National Institute for Health and Care Excellence

Final

Chapter 27 Critical care outreach teams

Emergency and acute medical care in over 16s: service delivery and organisation

NICE guideline 94

March 2018

Developed by the National Guideline Centre, hosted by the Royal College of Physicians

1

Disclaimer

Healthcare professionals are expected to take NICE clinical guidelines fully into account when exercising their clinical judgement. However, the guidance does not override the responsibility of healthcare professionals to make decisions appropriate to the circumstances of each patient, in consultation with the patient and, where appropriate, their guardian or carer.

ISBN: 978-1-4731-2741-8

Chapter 27 Critical care outreach teams

Contents

1

27 Critical care outreach teams

27.1 Introduction

Critical care outreach teams (CCOT) offer intensive care skills to patients with, or at risk of, critical illness receiving care in locations outside the intensive care unit – for example, on ordinary wards. CCOTs are the UK version of what is known in the USA as Rapid Response Teams (RRTs) and in Australia as Medical Emergency Teams (METs). CCOTs differ from RRTs and METs in that they are generally nurse-led, doctor supported, whereas RRTs and METs are led by medical staff supported by nurses or technicians. CCOTs were instituted following the publication of Comprehensive Critical Care 2000[54] in response to evidence that ward care of acutely deteriorating patients was suboptimal and that ward staff needed more support in their management. Many, but not all, hospitals in the UK now have some form of CCOT.

The main role of a CCOT is to identify and institute treatment in patients who are deteriorating within the hospital but outside of the ICU and either help to prevent admission to ICU or ensure that admission to a critical care bed happens in a timely manner to ensure best outcome. Other potential benefits include enabling discharges from ICU by supporting the continuing recovery of discharged patients on wards. Ward staff education is a third important role.

Whilst the majority of NHS Trusts have some form of CCOTs, there is still much inconsistency in the service offered in terms of:

- Composition of outreach teams (that is, nurse-led or doctor-led part of the cardiac arrest team or a separate entity),
- The way the teams are accessed (that is, there is variability in the physiological trigger tools used for example, Modified Early Warning Score or National Early Warning Score),
- Whether these teams operate as a 7-day, 24 hour service or lesser periods, for example, handing over to the 'hospital at night' team after 20:00 hours.

Given this lack of consistency in CCOT services, the guideline committee aimed to address the question "does the provision of a critical care outreach team in secondary care improve patient outcomes?" in order to help inform the configuration of these services in the NHS with particular emphasis on whether CCOT should be available 24 hours per day, 7 days per week. The committee had to take into account a diverse literature with considerable variation in the nature of the intervention.

27.2 Review question: Does the provision of a critical care outreach team in secondary care improve outcomes?

For full details see review protocol in Appendix A.

Table 1: PICO characteristics of review question

Population	Adults and young people (16 years and over) in hospital with a suspected or confirmed AME.
Intervention(s)	• Critical care outreach team present in hospital as follows • 24-hour/7-day • 24-hour/5-day • 12-hour/5-day • 12-hour/7 day • 8 hour/5 day

	Note: daytime versus 24 hours "hospital at night", rapid response teams, medical emergency teams, outreach teams. • No critical care outreach team in hospital.
Comparison(s)	All critical care outreach models versus each other (including absence of critical care outreach team).
Outcomes	• Mortality (CRITICAL) • Number of DNAR orders (CRITICAL) • In-hospital mortality due to cardiac arrest (CRITICAL) • Quality of life (CRITICAL) • Avoidable adverse events including cardiac arrest (CRITICAL) • Patient and/or carer satisfaction (CRITICAL) • Length of stay (CRITICAL) • ICU avoidance (IMPORTANT) • Readmission to ICU (IMPORTANT)
Study design	Systematic reviews (SRs) of RCTs, RCTs, observational studies only to be included if no relevant SRs or RCTs are identified.

27.3 Clinical evidence

One Cochrane review[116] and 3 RCTs were included in the review;[47,77,84,131] these are summarised in Table 2 below. Evidence from these studies is summarised in the GRADE clinical evidence summary below (Table 3). See also the study selection flow chart in Appendix B, study evidence tables in Appendix D, forest plots in Appendix C, GRADE tables in Appendix F and excluded studies list in Appendix G.

We searched for randomised controlled trials comparing the effectiveness of a critical care outreach teams versus usual care (for example, cardiac arrest team) for inpatients with a suspected or confirmed AME. Three cluster-randomised controlled trials and 1 Cochrane review were identified. Two of the RCTs are the only studies contained in the Cochrane review. The Cochrane review presents a narrative summary of the results and does not report all the outcomes from the studies relevant to this review protocol. As part of this review, further analysis was undertaken and results are presented (see clinical evidence profiles in Table 3 and forest plots in Appendix D).

Table 2: Summary of studies included in the review

Study	Intervention and comparison	Population	Outcomes	Comments
Cochrane review				
McGaughey 2007[116]	Outreach and early warning systems (EWS) for the prevention of intensive care admission and death of critically ill patients on general hospital wards. Study designs in the review included randomised controlled trials, controlled clinical trials, controlled before and after studies and interrupted time series designs comparing	Deteriorating adult patients on general hospital wards.	Hospital mortality, ICU admission, length of hospital stay and adverse events.	Only the 2 RCTs listed below were included in the review.

Study	Intervention and comparison	Population	Outcomes	Comments
	implementation of outreach and EWS in a general hospital ward to identify deteriorating adult patients versus general hospital ward setting without outreach and EWS.			
Critical care outreach teams				
Hillman 2005[77] Chen 2008[47] RCT	Hospitals introducing a medical emergency team (MET; n=12). Versus Hospitals continuing to function as usual (n=11). Standardised education and implementation strategy was used to introduce MET (including education of clinical staff about the calling criteria, identifying patients at risk and how to call MET). Four month training period. Staff got regular reminders about the use of the system. MET had to be at least the equivalent of the pre-existing cardiac arrest team and should at least contain a doctor and a nurse from ED or ICU. Team composition varied depending on local circumstances. Control: no information given.	23 hospitals (with more than 20,000 admissions per year and no MET) in Australia were randomised. Patient numbers: MET hospitals (n=68,376). Control hospitals (n=56,756). Age: 14 and older.	Cardiac arrests, unplanned ICU admissions, unexpected deaths and number of DNAR orders issued.	Included in Cochrane review: Outreach and early warning systems for the prevention of intensive care admission and death of critically ill patients on general hospital wards. Cluster-randomised controlled trial. Six month trial period.
Jeddian 2016[84] RCT	Critical care outreach delivered by a team of 6 intensive care nurses for acutely ill patients. Versus Usual care – ward nurses cared for acutely ill patients under the supervision of ward physicians, physicians could request transfer to intensive care.	n=18,684 patients admitted to 13 adult general wards during the unexposed and exposed phases of the trial.	In-hospital mortality, cardiopulmonary resuscitation and ICU admission.	Published after Cochrane review. Stepped wedge cluster design - 13 wards grouped in to pairs (1 group of 3) with similar expected mortality rates. For each pair, 1 ward was randomly allocated to initiate the intervention first and the other second. The 6 pairs were then randomly allocated to their order in

Study	Intervention and comparison	Population	Outcomes	Comments
				sequence. Outcomes adjusted for age, sex, SAPS II score, cluster and time effects.
Priestley 2004[131] RCT	Wards with critical care outreach team (CCOT). Versus Wards without CCOT. Wards were paired, on the basis of professional judgement, to match for overall risk of death or other serious adverse events; then pair was randomised. CCOT: led by nurse consultant with a team of experienced nurses providing 24 hour cover. CCOT trained all nurses and doctors on the ward for 4 weeks, including training on 'patient at risk' score (PAR). PAR was used to trigger CCOT and involvement of the admitting team's consultant. The level of involvement was determined by discussions with ward staff and the admitting team. CCOT might support and advise ward staff, remain with the patient and provide individual nursing care on the ward during crisis period, or facilitate admission to ICU. Control: no information given.	Adult wards (n=16; medical, surgical, elderly) in an 800-bed general hospital in the North of England. Patient numbers: Outreach intervention: (n=3391). Control wards (n=3,090).	In-hospital deaths and length of hospital stay.	Included in Cochrane review: Outreach and early warning systems for the prevention of intensive care admission and death of critically ill patients on general hospital wards. Pragmatic ward (cluster)-randomised trial with phased introduction of intervention (stepped-wedge design). 32 weeks trial period.

Table 3: Clinical evidence profile: Critical care outreach team versus usual care

Outcomes	No of Participants (studies) Follow up	Quality of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects	
				Risk with Control	Risk difference with All interventions (95% CI)
In-hospital mortality	57,654 (3 studies) 12 – 32 weeks	⨁⨁⊖⊖ LOWa,b due to risk of bias, inconsistency	OR 0.95 (0.8 to 1.12)	-	Absolute values could not be calculated as the papers reported adjusted analyses only without a control event rate.
Length of inpatient stay (hazard ratio)	2,903 – 16 wards (1 study) 32 weeks	⨁⨁⊖⊖ LOWa due to risk of bias	HR 0.91 (0.84 to 0.99)	-	Absolute values could not be calculated as the papers reported adjusted analyses only without a control event rate.
Cardiac arrest	36,067 – 23 hospitals (1 study) 6 months	⨁⨁⨁⊖ MODERATEa due to risk of bias	OR 0.94 (0.79 to 1.12)	-	Absolute values could not be calculated as the papers reported adjusted analyses only without a control event rate.
Cardiopulmonary resuscitation	18,684 (1 study) 12 weeks	⨁⨁⊖⊖ LOWc due to imprecision	OR 1.00 (0.69 to 1.45)	-	Absolute values could not be calculated as the papers reported adjusted analyses only without a control event rate.
Unplanned ICU admission	36,067 - 23 hospitals (1 study) 6 months	⨁⨁⨁⊖ MODERATEa due to risk of bias	OR 1.04 (0.89 to 1.22)	-	Absolute values could not be calculated as the papers reported adjusted analyses only without a control event rate.
ICU admission	18,684 (1 study) 12 weeks	⨁⊖⊖⊖ VERY LOWa,c due to risk of bias, imprecision	OR 1.15 (0.64 to 2.07)	-	Absolute values could not be calculated as the papers reported adjusted analyses only without a control event rate.
DNAR orders issued	6,780 – of 23 hospitals (1 study) 6 months	⨁⨁⨁⊖ MODERATEa due to risk of bias	RR 2.24 (1.61 to 3.1)	17 per 1000	21 more per 1000 (from 10 more to 36 more)

(a) Downgraded by 1 increment if the majority of the evidence was at high risk of bias, and downgraded by 2 increments if the majority of the evidence was at very high risk of bias.

(b) Downgraded by 1 or 2 increments because: the point estimate varies widely across studies, the confidence intervals across studies show minimal or no overlap, Heterogeneity, I2>50%, unexplained by subgroup analysis.

(c) Downgraded by 1 increment if the confidence interval crossed 1 MID or by 2 increments if the confidence interval crossed both MIDs.

27.3.1 Narrative findings

Number of do-not-attempt-resuscitation orders (DNAR) issued

Chen 2008[47] reports that a DNAR order was issued at the time of an event for 3.85% of the aggregated events in MET hospitals compared with 1.72% in control hospitals (p=0.005). The weighted regression coefficient (95% CI) for the difference in the rate of DNAR orders issued at the time of the event (per 1000 admissions) in MET hospitals and control hospitals adjusted for the characteristics of the hospitals was 0.474 (0.089-0.859).

