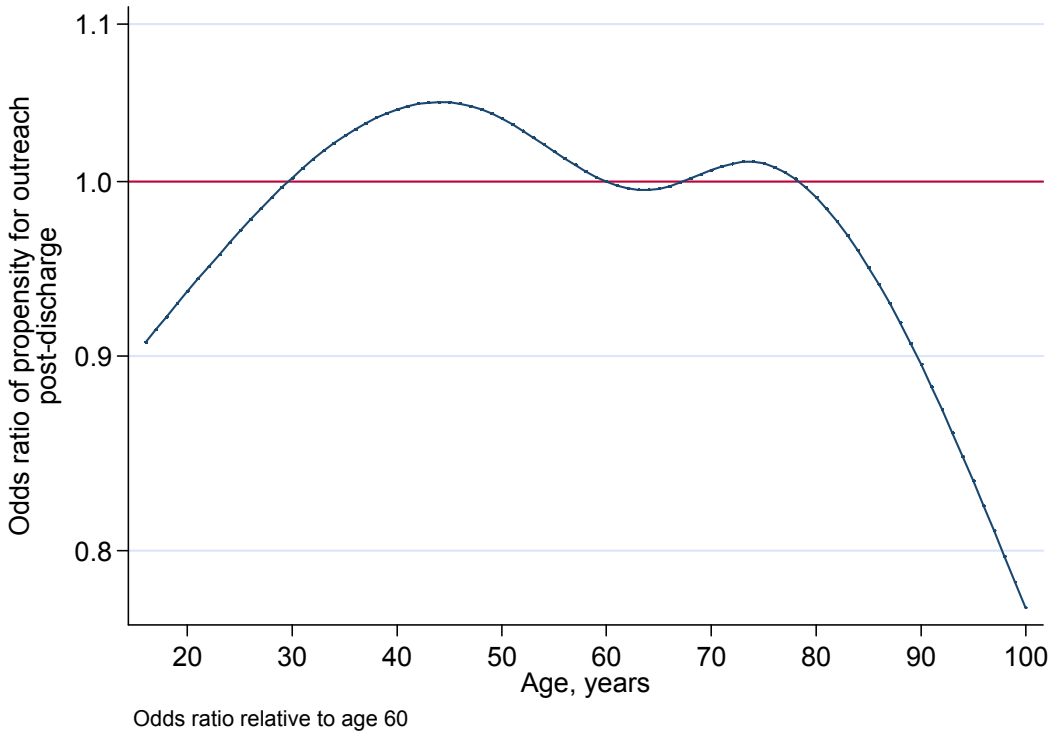
Table A5.27: Propensity model for CCOS post-discharge

Factor	Odds ratio (95% CI)	P-value
Age	See Figure A5.7	0.47
ICNARC physiology score	See Figure A5.8	0.010
Severe past medical history	1.08 (0.99, 1.19)	0.089
Source of admission:		<0.001
Ward	1.00	
Critical care unit (ICU or HDU)	0.77 (0.66, 0.91)	
Theatre (elective)	1.09 (0.98, 1.21)	
Theatre (emergency)	1.19 (1.07, 1.32)	
A&E/other hospital/clinic or home	0.92 (0.83, 1.03)	
Reason for admission:		0.032
Respiratory	1.00	
Cardiovascular	0.97 (0.87, 1.09)	
Gastrointestinal	1.07 (0.96, 1.19)	
Neurological	1.11 (0.98, 1.26)	
Genitourinary	1.03 (0.90, 1.18)	
Endocrine	1.21 (1.04, 1.42)	
Haematological	0.93 (0.72, 1.22)	
Musculoskeletal	0.85 (0.71, 1.02)	
Dermatological	0.90 (0.60, 1.37)	
Length of stay in critical care unit (ICU), days:		0.056

Factor	Odds ratio (95% CI)	P-value
Age	See Figure A5.7	0.47
0	1.00	
1	1.24 (1.08, 1.43)	
2	1.18 (1.01, 1.38)	
3-6	1.20 (1.04, 1.40)	
7+	1.17 (1.00, 1.37)	
Destination following discharge:		<0.001
Ward	1.00	
Intermediate care	0.64 (0.53, 0.77)	
HDU	0.81 (0.72, 0.91)	
Critical care unit (ICU)	0.51 (0.27, 0.94)	
Recovery	0.45 (0.24, 0.85)	