27.4 Economic evidence

Published literature

One economic evaluation was identified with the relevant comparison and has been included in this review.[146] This is summarised in the economic evidence profile below (Table 4) and the economic evidence tables in Appendix E.

The economic article selection protocol and flow chart for the whole guideline can found in the guideline's Appendix 41A and Appendix 41B.

Table 4: Economic evidence profile: Critical care outreach team (24/7) versus no critical care outreach team

Study	Applicability	Limitations	Other comments	Incremental cost[(c)]	Incremental effects	Cost effectiveness	Uncertainty
Simmes 2014[146] ([The Netherland])	Partially applicable[(a)]	Potentially serious limitations[(b)]	• Study design: Before and after observational study (n=3786) • Intervention: Rapid-response team on a surgical ward (doctor-led team including an intensivist and a critical care nurse, accessible 24/7) • Follow-up: 1 year before and 2 year after.	£21 per patient-day	2.5 cardiac arrests and/or deaths averted per 1000 patients Severity of disease (APACHEII score) (Mean difference): 0.1 17 more unplanned ICU admission per 1000 patients -0.5 days (ICU LOS)	NR[(d)]	Differences in costs and outcomes were all non-significant except for unplanned ICU admission, where the difference was significant. A scenario analysis where less severely ill patients were referred to ICU had a lower incremental cost of £8 per patient-day.

Abbreviations: ICU: Intensive care unit

(a) The population is patients recovering from general surgery, not acute medical emergency. Some uncertainty regarding the applicability of resource use and costs from the Netherlands in 2009 to the current UK NHS context.

(b) QALYs were not used as an outcome. Costs and outcomes were not discounted. Longitudinal observational study with no adjustment for temporal variation or confounders. The follow-up was different in the before and after periods (1 year versus 2 years) and it is not clear whether this follow-up adequately captures all relevant costs and outcomes. Only 1 scenario analysis is reported.

(c) Mean cost per patient- day, expressed in 2009 UK pounds.

(d) It was not possible to calculate an incremental cost effectiveness ratio because the denominator for costs was per day not per patient.

27.5 Evidence statements

Clinical

Three studies comprising 57,654 participants evaluated the effect of critical care outreach teams for improving outcomes in secondary care in adults and young people at risk of an AME, or with a suspected or confirmed AME. The evidence suggested that critical care outreach teams may provide a benefit in increased number of DNAR orders issued (1 study, moderate quality). The evidence suggested there was no difference in in-hospital mortality (3 studies, low quality), avoidable adverse events - cardiac arrest (1 study, moderate quality) or cardiopulmonary resuscitation (1 study, low quality), unplanned ICU admission (1 study, moderate quality) or ICU admissions (1 study, very low quality). The evidence suggested a possible increase in length of stay associated with critical care outreach teams (1 study, low quality).

Economic

One cost-consequences analysis[146] found that rapid response team was more costly than no rapid response team for responding to rapidly deteriorating patients in hospital (£21 more per patient-day) and had 0.0025 fewer cardiac arrests and/or deaths per patient, 0.017 more unplanned ICU admissions per patient, 0.5 days shorter ICU length of stay and higher severity of illness (0.1 higher APACHE II score). This study was assessed as partially applicable with potentially serious limitations.

27.6 Recommendations and link to evidence

Recommendations	**14. Consider providing access to critical care outreach teams (CCOTs) for people in hospital who have, or are at risk of, acute deterioration, accompanied by local evaluation of the CCOT service.**
Research recommendation	**-**
Relative values of different outcomes	Mortality, in-hospital mortality due to cardiac arrest, avoidable adverse events including cardiac arrest, number of DNAR orders issued, patient and/or carer satisfaction, length of stay and quality of life were considered by the committee to be critical outcomes. ICU avoidance and readmission to ICU were considered important outcomes. The committee discussed whether the outcome 'unplanned ICU admission' which captures the 2 important outcomes of ICU avoidance and readmission to ICU, was a positive or negative outcome. It could be seen as a positive outcome on the basis that the critical care outreach team has correctly identified the severity of the patient's condition and acted upon it, or a negative outcome if ICU admission were avoidable given earlier or more expert treatment. Accordingly, for the purposes of assigning the direction of the axes on the forest plots, the committee decided to consider unplanned ICU admission as a negative outcome as this is how it was interpreted within the study. It is also a component of resource use, which feeds in to economic evaluation.
Trade-off between benefits and harms	Three studies comprising 57,654 participants evaluated the effect of critical care outreach teams for improving outcomes in secondary care in adults and young people at risk of an AME, or with a suspected or confirmed AME. The evidence suggested that critical care outreach teams may provide a benefit in increased number of DNAR orders issued. The evidence suggested there was no difference in in-hospital mortality, avoidable adverse events (cardiac arrest or cardiopulmonary resuscitation), unplanned ICU admissions or ICU admissions. The evidence suggested a possible increase in length of stay associated with critical care outreach teams. When the data of the most applicable trial to the UK context[131] was evaluated on its own, the evidence suggested a reduction in mortality with critical care teams. The committee felt that this study was directly applicable to the UK setting in terms of service, population and critical care team composition. One study was conducted in Australia and considered less applicable to the UK NHS setting. The composition of the Australian critical care team was not considered by the committee to be directly reflective of the NHS setting as the UK model is primarily a nurse-led, doctor-supported system, whereas the Australian Medical Emergency Team is doctor-led. No evidence was identified for quality of life or in-hospital mortality due to cardiac arrest and patient and/or carer satisfaction. The trend towards increased length of stay associated with the provision of critical care outreach teams was considered by the committee to be consistent with the likely need for prolonged in-hospital care of critically ill patients who might otherwise not have survived without timely outreach interventions. The committee considered that the potential harms of prolonged hospital stay were outweighed by the benefits of reduced mortality, cardiac arrests and increased numbers of DNAR orders issued and made a recommendation that critical care outreach teams should be provided. Hospital Trusts should take local decisions on whether outreach teams should subsume the responsibilities of the cardiac arrest team, or work in parallel with

Recommendations	14. Consider providing access to critical care outreach teams (CCOTs) for people in hospital who have, or are at risk of, acute deterioration, accompanied by local evaluation of the CCOT service.
Research recommendation	-
	them. The committee noted that in their experience CCOT provides an essential supportive service to patients and clinical staff in terms of practical care delivery, particularly in an overstretched system. They have an essential role in facilitating early alerts, timely intervention, and continuity of care at times of transition between ward and ICU. However, from a commissioning perspective, the scientific evidence did not provide such a compelling argument, given competition for scarce resources. The committee took note of data kindly provided by a research group at the London School of Hygiene and Tropical Medicine[78] who surveyed Outreach provision in 171 acute Trusts in England: in the 80% of Trusts which responded to the survey, Outreach services were available in 82%; of these, 39% provided the service 24/7, 39% provided it 7/7, and 5% from Monday-Friday daytime only. Given the lack of strong research evidence and the variability in local provision, the committee opted to make a 'consider' recommendation to permit Trusts a degree of flexibility in how they choose to provide optimal care for deteriorating patients in ordinary wards, and continuing care following discharge from intensive care.
Trade-off between net effects and costs	One economic evaluation was included.[146] The committee discussed the findings of the study, which showed that a rapid response system had an incremental cost of £21 per patient-day due to an increase in unplanned ICU admissions. The committee considered that this incremental cost could be justifiable given QALY gain that would be achievable from the reduction in mortality and cardiac arrests seen in the clinical evidence and also in this economic evaluation study. The committee recognised the severe limitations of this economic evaluation study. However, the committee also highlighted that the critical care outreach teams in the UK are nurse-led, doctor-supported, and hence are likely to have lower cost compared to that reported in the study which was doctor-led. The committee highlighted that the study included in the health economics appraisal did not assess the number of do not attempt resuscitation (DNAR) orders that were enacted, which are likely to be modified by the presence of a rapid response system. Enacting DNARs is likely to be associated with cost saving as it would reduce inappropriate resuscitation attempts. The committee acknowledged that providing a critical care outreach team for services without one would require significant resources to implement. Typically, critical care outreach would require one member of the team to attend each high NEWs (=/>7) patient for about 45 minutes. Although the clinical review identified a small reduction in cardiac arrests, given the incidence rate of cardiac arrests in medical patients is 3.6 per 1,000[a] it is unlikely the cost savings from reduced cardiac admissions would make the intervention cost saving. Therefore the next question is whether the benefits from the intervention justify the additional cost. An additional cost of £21 per patient-day would equate to about £134 per medical admission, which to be cost effective would require a health gain of 0.07 QALYS per patient. This would be the equivalent of 9 deaths averted per 1000 admissions – a relative reduction of about 15%. However, this is not taking in to account potential

[a] Incidence from NCAA 2014/15[81] = 15,779 out of 11.2m patients=0.14%. 13,264 were medical patients. Adult medical patients as a proportion of all admissions (HES 2014-15)=5.2m/15.9m=33%. Therefore very approximately the incidence in adult medical inpatients is 13,264/(11.2m x 33%)=0.36%

Recommendations	**14. Consider providing access to critical care outreach teams (CCOTs) for people in hospital who have, or are at risk of, acute deterioration, accompanied by local evaluation of the CCOT service.**
Research recommendation	**-**
	cost savings. The committee members highlighted that critical care outreach teams can save consultants' time as the team can carry out the initial assessment and work-up before referring to the consultant. They can also enable palliative care to be initiated on the wards and free-up other doctors' and nurses' time, for example, by supporting ward staff in performing tracheostomy care or by improved acute pain management. Other benefits include training ward staff in the care of acutely ill patients. There is also potential for downstream cost-saving through early detection of patient deterioration, which could also improve prognosis and avert some deaths. Another important benefit would be improving the quality of deaths for some patients. However as none of this evidence was identified in the clinical review and the scale to which these benefits would be realised is unknown, there was considerable uncertainty concerning the cost effectiveness of CCOTs. This level of uncertainty is reflected in the strength of recommendation made for the use of CCOTs.
Quality of evidence	The evidence reviewed was of moderate to very low quality. The outcome 'in-hospital mortality' was graded low due to high risk of bias and inconsistency. The evidence for length of inpatient stay was of low quality, due to very high risk of bias. The evidence for cardiopulmonary resuscitation (adverse event) was graded low quality due to imprecision. The evidence for cardiac arrest (adverse event), unplanned ICU admissions and DNAR orders issued was of moderate quality due to risk of bias. The evidence for ICU admissions was graded very low quality due to risk of bias and imprecision. The economic evaluation was assessed as partially applicable because the population was patients recovering from general surgery, not an acute medical emergency; the setting was the Netherlands not the UK and QALYs were not estimated. It was assessed to have potentially serious limitations because it was based on observational evidence with no adjustment for temporal variation or confounders.
Other considerations	Critical care outreach is a complex intervention, the nature of which is often poorly characterised in the research literature.[51] CCOTs were implemented gradually from 2000, following publication of the national review of intensive care services, "Comprehensive Critical Care", which recommended the establishment of CCOT on the basis of pragmatic clinical support.[54] The committee recognised that the majority of NHS trusts have critical care outreach teams (see data above), but also that the extent of provision (day, night and weekends) and the way these services are configured, managed and delivered is not standardised. In the UK the majority of critical care outreach teams (CCOTs) are nurse-led, doctor-supported (usually by the intensive care registrar or consultant). In Australia, the service takes the form of an intensive care doctor-led multidisciplinary medical emergency team (MET). These different models may also be described generically as 'rapid response teams' (RRT) or 'rapid response systems' (RRS). While there is no uniform international set of criteria for calling the CCOT, in the UK the introduction of the National Early Warning Score[136] (https://www.rcplondon.ac.uk/projects/outputs/national-early-warning-score-news) represents clinical consensus on the need for escalation and clinical review based on vital signs. However, contextual and social factors influence the extent to which CCOTs may impact on patient care.[110]

Recommendations	**14. Consider providing access to critical care outreach teams (CCOTs) for people in hospital who have, or are at risk of, acute deterioration, accompanied by local evaluation of the CCOT service.**
Research recommendation	**-**
	The committee noted the large observational literature on the clinical effectiveness of the various forms of rapid response system (RRS). This included an 8-year study involving 9,221,138 hospital admissions to 82 public acute hospitals in New South Wales which associated the introduction of RRSs with a 52% reduction in the hospital cardiac arrest rate and a 23% reduction in overall hospital mortality, but no impact on survival rates at 1 year following discharge. However, secular trends were not assessed independently of the intervention.[48] In a secondary analysis of a subset of the hospitals, the authors found that 3 hospitals reduced cardiac arrest rates and mortality by 22% following the introduction of a RRS while a hospital with a mature RRS in place showed no secular change during that time.[44] Other studies have shown that RRSs/CCOTs stimulate the application of treatment limitation decisions to facilitate a peaceful death in patients nearing the end of their lives.[120] A parallel-control non-randomised study of 4 centres in France estimated the impact of a RRT in 1 hospital as saving 1.5 lives per week, increasing the number of ICU admissions and reducing the severity of illness on admission, compared with the control hospitals which showed no change in unexpected death rates.[94] The committee also noted that there are other potential benefits to the provision of care by these teams, for example, providing follow-up care for patients discharged from the ICU, such as tracheostomy management and providing support, education and training to nurses and doctors in general wards. Retention of these highly experienced staff may be best assured by siting their professional development and line management within critical care. Recommendations on the training and education of critical care outreach staff can be found in NICE guideline 50 'Acutely ill patients in hospital: recognising and responding to deterioration (2007)'.[40] Given the strength of evidence available, the extent of and variability in local provision and the clinical experience of the members, the committee opted to develop a 'consider' recommendation accompanied by local evaluation to permit Trusts to develop systems that best meet their specific needs.

References

1 Erratum: Introduction of the medical emergency team (MET) system: a cluster-randomised controlled trial (Lancet (2005) 365 (2091-2097)). The Lancet. 2005; 366(9492):1164

2 Rapid response team reduces cardiac and respiratory arrests. Performance Improvement Advisor. 2005; 9(3):25-27

3 After-hours acute care. Night nurse. Health Service Journal. 2006; 116(6006):Suppl 8-9

4 Rapid response teams reduce mortality rates, complications. Performance Improvement Advisor. 2006; 10(8):85-90

5 Study is first to show RRTs decrease pediatric deaths. Healthcare Benchmarks and Quality Improvement. 2008; 15(8):80-83

6 Are rapid response teams saving lives? A new study says no. Hospital Peer Review. 2009; 34(1):1-3

7 Rapid-response process reduces mortality, facilitates speedy treatment for patients with sepsis. ED Management. 2013; 25(8):89-92

8 Adelstein BA, Piza MA, Nayyar V, Mudaliar Y, Klineberg PL, Rubin G. Rapid response systems: a prospective study of response times. Journal of Critical Care. 2011; 26(6):635-638

9 Aftyka A, Rudnicka-Drozak E, Rybojad B. A comparison of ambulance responses to incidents of Medical Emergency Teams led by nurses and paramedics--a retrospective single-center study. International Journal of Nursing Studies. 2014; 51(4):555-561

10 Aftyka A, Rybojad B, Rudnicka-Drozak E. Are there any differences in medical emergency team interventions between rural and urban areas? A single-centre cohort study. Australian Journal of Rural Health. 2014; 22(5):223-228

11 Al Kadri HMF. Obstetric medical emergency teams are a step forward in maternal safety! Journal of Emergencies, Trauma, and Shock. 2010; 3(4):337-341

12 Al-Qahtani S, Al-Dorzi HM, Tamim HM, Hussain S, Fong L, Taher S et al. Impact of an intensivist-led multidisciplinary extended rapid response team on hospital-wide cardiopulmonary arrests and mortality. Critical Care Medicine. 2013; 41(2):506-517

13 Aneman A, Parr M. Medical emergency teams: a role for expanding intensive care? Acta Anaesthesiologica Scandinavica. 2006; 50(10):1255-1265

14 Anwar uH, Saleem AF, Zaidi S, Haider SR. Experience of pediatric rapid response team in a tertiary care hospital in Pakistan. Indian Journal of Pediatrics. 2010; 77(3):273-276

15 Austin CA, Hanzaker C, Stafford R, Mayer C, Culp L, Lin FC et al. Utilization of rapid response resources and outcomes in a comprehensive cancer center. Critical Care Medicine. 2014; 42(4):905-909

16 Ball C, Kirkby M, Williams S. Effect of the critical care outreach team on patient survival to discharge from hospital and readmission to critical care: non-randomised population based study. BMJ. 2003; 327(7422):1014

17 Bannard-Smith J, Lighthall GK, Subbe CP, Durham L, Welch J, Bellomo R et al. Clinical outcomes of patients seen by Rapid Response Teams: a template for benchmarking international teams. Resuscitation. 2016; October(107):7-12

18 Barbetti J, Lee G. Medical emergency team: a review of the literature. Nursing in Critical Care. 2008; 13(2):80-85

19 Barnes RJ. Impact of outreach on emergency surgical admissions to an intensive care unit. British Journal of Anaesthesia. 2015; 90(4)

20 Baxter AD, Cardinal P, Hooper J, Patel R. Medical emergency teams at The Ottawa Hospital: the first two years. Canadian Journal of Anaesthesia. 2008; 55(4):223-231

21 Beckett DJ, Gordon CF, Paterson R, Chalkley S, Stewart C, Jones MC et al. Improvement in out-of-hours outcomes following the implementation of Hospital at Night. QJM. 2009; 102(8):539-546

22 Beitler JR, Link N, Bails DB, Hurdle K, Chong DH. Reduction in hospital-wide mortality after implementation of a rapid response team: a long-term cohort study. Critical Care. 2011; 15(6):R269

23 Bellomo R, Goldsmith D, Uchino S, Buckmaster J, Hart GK, Opdam H et al. A prospective before-and-after trial of a medical emergency team. Medical Journal of Australia. 2003; 179(6):283-287

24 Bellomo R, Goldsmith D, Uchino S, Buckmaster J, Hart G, Opdam H et al. Prospective controlled trial of effect of medical emergency team on postoperative morbidity and mortality rates. Critical Care Medicine. 2004; 32(4):916-921

25 Blotsky A, Mardini L, Jayaraman D. Impact of a local low-cost ward-based response system in a Canadian tertiary care hospital. Critical Care Research and Practice. 2016; 2016:1518760

26 Bokhari SWI, Munir T, Memon S, Byrne JL, Russell NH, Beed M. Impact of critical care reconfiguration and track-and-trigger outreach team intervention on outcomes of haematology patients requiring intensive care admission. Annals of Hematology. 2010; 89(5):505-512

27 Bonafide CP, Localio AR, Roberts KE, Nadkarni VM, Weirich CM, Keren R. Impact of rapid response system implementation on critical deterioration events in children. JAMA Pediatrics. 2014; 168(1):25-33

28 Boniatti MM, Azzolini N, Viana MV, Ribeiro BSP, Coelho RS, Castilho RK et al. Delayed medical emergency team calls and associated outcomes. Critical Care Medicine. 2014; 42(1):26-30

29 Bosch FH, de Jager CPC. Number of resuscitations for in hospital cardio-pulmonary arrests decreases introduction of a medical emergency team. The "Arnhem" experience. Netherlands Journal of Critical Care. 2008; 12(6):256-259

30 Brilli RJ, Gibson R, Luria JW, Wheeler TA, Shaw J, Linam M et al. Implementation of a medical emergency team in a large pediatric teaching hospital prevents respiratory and cardiopulmonary arrests outside the intensive care unit. Pediatric Critical Care Medicine. 2007; 8(3):236-247

31 Bristow PJ, Hillman KM, Chey T, Daffurn K, Jacques TC, Norman SL et al. Rates of in-hospital arrests, deaths and intensive care admissions: the effect of a medical emergency team. Medical Journal of Australia. 2000; 173(5):236-240

32 Buist M, Harrison J, Abaloz E, van Dyke S. Quality improvement report: six year audit of cardiac arrests and medical emergency team calls in an Australian outer metropolitan teaching hospital. BMJ. 2007; 335(7631):1210-1212

33 Buist MD, Moore GE, Bernard SA, Waxman BP, Anderson JN, Nguyen TV. Effects of a medical emergency team on reduction of incidence of and mortality from unexpected cardiac arrests in hospital: preliminary study. BMJ. 2002; 324(7334):387-390

34 Cabrini L, Monti G, Villa M, Pischedda A, Masini L, Dedola E et al. Non-invasive ventilation outside the Intensive Care Unit for acute respiratory failure: the perspective of the general ward nurses. Minerva Anestesiologica. 2009; 75(7-8):427-433

35 Calzavacca P. The activity of a medical emergency team at an Australian teaching hospital. European Journal of Anaesthesiology. 2009; 26:S45

36 Calzavacca P, Licari E, Tee A, Egi M, Downey A, Quach J et al. The impact of Rapid Response System on delayed emergency team activation patient characteristics and outcomes--a follow-up study. Resuscitation. 2010; 81(1):31-35

37 Calzavacca P, Licari E, Tee A, Egi M, Haase M, Haase-Fielitz A et al. A prospective study of factors influencing the outcome of patients after a Medical Emergency Team review. Intensive Care Medicine. 2008; 34(11):2112-2116

38 Calzavacca P, Licari E, Tee A, Mercer I, Haase M, Haase-Fielitz A et al. Features and outcome of patients receiving multiple Medical Emergency Team reviews. Resuscitation. 2010; 81(11):1509-1515

39 Campello G, Granja C, Carvalho F, Dias C, Azevedo LF, Costa-Pereira A. Immediate and long-term impact of medical emergency teams on cardiac arrest prevalence and mortality: a plea for periodic basic life-support training programs. Critical Care Medicine. 2009; 37(12):3054-3061

40 Centre for Clinical Practice at NICE. Acutely ill patients in hospital: recognition of and response to acute illness in adults in hospital. NICE clinical guideline 50. London. National Institute of Health and Clinical Excellence, 2007. Available from: http://guidance.nice.org.uk/CG50

41 Chaboyer W. Ball C, Kirby M, Williams S. Effect of the critical care outreach team on patient survival to discharge from hospital and readmission to critical care: non-randomised population based study. British Medical Journal 2003; 327:1014-1017. Intensive and Critical Care Nursing. 2004; 20(4):236-238