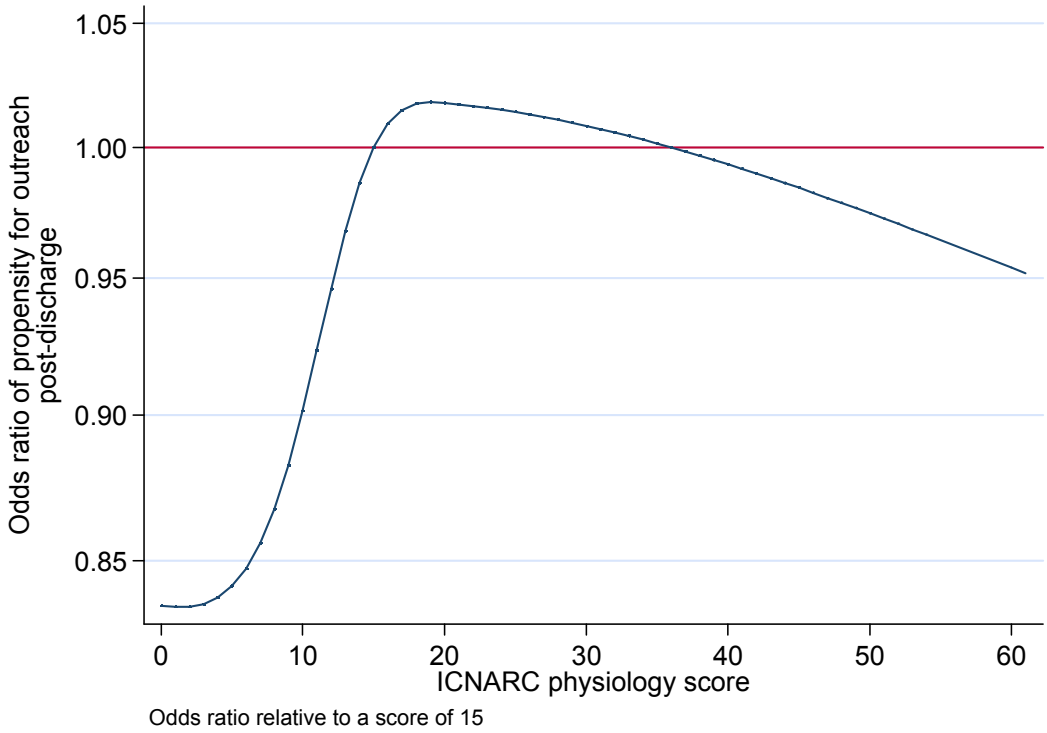
CCOS critical care outreach service(s), ICNARC intensive care national audit & research centre, The relationship between age and propensity for receiving CCOS visits following discharge from the critical care unit is illustrated in Figure A5.7. The relationship between acute severity of illness (ICNARC physiology score) and propensity for receiving CCOS visits following discharge from the critical care unit is illustrated in Figure A5.8, CI confidence interval, ICU intensive care unit, HDU high dependency unit, A&E accident & emergency department

Figure A5.7: Propensity for CCOS post-discharge by age



CCOS critical care outreach service(s)

Figure A5.8: Propensity for CCOS post-discharge by ICNARC physiology score



CCOS critical care outreach service(s), ICNARC intensive care national audit & research centre

The area under the Receiver Operating Characteristic (ROC) curve for the propensity model was 0.550 (95% confidence interval 0.541 - 0.559) indicating discrimination of cases that is little better than by chance. The measures of explained variation were R^2_{SS} = 0.008 and R^2_{E} = 0.006. These suggest the propensity model does not explain the decision to follow-up certain patients and that matching on propensity (or individual matching on these factors) will do a poor job of controlling for selection bias, especially in the contemporaneous match where the problem of selection bias is inherently greater

Appendix 6

Topic guides for qualitative evaluation of CCOS

Topic guide for ward staff and managers

Introduction

- The purpose of this study is to explore the experiences and views of patients, relatives and staff on the activities of the critical care outreach service.
- You are free to disclose as little or as much as you wish, and may terminate the interview at any time without giving a reason.
- The interview is intended to be conversational: please feel free to make further comments as you wish.
- We will analyse the data and may use direct quotations in a research report, but all information will be made anonymous prior to analysis.
- We expect the interview to last about thirty minutes.