42 Chan PS, Jain R, Nallmothu BK, Berg RA, Sasson C. Rapid response teams: a systematic review and meta-analysis. Archives of Internal Medicine. 2010; 170(1):18-26

43 Chan PS, Khalid A, Longmore LS, Berg RA, Kosiborod M, Spertus JA. Hospital-wide code rates and mortality before and after implementation of a rapid response team. JAMA - Journal of the American Medical Association. 2008; 300(21):2506-2513

44 Chen J, Ou L, Hillman K, Flabouris A, Bellomo R, Hollis SJ et al. The impact of implementing a rapid response system: a comparison of cardiopulmonary arrests and mortality among four teaching hospitals in Australia. Resuscitation. 2014; 85(9):1275-1281

45 Chen J, Bellomo R, Flabouris A, Hillman K, Assareh H, Ou L. Delayed emergency team calls and associated hospital mortality: a multicenter study. Critical Care Medicine. 2015; 43(10):2059-2065

46 Chen J, Bellomo R, Flabouris A, Hillman K, Finfer S, MERIT Study Investigators for the Simpson Centre et al. The relationship between early emergency team calls and serious adverse events. Critical Care Medicine. 2009; 37(1):148-153

47 Chen J, Flabouris A, Bellomo R, Hillman K, Finfer S, MERIT Study Investigators for the Simpson Centre and the ANZICS Clinical Trials Group. The Medical Emergency Team System and not-for-resuscitation orders: results from the MERIT study. Resuscitation. 2008; 79(3):391-397

48 Chen J, Ou L, Hillman KM, Flabouris A, Bellomo R, Hollis SJ et al. Cardiopulmonary arrest and mortality trends, and their association with rapid response system expansion. Medical Journal of Australia. 2014; 201(3):167-170

49 Chittawatanarat K, Ditsatham C, Chandacham K, Chotirosniramit N. Effects of rapid response trauma team in thoracic injuries in northern trauma center level I. Journal of the Medical Association of Thailand. 2013; 96(10):1319-1325

50 Dacey MJ, Mirza ER, Wilcox V, Doherty M, Mello J, Boyer A et al. The effect of a rapid response team on major clinical outcome measures in a community hospital. Critical Care Medicine. 2007; 35(9):2076-2082

51 Davidoff F, Dixon-Woods M, Leviton L, Michie S. Demystifying theory and its use in improvement. BMJ Quality & Safety. 2015; 24(3):228-238

52 De Jong A, Jung B, Daurat A, Chanques G, Mahul M, Monnin M et al. Effect of rapid response systems on hospital mortality: a systematic review and meta-analysis. Intensive Care Medicine. 2016;1-3

53 Dechert TA, Sarani B, McMaster M, Sonnad S, Sims C, Pascual JL et al. Medical emergency team response for the non-hospitalized patient. Resuscitation. 2013; 84(3):276-279

54 Department of Health. Comprehensive Critical Care: a review of adult critical care services, 2000. Available from: http://webarchive.nationalarchives.gov.uk/+/www.dh.gov.uk/en/publicationsandstatistics/publications/publicationspolicyandguidance/dh_4006585

55 Devita MA, Braithwaite RS, Mahidhara R, Stuart S, Foraida M, Simmons RL et al. Use of medical emergency team responses to reduce hospital cardiopulmonary arrests. Quality and Safety in Health Care. 2004; 13(4):251-254

56 Downar J, Barua R, Rodin D, Lejnieks B, Gudimella R, McCredie V et al. Changes in end of life care 5 years after the introduction of a rapid response team: a multicentre retrospective study. Resuscitation. 2013; 84(10):1339-1344

57 Downey AW, Quach JL, Haase M, Haase-Fielitz A, Jones D, Bellomo R. Characteristics and outcomes of patients receiving a medical emergency team review for acute change in conscious state or arrhythmias. Critical Care Medicine. 2008; 36(2):477-481

58 Eliott SJ, Ernest D, Doric AG, Page KN, Worrall-Carter LJ, Thalib L et al. The impact of an ICU liaison nurse service on patient outcomes. Critical Care and Resuscitation. 2008; 10(4):296-300

59 Esmonde L, McDonnell A, Ball C, Waskett C, Morgan R, Rashidian A et al. Investigating the effectiveness of critical care outreach services: a systematic review. Intensive Care Medicine. 2006; 32(11):1713-1721

60 Findlay J, Boulton C, Forward D, Moran C. 'Hospital-at-Night' expedites review of trauma patients without affecting outcome from hip fracture. Journal of Perioperative Practice. 2011; 21(10):346-351

61 Flabouris A, Chen J, Hillman K, Bellomo R, Finfer S, MERIT Study Investigators from the Simpson Centre and the ANZICs Clinical Trials Group. Timing and interventions of emergency teams during the MERIT study. Resuscitation. 2010; 81(1):25-30

62 Galhotra S, Devita MA, Dew MA, Simmons RL. A 5-year analysis of rapid response system activation at an in-hospital haemodialysis unit. Quality and Safety in Health Care. 2010; 19(6):e38

63 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(5):R113

64 Garcea G, Thomasset S, McClelland L, Leslie A, Berry DP. Impact of a critical care outreach team on critical care readmissions and mortality. Acta Anaesthesiologica Scandinavica. 2004; 48(9):1096-1100

65 Georgeto AAFS, Tanita MT, Taguti PS, Pariz PS, Kamiji D, Sacon MF et al. Improved outcome of critically ill patients treated by the Rapid Response Team outside the intensive care unit. Critical Care. 2011; 15(Suppl 2):P56

66 Gerdik C, Vallish RO, Miles K, Godwin SA, Wludyka PS, Panni MK. Successful implementation of a family and patient activated rapid response team in an adult level 1 trauma center. Resuscitation. 2010; 81(12):1676-1681

67 Gessner P. Benefits of a rapid response system at a community hospital. Joint Commission Journal on Quality and Patient Safety. 2007; 33(6):350-354

68 Gilman MP, Lei Y, Liesching TN, Dargin JM. An assessment of critical care interventions and resource utilization during medical emergency team activations in nonhospitalized patients. Joint Commission Journal on Quality and Patient Safety. 2014; 40(12):567-574

69 Goncales PDS, Polessi JA, Bass LM, Santos GdPD, Yokota PKO, Laselva CR et al. Reduced frequency of cardiopulmonary arrests by rapid response teams. Einstein. 2012; 10(4):442-448

70 Gray R, Morgan L, Smith H, Benson M, Morgan P. The outcomes following the introduction of a medical emergency team. Intensive Care Medicine. 2011;

71 Haji M. Critical care outreach improves outcome of haematological oncology patients needing critical care admission. British Journal of Anaesthesia. 2004; 94:612

72 Hanson CC, Randolph GD, Erickson JA, Mayer CM, Bruckel JT, Harris BD et al. A reduction in cardiac arrests and duration of clinical instability after implementation of a paediatric rapid response system. Quality and Safety in Health Care. 2009; 18(6):500-504

73 Hanson CC, Randolph GD, Erickson JA, Mayer CM, Bruckel JT, Harris BD et al. A reduction in cardiac arrests and duration of clinical instability after implementation of a paediatric rapid response system. Postgraduate Medical Journal. 2010; 86(1015):314-318

74 Harrison DA, Gao H, Welch CA, Rowan KM. The effects of critical care outreach services before and after critical care: a matched-cohort analysis. Journal of Critical Care. 2010; 25(2):196-204

75 Hatler C, Mast D, Bedker D, Johnson R, Corderella J, Torres J et al. Implementing a rapid response team to decrease emergencies outside the ICU: one hospital's experience. Medsurg Nursing. 2009; 18(2):84-126

76 Hayani O, Al-Beihany A, Zarychanski R, Chou A, Kharaba A, Baxter A et al. Impact of critical care outreach on hematopoietic stem cell transplant recipients: a cohort study. Bone Marrow Transplantation. 2011; 46(8):1138-1144

77 Hillman K, Chen J, Cretikos M, Bellomo R, Brown D, Doig G et al. Introduction of the medical emergency team (MET) system: a cluster-randomised controlled trial. The Lancet. 2005; 365(9477):2091-2097

78 Hogan H. Avoidable mortality from in-hospital cardiac arrest: have interventions aimed at recognising and rescuing deteriorating patients made an impact on incidence and outcomes?, 2014. Available from: http://www.nets.nihr.ac.uk/projectsOld/hsdr/1217818

79 Hourihan F, Bishop G, Hillman KM, Daffurn K, Lee A. The Medical Emergency Team: a new strategy to identify and intervene in high-risk patients. Clinical Intensive Care. 1995; 6(6):269-272

80 Howell MD, Ngo L, Folcarelli P, Yang J, Mottley L, Marcantonio ER et al. Sustained effectiveness of a primary-team-based rapid response system. Critical Care Medicine. 2012; 40(9):2562-2568

81 Intensive Care National Audit & Research Centre and Resuscitation Council (UK). Key statistics from the National Cardiac Arrest Audit 2014/15, 2015. Available from: https://www.icnarc.org/Our-Audit/Audits/Ncaa/Reports/Key-Statistics

82 Jaderling G, Bell M, Martling CR, Ekbom A, Bottai M, Konrad D. ICU admittance by a rapid response team versus conventional admittance, characteristics, and outcome. Critical Care Medicine. 2013; 41(3):725-731

83 Jaderling G, Calzavacca P, Bell M, Martling CR, Jones D, Bellomo R et al. The deteriorating ward patient: a Swedish-Australian comparison. Intensive Care Medicine. 2011; 37(6):1000-1005

84 Jeddian A, Hemming K, Lindenmeyer A, Rashidian A, Sayadi L, Jafari N et al. Evaluation of a critical care outreach service in a middle-income country: a stepped wedge cluster randomized trial and nested qualitative study. Journal of Critical Care. 2016; 36:212-217

85 Jolley J, Bendyk H, Holaday B, Lombardozzi KAK, Harmon C. Rapid response teams: do they make a difference? Dimensions of Critical Care Nursing. 2007; 26(6):253-2

86 Jones DA, Drennan K, Bailey M, Hart GK, Bellomo R, Webb SAR et al. Mortality of rapid response team patients in Australia: a multicentre study. Critical Care and Resuscitation. 2013; 15(4):273-278

87 Jones D, Bellomo R, Bates S, Warrillow S, Goldsmith D, Hart G et al. Long term effect of a medical emergency team on cardiac arrests in a teaching hospital. Critical Care. 2005; 9(6):R808-R815

88 Jones D, Egi M, Bellomo R, Goldsmith D. Effect of the medical emergency team on long-term mortality following major surgery. Critical Care. 2007; 11(1):R12

89 Jones D, George C, Hart GK, Bellomo R, Martin J. Introduction of medical emergency teams in Australia and New Zealand: a multi-centre study. Critical Care. 2008; 12(2):R46

90 Jones D, Moran J, Winters B, Welch J. The rapid response system and end-of-life care. Current Opinion in Critical Care. 2013; 19(6):616-623

91 Jones D, Opdam H, Egi M, Goldsmith D, Bates S, Gutteridge G et al. Long-term effect of a Medical Emergency Team on mortality in a teaching hospital. Resuscitation. 2007; 74(2):235-241

92 Jones DA, Bagshaw SM, Barrett J, Bellomo R, Bhatia G, Bucknall TK et al. The role of the medical emergency team in end-of-life care: a multicenter, prospective, observational study. Critical Care Medicine. 2012; 40(1):98-103

93 Jones DA, McIntyre T, Baldwin I, Mercer I, Kattula A, Bellomo R. The medical emergency team and end-of-life care: a pilot study. Critical Care and Resuscitation. 2007; 9(2):151-156

94 Jung B, Daurat A, De Jong A, Chanques G, Mahul M, Monnin M et al. Rapid response team and hospital mortality in hospitalized patients. Intensive Care Medicine. 2016; 42(4):494-504

95 Karpman C, Keegan MT, Jensen JB, Bauer PR, Brown DR, Afessa B. The impact of rapid response team on outcome of patients transferred from the ward to the ICU: a single-center study. Critical Care Medicine. 2013; 41(10):2284-2291

96 Karvellas CJ, de Souza IAO, Gibney RTN, Bagshaw SM. Association between implementation of an intensivist-led medical emergency team and mortality. BMJ Quality & Safety. 2012; 21(2):152-159

97 Kenward G, Castle N, Hodgetts T, Shaikh L. Evaluation of a medical emergency team one year after implementation. Resuscitation. 2004; 61(3):257-263

98 Kim IH, Park SB, Kim S, Han S-D, Ki SS, Chon GR. The impact of implementing critical care team on open general intensive care unit. Tuberculosis and Respiratory Diseases. 2012; 73(2):100-106

99 King E, Horvath R, Shulkin DJ. Establishing a rapid response team (RRT) in an academic hospital: one year's experience. Journal of Hospital Medicine. 2006; 1(5):296-305

100 Knott CI, Psirides AJ, Young PJ, Sim D. A retrospective cohort study of the effect of medical emergency teams on documentation of advance care directives. Critical Care and Resuscitation. 2011; 13(3):167-174

101 Konrad D, Jaderling G, Bell M, Granath F, Ekbom A, Martling CR. Reducing in-hospital cardiac arrests and hospital mortality by introducing a medical emergency team. Intensive Care Medicine. 2010; 36(1):100-106

102 Kotsakis A, Lobos AT, Parshuram C, Gilleland J, Gaiteiro R, Mohseni-Bod H et al. Implementation of a multicenter rapid response system in pediatric academic hospitals is effective. Pediatrics. 2011; 128(1):72-78

103 Kwak HJ, Yun I, Kim SH, Sohn JW, Shin DH, Yoon HJ et al. The extended rapid response system: 1-year experience in a university hospital. Journal of Korean Medical Science. 2014; 29(3):423-430

104 Laurens N, Dwyer T. The impact of medical emergency teams on ICU admission rates, cardiopulmonary arrests and mortality in a regional hospital. Resuscitation. 2011; 82(6):707-712

105 Laurens NH, Dwyer TA. The effect of medical emergency teams on patient outcome: a review of the literature. International Journal of Nursing Practice. 2010; 16(6):533-544

106 Leary T, Ridley S. Impact of an outreach team on re-admissions to a critical care unit. Anaesthesia. 2003; 58(4):328-332

107 Lee A, Bishop G, Hillman KM, Daffurn K. The Medical Emergency Team. Anaesthesia and Intensive Care. 1995; 23(2):183-186

108 Lighthall GK, Parast LM, Rapoport L, Wagner TH. Introduction of a rapid response system at a United States veterans affairs hospital reduced cardiac arrests. Anesthesia and Analgesia. 2010; 111(3):679-686

109 Lim SY, Park SY, Park HK, Kim M, Park HY, Lee B et al. Early impact of medical emergency team implementation in a country with limited medical resources: a before-and-after study. Journal of Critical Care. 2011; 26(4):373-378

110 Mackintosh N, Rainey H, Sandall J. Understanding how rapid response systems may improve safety for the acutely ill patient: learning from the frontline. BMJ Quality & Safety. 2012; 21(2):135-144

111 Maharaj R, Raffaele I, Wendon J. Rapid response systems: a systematic review and meta-analysis. Critical Care. 2015; 19:254

112 Mailey J, Digiovine B, Baillod D, Gnam G, Jordan J, Rubinfeld I. Reducing hospital standardized mortality rate with early interventions. Journal of Trauma Nursing. 2006; 13(4):178-182

113 Massey D, Aitken LM, Chaboyer W. Literature review: do rapid response systems reduce the incidence of major adverse events in the deteriorating ward patient? Journal of Clinical Nursing. 2010; 19(23-24):3260-3273

114 McArthur-Rouse F. Critical care outreach services and early warning scoring systems: a review of the literature. Journal of Advanced Nursing. 2001; 36(5):696-704

115 McFarlan SJ, Hensley S. Implementation and outcomes of a rapid response team. Journal of Nursing Care Quality. 2007; 22(4):307-5

116 McGaughey J, Alderdice F, Fowler R, Kapila A, Mayhew A, Moutray M. Outreach and Early Warning Systems (EWS) for the prevention of Intensive Care admission and death of critically ill adult patients on general hospital wards. Cochrane Database of Systematic Reviews. 2007; Issue 3:CD005529. DOI:10.1002/14651858.CD005529.pub2

117 McNeill G, Bryden D. Do either early warning systems or emergency response teams improve hospital patient survival? A systematic review. Resuscitation. 2013; 84(12):1652-1667

118 Medina-Rivera B, Campos-Santiago Z, Palacios AT, Rodriguez-Cintron W. The effect of the medical emergency team on unexpected cardiac arrest and death at the VA Caribbean Healthcare System: a retrospective study. Critical Care and Shock. 2010; 13(3):98-105

119 Meredith A, Simpson SQ, Cleek C, Williamson T, O'Brien-Ladner A. Improved hospital mortality by institution of a rapid response team in a university. Chest. 2005; 128(No. 4_MeetingAbstracts):182S

120 Micallef S, Skrifvars MB, Parr MJA. Level of agreement on resuscitation decisions among hospital specialists and barriers to documenting do not attempt resuscitation (DNAR) orders in ward patients. Resuscitation. 2011; 82(7):815-818

121 Moriarty JP, Schiebel NE, Johnson MG, Jensen JB, Caples SM, Morlan BW et al. Evaluating implementation of a rapid response team: considering alternative outcome measures. International Journal for Quality in Health Care. 2014; 26(1):49-57

122 Moroseos T, Bidwell K, Rui L, Fuhrman L, Gibran NS, Honari S et al. Rapid response team implementation on a burn surgery/acute care ward. Journal of Burn Care and Research. 2014; 35(1):21-27

123 Morris A, Owen HM, Jones K, Hartin J, Welch J, Subbe CP. Objective patient-related outcomes of rapid-response systems - a pilot study to demonstrate feasibility in two hospitals. Critical Care and Resuscitation. 2013; 15(1):33-39

124 Muchoki N. Impact of extended critical care outreach service with consultant input at queens hospital. Intensive Care Medicine Experimental. 2015; 3(Suppl 1):A142

125 Niven DJ, Bastos JF, Stelfox HT. Critical care transition programs and the risk of readmission or death after discharge from an ICU: a systematic review and meta-analysis. Critical Care Medicine. 2014; 42(1):179-187

126 Offner PJ, Heit J, Roberts R. Implementation of a rapid response team decreases cardiac arrest outside of the intensive care unit. Journal of Trauma. 2007; 62(5):1223-1228

127 Organisation for Economic Co-operation and Development (OECD). Purchasing power parities (PPP), 2007. Available from: http://www.oecd.org/std/ppp

128 Orosz J, Bailey M, Bohensky M, Gold M, Zalstein S, Pilcher D. Deteriorating patients managed with end-of-life care following Medical Emergency Team calls. Internal Medicine Journal. 2014; 44(3):246-254

129 Pirret AM. The role and effectiveness of a nurse practitioner led critical care outreach service. Intensive and Critical Care Nursing. 2008; 24(6):375-382

130 Pittard AJ. Out of our reach? Assessing the impact of introducing a critical care outreach service. Anaesthesia. 2003; 58(9):882-885

131 Priestley G, Watson W, Rashidian A, Mozley C, Russell D, Wilson J et al. Introducing critical care outreach: a ward-randomised trial of phased introduction in a general hospital. Intensive Care Medicine. 2004; 30(7):1398-1404

132 Ranji SR, Auerbach AD, Hurd CJ, O'Rourke K, Shojania KG. Effects of rapid response systems on clinical outcomes: systematic review and meta-analysis. Journal of Hospital Medicine. 2007; 2(6):422-432

133 Rashid MF, Imran M, Javeri Y, Rajani M, Samad S, Singh O. Evaluation of rapid response team implementation in medical emergencies: a gallant evidence based medicine initiative in developing countries for serious adverse events. International Journal of Critical Illness and Injury Science. 2014; 4(1):3-9

134 Reza N, Dudzinski DM. Pulmonary embolism response teams. Current Treatment Options in Cardiovascular Medicine. 2015; 17(6):387

135 Rothschild JM, Woolf S, Finn KM, Friedberg MW, Lemay C, Furbush KA et al. A controlled trial of a rapid response system in an academic medical center. Joint Commission Journal on Quality and Patient Safety. 2008; 34(7):417-365

136 Royal College of Physicians. National Early Warning Score (NEWS), 2015. Available from: https://www.rcplondon.ac.uk/projects/outputs/national-early-warning-score-news

137 Sabahi M, Fanaei SA, Ziaee SA, Falsafi FS. Efficacy of a rapid response team on reducing the incidence and mortality of unexpected cardiac arrests. Trauma Monthly. 2012; 17(2):270-274

138 Salamonson Y, Kariyawasam A, van Heere B, O'Connor C. The evolutionary process of Medical Emergency Team (MET) implementation: reduction in unanticipated ICU transfers. Resuscitation. 2001; 49(2):135-141

139 Salvatierra G, Bindler RC, Corbett C, Roll J, Daratha KB. Rapid response team implementation and in-hospital mortality*. Critical Care Medicine. 2014; 42(9):2001-2006

140 Santamaria J, Tobin A, Holmes J. Changing cardiac arrest and hospital mortality rates through a medical emergency team takes time and constant review. Critical Care Medicine. 2010; 38(2):445-450

141 Sarani B, Palilonis E, Sonnad S, Bergey M, Sims C, Pascual JL et al. Clinical emergencies and outcomes in patients admitted to a surgical versus medical service. Resuscitation. 2011; 82(4):415-418

142 Sebat F, Musthafa AA, Johnson D, Kramer AA, Shoffner D, Eliason M et al. Effect of a rapid response system for patients in shock on time to treatment and mortality during 5 years. Critical Care Medicine. 2007; 35(11):2568-2575

143 Segon A, Ahmad S, Segon Y, Kumar V, Friedman H, Ali M. Effect of a rapid response team on patient outcomes in a community-based teaching hospital. Journal of Graduate Medical Education. 2014; 6(1):61-64

144 Shah SK, Cardenas VJJ, Kuo YF, Sharma G. Rapid response team in an academic institution: does it make a difference? Chest. 2011; 139(6):1361-1367

145 Sharek PJ, Parast LM, Leong K, Coombs J, Earnest K, Sullivan J et al. Effect of a rapid response team on hospital-wide mortality and code rates outside the ICU in a Children's Hospital. JAMA - Journal of the American Medical Association. 2007; 298(19):2267-2274

146 Simmes F, Schoonhoven L, Mintjes J, Adang E, van der Hoeven JG. Financial consequences of the implementation of a rapid response system on a surgical ward. Journal of Evaluation in Clinical Practice. 2014; 20(4):342-347