Background

1. Please could you start by telling me your current job title?
   Prompt if necessary: for grade, qualifications, time in current role.
2. How long have you been working in [this/any] hospital?
   Prompt if necessary: type of experience.
3. What do you know about the Critical Care Outreach Service (CCOS)? When were you first aware of the service & what kind of contact do you have with them? Has the nature of the contact with the CCOS changed since its introduction?

Organisation

4. What do you understand to be the objectives of the CCOS? In your view, do you think these objective been met?
   Prompt if necessary: education or sharing skills or team training or averting admissions or supporting post-ICU care.
5. What hours does the CCOS operate? Is this adequate to provide the service this hospital requires? *If not 24 hrs do you have other services covering nights etc. like the hospital at night service?*
6. What is the usual form of your contact with the CCOS?
   Prompt if necessary: supporting post-ICU care or response to EWS team or ad hoc., etc.
   *** Make note of forms of contact **.*
   What actually happens when you are in contact with the outreach team?
7. Overall, how well is *your area [hospital]* supported by the CCOS?

Education

8. Do ward staff feel appropriately educated for the job of looking after very ill patients?
9. Has the CCOS made any difference to this?
10. Are you aware if the CCOS deliver education and training?
    If yes: Of what does this consist?
11. Is the education and training working? Why?

Operation

12. Are there standards and protocols for calling out the CCOS? Are they followed?
13. Would you say the CCOS is flexible in its approach? What happens if it is not operating (*e.g.* if not 24 hour service)?
14. Do you think the CCOS is supportive to the general ward?
    If so, how and when is it most supportive?
    If not, how do you think they could be more supportive?
15. What form does communication between the ward and the CCOS take? How well does it work?
    Prompt if necessary: telephone, email, other computer system etc.

Trigger scores

16. Is there any role for physiological scoring systems? Are they used across the whole hospital? Are they working?
17. How well are sick patients identified on the ward in general (before / after introduction of trigger scores)? Do you think admissions to ICU have been averted as a result of the CCOS? Why?
    Prompt: involvement in precipitating DNAR decisions?
18. Is there an implication in terms of equipment?

Follow-up

19. Do you think post-ICU care has improved as a result of the CCOS? Why?
20. Are you aware if there is a separate or integrated follow-up service?
21. Has there been increased support for patients and relatives?
22. Has there been any change in the quality and type of contact with the ICU since the introduction of the CCOS?

Local Evaluation

23. Do you think there has been a benefit in having a CCOS?
24. Overall, what would you say has been the biggest change as a result of the CCOS?
25. Has there been any benefit in terms of morale, recruitment and retention?
26. Have there been any detrimental effects of the CCOS?
    Prompt if necessary: e.g., de-skilling of ward staff
27. Has there been any impact from the CCOS onto other hospital services or services outside the hospital?

Close

28. Would you like to add any more comments about the outreach service, or this interview, or this research more generally?
29. Would like to know about the study findings?

Thank the respondent for their time and contribution.

Topic guide for critical care unit and CCOS staff

Introduction

- The purpose of the study is to obtain and analyse information on the experiences of different groups of patients, relatives and staff on the activities of the critical care outreach service.
- You are free to disclose as little or as much as you wish, and may terminate the interview at any time.
- The interview is intended to be conversational: please feel free to make further comments as you wish.
- We will analyse the data and may use direct quotations in a research report, but all information will be made anonymous prior to analysis.
- We expect the interview to last about three-quarters of an hour.

Personal background

1. Please could you start by telling me your current job title & how long you have worked here?
   Prompt if necessary: for grade, qualifications, time in current role, extent of critical care experience.

History

2. Do you know when the Critical Care Outreach Service (CCOS) was first developed? If yes when was it first implemented, and how has it changed since that time?
   Prompt if necessary: was it reactive or proactive? Were there any problems in setting up the CCOS?
3. What were the original objectives of the CCOS service?
   Prompt: Is it for any of the following? Education / sharing skills / training / averting admissions / supporting post-critical care unit care

4. How far have these objective been met? Have they changed over time? What areas of your role do you feel are the most important / most needed?

If ICU/HDU staff: What has been the impact on the ICU and/or HDU? Have there been changed admission patterns? Does ICU/HDU care feel less or more reactive?