147 Simmes F, Schoonhoven L, Mintjes J, Fikkers BG, van der Hoeven JG. Effects of a rapid response system on quality of life: a prospective cohort study in surgical patients before and after implementing a rapid response system. Health and Quality of Life Outcomes. 2013; 11:74

148 Simmes FM, Schoonhoven L, Mintjes J, Fikkers BG, van der Hoeven JG. Incidence of cardiac arrests and unexpected deaths in surgical patients before and after implementation of a rapid response system. Annals of Intensive Care. 2012; 2(1):20

149 Smith RJ, Santamaria JD, Reid DA, Faraone EE. The mortality associated with review by the rapid response team for non-arrest deterioration: a cohort study of acute hospital adult patients. Critical Care and Resuscitation. 2014; 16(2):119-126

150 Solomon RS, Corwin GS, Barclay DC, Quddusi SF, Dannenberg MD. Effectiveness of rapid response teams on rates of in-hospital cardiopulmonary arrest and mortality: a systematic review and meta-analysis. Journal of Hospital Medicine. 2016; 11(6):438-445

151 Story DA, Shelton A, Jones D, Heland M, Belomo R, Austin Health Post-Operative Surveillance Team. Audit of co-management and critical care outreach for high risk postoperative patients (The POST audit). Anaesthesia and Intensive Care. 2013; 41(6):793-798

152 Story DA, Shelton AC, Poustie SJ, Colin-Thome NJ, McNicol PL. The effect of critical care outreach on postoperative serious adverse events. Anaesthesia. 2004; 59(8):762-766

153 Subbe CP. Critical care outreach and use of intensive care unit resources: attempt of a single-centre randomised controlled trial at physiological scoring? British Journal of Anaesthesia. 2003; 90(4):567

154 Tam B, Salib M, Fox-Robichaud A. The effect of rapid response teams on end-of-life care: a retrospective chart review. Canadian Respiratory Journal. 2014; 21(5):302-306

155 Tan LH, Delaney A. Medical emergency teams and end-of-life care: a systematic review. Critical Care and Resuscitation. 2014; 16(1):62-68

156 Tibballs J, Kinney S, Duke T, Oakley E, Hennessy M. Reduction of paediatric in-patient cardiac arrest and death with a medical emergency team: preliminary results. Archives of Disease in Childhood. 2005; 90(11):1148-1152

157 Tibballs J, Kinney S. Reduction of hospital mortality and of preventable cardiac arrest and death on introduction of a pediatric medical emergency team. Pediatric Critical Care Medicine. 2009; 10(3):306-312

158 Tobin AE, Santamaria JD. Medical emergency teams are associated with reduced mortality across a major metropolitan health network after two years service: a retrospective study using government administrative data. Critical Care. 2012; 16(5):R210

159 Vazquez R, Gheorghe C, Grigoriyan A, Palvinskaya T, Amoateng-Adjepong Y, Manthous CA. Enhanced end-of-life care associated with deploying a rapid response team: a pilot study. Journal of Hospital Medicine. 2009; 4(7):449-452

160 Williams TA, Leslie G, Finn J, Brearley L, Asthifa M, Hay B et al. Clinical effectiveness of a critical care nursing outreach service in facilitating discharge from the intensive care unit. American Journal of Critical Care. 2010; 19(5):e63-e72

161 Winters BD, Pham JC, Hunt EA, Guallar E, Berenholtz S, Pronovost PJ. Rapid response systems: a systematic review. Critical Care Medicine. 2007; 35(5):1238-1243

162 Winters BD, Weaver SJ, Pfoh ER, Yang T, Pham JC, Dy SM. Rapid-response systems as a patient safety strategy: a systematic review. Annals of Internal Medicine. 2013; 158(5 Pt 2):417-425

163 Young C, Millo JL, Salmon J. Reduction in post-ICU inhospital mortality following the introduction of an ICU nursing outreach service. Critical Care. 2002; 6(Suppl 1):P247

164 Young L, Donald M, Parr M, Hillman K. The Medical Emergency Team system: a two hospital comparison. Resuscitation. 2008; 77(2):180-188

165 Zorko DJ, Choong K, Gilleland J, Agar B, Baker S, Brennan C et al. Urgent ultrasound guided hemodynamic assessments by a pediatric medical emergency team: a pilot study. PloS One. 2013; 8(6):e66951

Appendices

Appendix A: Review protocol

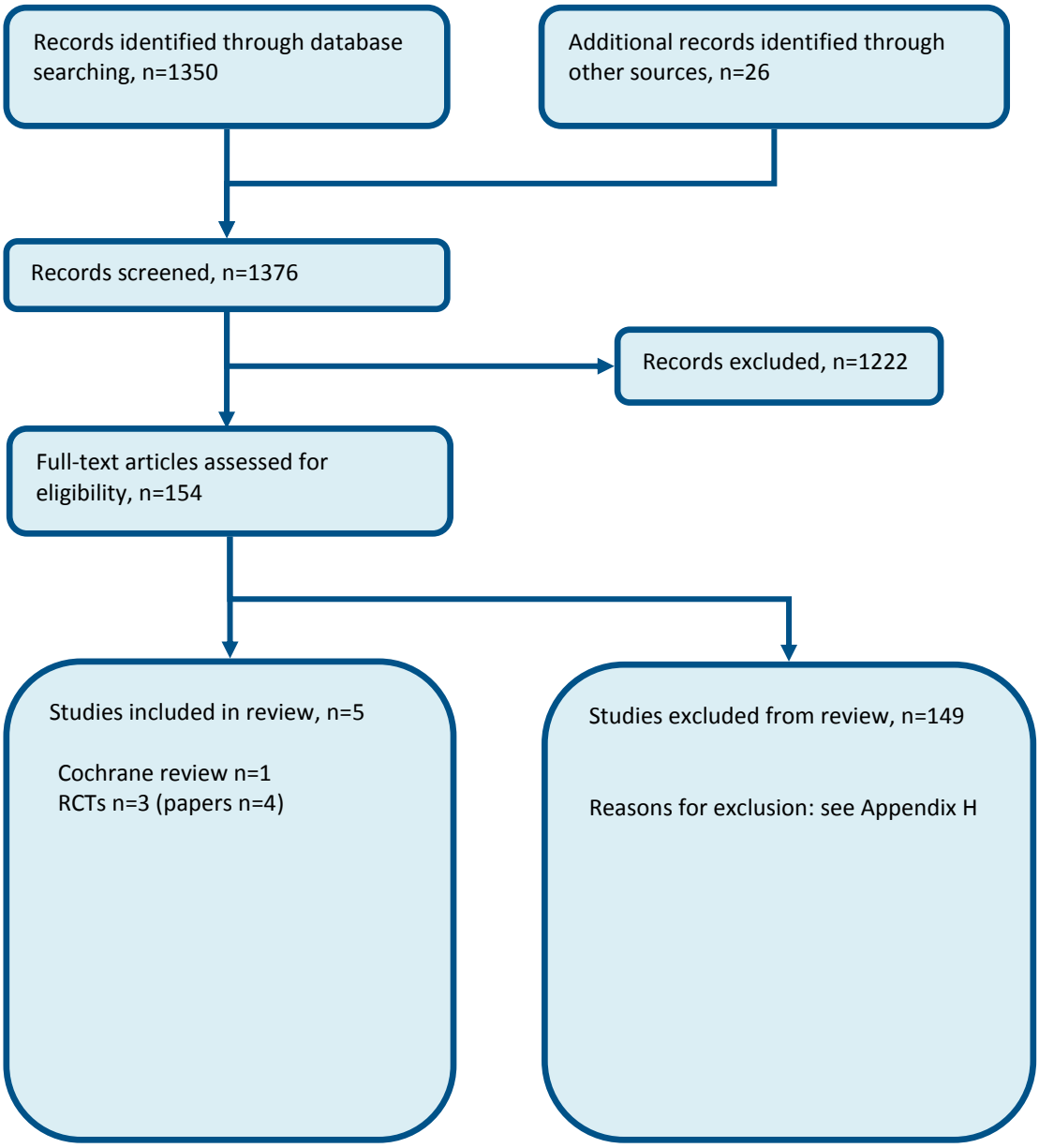
Table 5: Review protocol: Critical care outreach teams

Review question: Does the provision of a critical care outreach team in secondary care improve outcomes?	
Objective	To determine whether access to critical care outreach improves outcomes.
Rationale	Critical Care Outreach Teams are present in most hospitals within the UK. Their role developed since the publication of the Comprehensive Critical Care Report 2000. Their role is to identify and institute treatment in deteriorating patients in hospital and also to provide step down care for patients discharged from ICU to the general wards. Timely access to these skilled individuals should be important in terms of patient outcome. Look at before and after studies. A standard critical care outreach team comprises of usually a senior nurse with extensive critical care experience, sometimes a resuscitation officer.
Topic code	T3-3B.
Population	Adults and young people (16 years and over) in hospital with a suspected or confirmed AME.
Interventions	• Critical care outreach team present in hospital as follows ○ 24-hour/7-day ○ 24-hour/5-day ○ 12-hour/5-day ○ 12-hour/7 day ○ 8 hour/5 day Note: daytime versus 24 hours "hospital at night", rapid response teams, medical emergency teams and outreach teams. • No critical care outreach team in hospital.
Comparison	All critical care outreach models versus each other (including absence of critical care outreach team).
Outcomes	Patient outcomes: • Mortality (CRITICAL) • Health-related quality of life (CRITICAL) • Number of DNAR orders (CRITICAL) • In-hospital mortality due to cardiac arrest (CRITICAL) • Avoidable adverse events including cardiac arrest (CRITICAL) • Patient satisfaction (CRITICAL) • Length of stay (CRITICAL) • ICU avoidance (IMPORTANT) • Readmission to ICU (IMPORTANT)
Exclusion	None identified.
Search criteria	The databases to be searched are: Medline, Embase, the Cochrane Library. Date limits for search: None. Language: English only.
The review strategy	Systematic reviews (SRs) of RCTs, RCTs, observational studies only to be included if no relevant SRs or RCTs are identified.

Review question: Does the provision of a critical care outreach team in secondary care improve outcomes?	
Analysis	Data synthesis of RCT data or observational study data (as appropriate). Meta-analysis where appropriate will be conducted. Studies in the following subgroup populations will be included: • Frail elderly In addition, if studies have pre-specified in their protocols that results for any of these subgroup populations will be analysed separately, then they will be included. The methodological quality of each study will be assessed using the Evibase checklist and GRADE.

Appendix B: Clinical article selection

Figure 1: Flow chart of clinical article selection for the review of Critical care outreach teams



Appendix C: Forest plots

Figure 2: In-hospital mortality

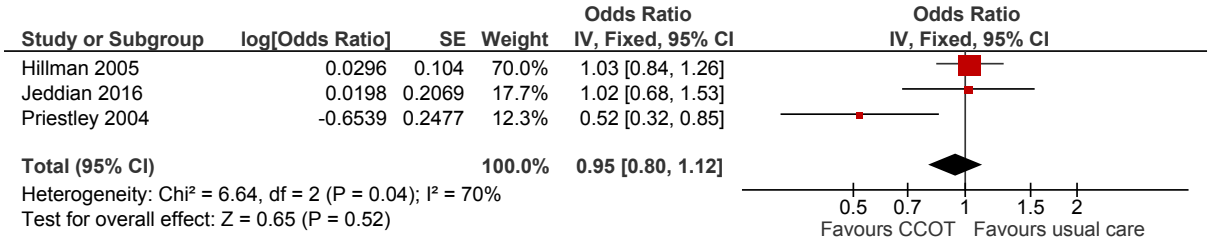
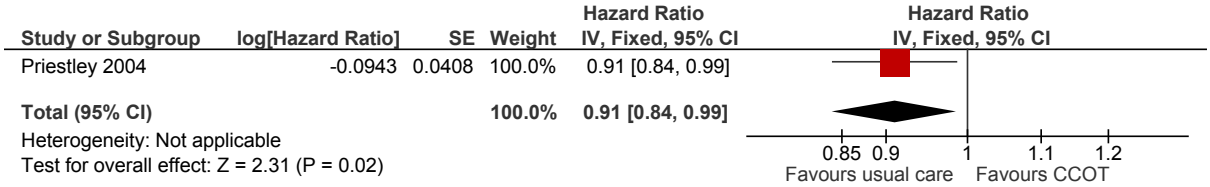


Figure 3: Length of in-patient stay (hazard ratio)



Note: axis label reversed in line with narration provided by the authors[131].

Figure 4: Cardiac arrest

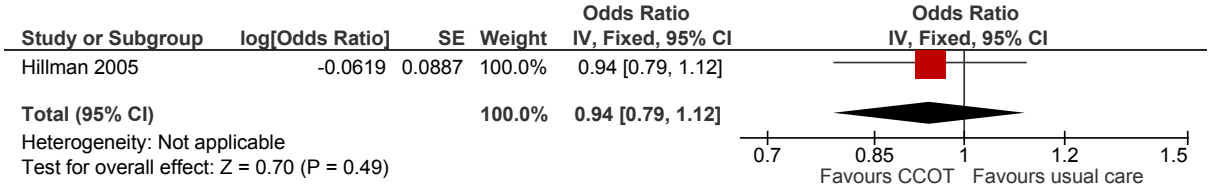


Figure 5: Cardiopulmonary resuscitation

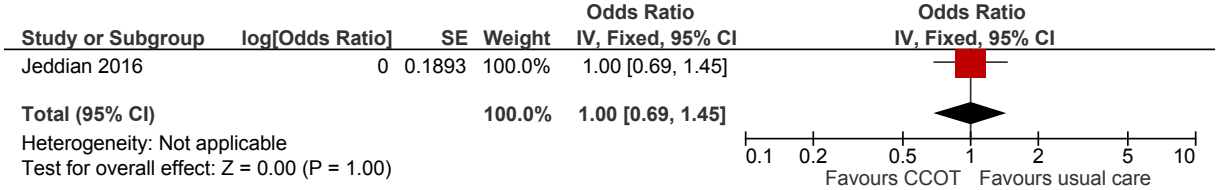
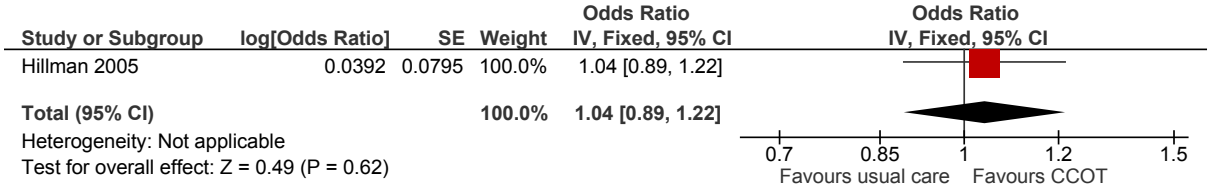


Figure 6: Unplanned ICU admission



Note: axis orientation reflects that unplanned ICU admission was considered a positive outcome by the committee.

Figure 7: ICU admission

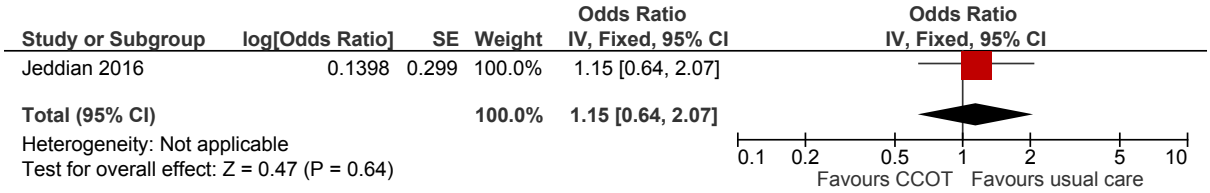
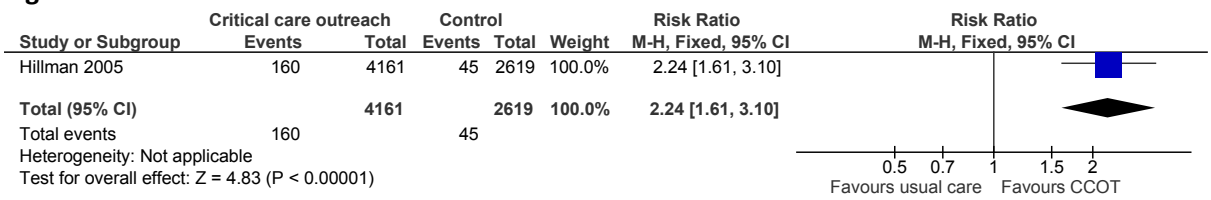


Figure 8: DNAR orders issued



Note: Note: axis orientation reflects that issuing a DNAR order was considered a positive outcome by the committee.

Appendix D: Clinical evidence tables

Study (subsidiary papers)	MERIT study: introduction of the medical emergency team (MET) system trial: Hillman 2005[77] (Chen 2008[47])
Study type	RCT (Hospital randomised; Parallel).
Number of studies (number of participants)	Four (Chen 2008, 2009A, Flabouris 2010 reported separately) (n=control) (hospitals n=11; patients median n=17,555); MET hospitals (hospitals n=12; patients median n=18,512).
Countries and setting	Conducted in Australia; setting: potential participating hospitals were identified using the Australian Hospital and Health Services Yearbook.
Line of therapy	Adjunctive to current care.
Duration of study	Intervention + follow up: 6 month trial period.
Method of assessment of guideline condition	Adequate method of assessment/diagnosis: patients who needed a medical emergency team during an admission to hospital.
Stratum	Overall.
Subgroup analysis within study	Not applicable.
Inclusion criteria	General inpatient wards, coronary care units and high dependency units which were not under direct supervision of an intensive care unit specialist. A general ward included any inpatient ward within the study hospitals.
Exclusion criteria	Excluded were events in patients younger than 14 years, patients who died on arrival to hospital, or patients who had not been formally admitted to hospital.
Recruitment/selection of patients	Public hospitals with more than 20,000 estimated admissions every year, with an ICU and an emergency department, and that did not have a medical emergency team (MET).
Age, gender and ethnicity	Age - Mean (SD): Control hospitals: 56.9 years (20.8); MET hospitals: 55.4 years (19.9). Gender (M:F): 1/1. Ethnicity: information not provided.
Further population details	1. Frail elderly.
Extra comments	Management and resuscitation committees of the control hospitals agreed that the operation of their cardiac arrest teams would continue unchanged during the implementation and study periods.
Indirectness of population	No indirectness.
Interventions	(n=12) Intervention 1: Critical care outreach team (rapid response team, hospital at night, medical emergency team and outreach team) present in hospital - 24 hour/7 day. Standardised education and implementation strategy was

Study (subsidiary papers)	MERIT study: introduction of the medical emergency team (MET) system trial: Hillman 2005[77] (Chen 2008[47])
	used to introduce MET (including education of clinical staff about the calling criteria, identifying patients at risk and how to call MET). Staff got regular reminders about the use of the system. MET had to be at least the equivalent of the pre-existing cardiac arrest team and should at least contain a doctor and a nurse from ED or ICU. Team composition varied depending on local circumstances. Duration: 2 month baseline period, 4 month training/implementation period, then MET system was activated in intervention hospitals and made available for the next 6 months. Concurrent medication/care: n/a. Comments: not mentioned if the system was 24/7 or less. (n=11) Intervention 2: No critical care outreach team (rapid response team, hospital at night, medical emergency team and outreach team) present in hospital - no critical care outreach team present in hospital. Control hospitals did not receive MET education. Cardiac arrest teams continued unchanged during implementation and study period. The study was not publicised in the control hospitals. Duration: same as intervention but without the training element. Concurrent medication/care: n/a.
Funding	Academic or government funding.

RESULTS (NUMBERS ANALYSED) AND RISK OF BIAS FOR COMPARISON: 24 HOUR/7 DAY versus NO CRITICAL CARE OUTREACH TEAM PRESENT IN HOSPITAL.

Protocol outcome 1: Re-admission to ICU during study period.
- Actual outcome: unplanned ICU admission at study period; OR 1.04 (95%CI 0.89 to 1.21); Comments: OR adjusted for stratification by teaching hospital status at randomisation and other differences in hospital (cluster-level) characteristics (including baseline outcome variables);
Risk of bias: All domain - High, Selection - Low, Blinding - High, Incomplete outcome data - Low, Outcome reporting - Low, Measurement - Low, Crossover - Low, Subgroups - Low; Indirectness of outcome: No indirectness,
Protocol outcome 2: In- hospital cardiac arrest during study period.
- Actual outcome: cardiac arrest at study period; OR 0.94 (95%CI 0.79 to 1.13); Comments: OR adjusted for stratification by teaching hospital status at randomisation and other differences in hospital (cluster-level) characteristics (including baseline outcome variables));
Risk of bias: All domain - High, Selection - Low, Blinding - High, Incomplete outcome data - Low, Outcome reporting - Low, Measurement - Low, Crossover - Low, Subgroups - Low; Indirectness of outcome: No indirectness

Protocol outcome 3: Unexpected death during study period.
- Actual outcome: unexpected death (without DNAR) - patients n per 1000 admissions at study period; OR 1.03 (95%CI 0.84 to 1.28); Comments: OR adjusted for stratification by teaching hospital status at randomisation and other differences in hospital (cluster-level) characteristics (including baseline outcome variables));
Risk of bias: All domain - High, Selection - Low, Blinding - High, Incomplete outcome data - Low, Outcome reporting - Low, Measurement - Low, Crossover - Low, Subgroups - Low; Indirectness of outcome: No indirectness
Protocol outcome 4: Number of DNAR orders issued during study period.

Study (subsidiary papers)	MERIT study: introduction of the medical emergency team (MET) system trial: Hillman 2005[77] (Chen 2008[47])
- Actual outcome: DNAR orders issued by emergency teams at the time of aggregated events at study period; Group 1: 160/4161, Group 2: 45/2619; Comments: data taken from Chen 2008 Risk of bias: All domain - High, Selection - Low, Blinding - High, Incomplete outcome data - Low, Outcome reporting - Low, Measurement - Low, Crossover - Low, Subgroups - Low; Indirectness of outcome: No indirectness	
Protocol outcomes not reported by the study	Quality of life at during study period; Patient and/or carer satisfaction at during study period; Avoidable adverse events at during study period; Length of hospital stay at during study period.