Staffing and organisation

5. How is the CCOS staffed? *Prompt if necessary: doctors, nurses, or both? Are these staff junior or senior?*
6. Is the CCOS multi-disciplinary?
7. Which areas of the hospital does the CCOS deal with most frequently? How well do you think these areas are supported?
8. Do CCOS staff feel appropriately educated for the job? What training have they had? Is it important that the staff on the service are senior / experienced / from ITU background?
9. Is it important that they retain their links with ITU (by rotating in / doing shifts etc.)?
10. *For outreach staff only What was your personal motivation for joining the CCOS?*

Education

11. What formal and informal education and training does the CCOS provide?
    If informal: what kinds of training opportunities are there?
12. Is the education and training working? Why?

Operation

13. Do you have standards and protocols for calling out the CCOS? What are they? Are they followed? If no where do they break down?
14. What hours do you operate? Is this system working?
    If not 24 hours 7 days a week are the hours you work adequate to provide the service that you want to provide? Does the hospital have other services covering nights i.e. hospital at night service?
15. Do you have issues regarding the availability of equipment (on wards / for transfers?)

EWS & Other trigger scores

16. Is there any role for physiological scoring systems? Do you feel they are working?
17. How well are sick patients identified on the ward? Do you think admissions have been averted as a result of the CCOS? Why?
18. Do you think post-ICU care has improved as a result of the CCOS? Why?
19. Has the CCOS increased contact with patients' relatives, or not?

Follow-up services

20. Do you have separate or combined outreach / follow-up services?
21. How do the two services work and do they communicate with one another?
22. Do you have any contact with community services outside of the hospital (for example Primary care / GP referral letters / social services / other?)
23. Is the CCOS involved with plans for patient rehabilitation post ICU as part of the follow-up service?

Local Evaluation

24. Do you conduct, or have you conducted, any formal audit or evaluation?
25. Overall, what would you say has been the biggest change as a result of the Outreach service?
26. What factors do you think can facilitate or act as barriers to a successful service?
27. Are there specific factors which prevent you from conducting outreach work?

Close

28. What are your plans for the future of the Outreach service?
    Prompt: Increased numbers / increased coverage / increased hours / increased duties or skills i.e. non-medical prescribing, blood gasses, etc.
29. Would you like to add any more comments about the outreach service, or this interview, or this research more generally?
30. Would like to know about the study findings?

Thank the respondent for their time and contribution.

Topic guide for patients/relatives/chaplains/AHPs

Introduction

- The purpose of the study is to explore the experiences and views of patients, relatives and staff on the activities of the critical care outreach service.
- You are free to disclose as little or as much as you wish, and may terminate the interview at any time without giving a reason.
- The interview is intended to be conversational: please feel free to make further comments as you wish.
- We will analyse the data and may use direct quotations in a research report, but all information will be made anonymous prior to analysis.
- We expect the interview to last about fifteen minutes.

Questions for patients and relatives:

1. For how long were you/your relative in hospital, and in the intensive care unit?
2. How are they doing now?
3. Can you remember any contact with the Critical Care Outreach Service (CCOS) service during your/your relative's period of critical care?

   If yes, ask the respondent to describe their experience. Was it important that you had continuing input from the critical care service throughout your time in hospital?

4. What do you think might have happened if the CCOS had not been there?

Go to question 9

Questions for chaplains and AHPs:

1. What contact do you have with Intensive Care patients and their relatives?
2. To your knowledge, how has CCOS affected patients and relatives?
3. To your knowledge, how has CCOS affected workers on the general ward?
4. How has the CCOS affected your work?
5. How well do you think areas like the general ward are supported?
6. How well do you think sick patients identified on the ward? Do you think admissions have been averted as a result of the CCOS? Why?
7. Do you think post-ICU care has improved as a result of the CCOS? Why?
8. Have CCOS services increased contact with patients' relatives, or not?

Closing questions, for all respondents:

9. Would you like to add any more comments about the outreach service, or this interview, or this research more generally?
10. Would you like to know about the study findings?

Thank the respondent for their time and contribution.

Disclaimer

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Addendum

This document was published by the National Coordinating Centre for the Service Delivery and Organisation (NCCSDO) research programme, managed by the London School of Hygiene & Tropical Medicine.

The management of the Service Delivery and Organisation (SDO) programme has now transferred to the National Institute for Health Research Evaluations, Trials and Studies Coordinating Centre (NETSCC) based at the University of Southampton. Prior to April 2009, NETSCC had no involvement in the commissioning or production of this document and therefore we may not be able to comment on the background or technical detail of this document. Should you have any queries please contact sdo@southampton.ac.uk.