Study	Jeddian 2016[84]
Study type	RCT (Ward randomised; Parallel).
Number of studies (number of participants)	1 (n=18,684).
Countries and setting	Conducted in Iran; setting: 13 adult general wards in a university and public teaching hospital, Iran.
Line of therapy	Not applicable.
Duration of study	Other: 72 weeks.
Method of assessment of guideline condition	Adequate method of assessment/diagnosis.
Stratum	Overall: n/a.
Subgroup analysis within study	Not applicable.
Inclusion criteria	Patients admitted to 13 adult general wards (general medical, orthopaedics, haematology, obstetrics, pulmonary, urology, surgery and maxillofacial) served by 3 of 5 intensive care units.
Exclusion criteria	No patient exclusion criteria.
Recruitment/selection of patients	Consecutive patients admitted to wards during the study period.
Age, gender and ethnicity	Age - Mean (SD): control 44 (20), intervention 43 (19). Gender (M:F): 7998/10686. Ethnicity: not reported.
Further population details	1. Frail elderly: Not applicable/Not stated/Unclear.
Extra comments	-
Indirectness of population	No indirectness.
Interventions	(n=10882) Intervention 1: Critical care outreach team (rapid response team, hospital at night, medical emergency

Study	Jeddian 2016[84]
	team and outreach team) present in hospital - 24 hour/7 day. CCO team including 6 experienced intensive care nurses trained using theory and management protocols and full-time practical training. Ward nurses had training on assessment, identification and management of acutely ill patients. A single parameter system was used to identify acutely ill patients for the CCO team. Eligibility criteria: physiological criteria, ward staff concern, recent discharge from ICU and actively identified by CCO team. CCO team managed all high risk patients and determined who should care for moderate risk patients. Stable patients discharged from CCO after 72 hours, those who remained acutely ill were transferred to ICU. Duration: 12 weeks. Concurrent medication/care: n/a. (n=7802) Intervention 2: No critical care outreach team (rapid response team, hospital at night, medical emergency team and outreach team) present in hospital - no critical care outreach team present in hospital. Usual care - ward nurses cared for acutely ill patients under the supervision of ward physicians. Physicians could request transfer to ICU based on individual judgment. Duration: 12 weeks. Concurrent medication/care: n/a.
Funding	Academic or government funding (Digestive Disease Research Institute, National Institute for Health Research Collaborations for Leadership in Applied Health Research and Care for West Midlands, Medical Research Council Midland Hub for Trials Methodology Research).
RESULTS (NUMBERS ANALYSED) AND RISK OF BIAS FOR COMPARISON: 24 HOUR/7 DAY versus NO CRITICAL CARE OUTREACH TEAM PRESENT IN HOSPITAL. Protocol outcome 1: Mortality during study period. - Actual outcome: mortality at 12 weeks; OR 1.02 (95%CI 0.68 to 1.55); Comments: adjusted for age, sex, SAPS II score, cluster and time effects; Risk of bias: All domain - Low, Selection - High, Blinding - Low, Incomplete outcome data - Low, Outcome reporting - Low, Measurement - Low, Crossover - Low; Indirectness of outcome: No indirectness ; Group 1 Number missing: ; Group 2 Number missing: Protocol outcome 2: Re-admission to ICU during study period. - Actual outcome: admission to ICU at 12 weeks; OR 1.15 (95%CI 0.64 to 2.09); Comments: adjusted for age, sex, SAPS II score, cluster and time effects ; Risk of bias: All domain - High, Selection - High, Blinding - High, Incomplete outcome data - Low, Outcome reporting - Low, Measurement - Low, Crossover - Low; Indirectness of outcome: No indirectness Protocol outcome 3: In- hospital cardiac arrest during study period. - Actual outcome: cardiopulmonary resuscitation at 12 weeks; OR 1.00 (95%CI 0.69 to 1.48); Comments: adjusted for age, sex, SAPS II score, cluster and time effects; Risk of bias: All domain - Low, Selection - High, Blinding - Low, Incomplete outcome data - Low, Outcome reporting - Low, Measurement - Low, Crossover - Low; Indirectness of outcome: No indirectness .	
Protocol outcomes not reported by the study	Quality of life during study period; Patient and/or carer satisfaction during study period; Avoidable adverse events

Study	Jeddian 2016[84]
	during study period; Number of DNAR orders during study period; Length of hospital stay during study period.

Study	Ward randomised trial of Critical Care Outreach introduction in a hospital trial: Priestley 2004[131]
Study type	RCT (Ward randomised; Parallel).
Number of studies (number of participants)	One (randomised: control n= 3090; intervention n=3391; analysed as dataset 2 which utilises the randomisation within ward pairings fully: control n=1428; intervention n=1475).
Countries and setting	Conducted in United Kingdom; setting: 16 acute adult wards of an 800-bed general hospital in the North of England. The 16 study wards had an average of 30 beds each and included 8 surgical wards, 5 medical wards and 3 elderly medicine wards.
Line of therapy	1st line.
Duration of study	Intervention time: 32 week study period.
Method of assessment of guideline condition	Adequate method of assessment/diagnosis.
Stratum	Overall.
Subgroup analysis within study	Not applicable.
Inclusion criteria	All patients admitted to 16 acute adult wards of 1 general hospital over a 32 week period.
Exclusion criteria	None mentioned.
Recruitment/selection of patients	All patients admitted to 16 acute adult wards of 1 general hospital over a 32 week period.
Age, gender and ethnicity	Age - Mean (range): outreach: 65.2 years (64.3 - 66.2); control: 57.4 years (56.3 - 58.5). Gender (M:F): 1/1. Ethnicity: information not provided.
Further population details	1. Frail elderly: Not applicable/Not stated/Unclear.
Extra comments	Pragmatic ward (cluster)-randomised design with phased introduction of intervention was used so that by the end of the study all 16 wards were included.
Indirectness of population	No indirectness.
Interventions	(n=3391) Intervention 1: Critical care outreach team (rapid response team, hospital at night, medical emergency team and outreach team) present in hospital - 24 hour/7 day. Critical care outreach service 24 hours a day, 7 days a week, across 16 study wards. In each ward, 4 weeks of training was provided after which outreach was fully operational. The control wards moved from control to intervention wards via the training period. Wards were paired on the basis of professional judgement. CCOT was led by nurse consultant with a team of experienced nurses providing 24 hour cover. Critical care medical support was available when required, as judged by the outreach nurses or the ward

Study	Ward randomised trial of Critical Care Outreach introduction in a hospital trial: Priestley 2004[131]
	medical team. Training of doctors and nurses included sessions on the use of an in-house 'patient at risk' (PAR) score to identify patients who might benefit from CCOT attention. Ward staff used PAR to trigger referral to CCOT and involvement of the admitting team's consultant. Depending on circumstances, CCOT might support and advise ward staff, remain with the patient and provide individual nursing care on the ward during crisis period, or facilitate admission to ICU. Duration 32 weeks (total trial period). Concurrent medication/care: for each of the randomised pairs of wards there were 3 consecutive 4-week periods with 1 ward in control and the other in outreach. Comments: analysed (n=1456) due to stepped wedge design not missing data. Dataset 2 (matched randomised) is reported here. Although this dataset includes fewer patients and did not allow for separate consideration of the training phase of intervention, it utilised the randomisation within ward pairings. (n=3090) Intervention 2: No critical care outreach team (rapid response team, hospital at night, medical emergency team and outreach team) present in hospital - No critical care outreach team present in hospital. The control wards moved from control to intervention wards via the 4 week training period. Duration: 32 weeks (total trial period). Concurrent medication/care: for each of the randomised pairs of wards there were 3 consecutive 4-week periods with 1 ward in control and the other in outreach. Comments: analysed (n=1336) due to stepped wedge design not missing data. Dataset 2 (matched randomised) is reported here. Although this dataset includes fewer patients, and did not allow for separate consideration of the training phase of intervention, it utilised the randomisation within ward pairings.
Funding	Academic or government funding.
RESULTS (NUMBERS ANALYSED) AND RISK OF BIAS FOR COMPARISON: 24 HOUR/7 DAY versus NO CRITICAL CARE OUTREACH TEAM PRESENT IN WARD. Protocol outcome 1: Length of hospital stay during study period. - Actual outcome: length of stay in hospital at 32 weeks trial; HR 0.907 (95%CI 0.835 to 0.985); Comments: Hazard ratio of data of 2733 patients. data set 2 (matched randomised). Although this dataset included fewer patients, and did not allow for separate consideration of the training phase of intervention, it utilised the randomisation within ward pairings. this had the advantage of excluding potential bias due to ward characteristics and time trends, as each outreach ward month is balanced by a control in the same month for the other (randomly chosen) member of the ward pair); Risk of bias: All domain - Very high, Selection - High, Blinding - High, Incomplete outcome data - High, Outcome reporting - Low, Measurement - Low, Crossover - Low; Indirectness of outcome: No indirectness ; Baseline details: control a bit younger and more females; but due to step wedge design all controls turned to intervention eventually; randomisation based on ward pairings; Group 1 Number missing: 33, Reason: patients excluded because of incomplete data; Group 2 Number missing: 137, Reason: patients excluded because of incomplete data Protocol outcome 2: Mortality during study period. - Actual outcome: in-hospital mortality at 32 weeks trial; OR 0.523 (95%CI 0.322 to 0.849); Comments: odds of death of data of 2733 patients. data set 2 (matched	

Study	Ward randomised trial of Critical Care Outreach introduction in a hospital trial: Priestley 2004[131]
randomised). Although this dataset included fewer patients, and did not allow for separate consideration of the training phase of intervention, it utilised the randomisation within ward pairings. this had the advantage of excluding potential bias due to ward characteristics and time trends, as each outreach ward month is balanced by a control in the same month for the other (randomly chosen) member of the ward pair); Risk of bias: All domain - Very high, Selection - High, Blinding - High, Incomplete outcome data - High, Outcome reporting - Low, Measurement - Low, Crossover - Low; Indirectness of outcome: No indirectness ; Baseline details: control a bit younger and more females; but due to step wedge design all controls turned to intervention eventually; randomisation based on ward pairings; Group 1 Number missing: 19, Reason: patients excluded because of incomplete data; Group 2 Number missing: 92, Reason: patients excluded because of incomplete data	
Protocol outcomes not reported by the study	Quality of life at during study period; Patient and/or carer satisfaction at during study period; Avoidable adverse events at during study period; In- hospital cardiac arrest at during study period; Number of DNAR orders at during study period; Re-admission to ICU at during study period.

Appendix E: Economic evidence tables

Study	Simmes 2014[146]			
Study details	**Population & interventions**	**Costs**	**Health outcomes**	**Cost effectiveness**
Economic analysis: CCA (health outcomes: cardiac arrests and/or deaths averted, severity of disease) **Study design:** before-and-after observational study **Approach to analysis:** bottom-up costing approach was used to calculate the mean cost per-patient day during the before and after study periods. **Perspective:** The Netherland healthcare perspective **Follow-up:** 1 year before and 2 year after **Treatment effect duration**[(a)]**:** 4 months **Discounting:** None	**Population:** Patients who stayed on the surgical ward for ≥ 72 hour after major general surgery. **Cohort settings:** Mean age: NR Male: NR **Intervention 1: (n=1376)** No rapid response system with consultation of doctor after observing abnormal vital signs was left to the discretion of the nurse, vital signs not routinely recorded 3 times daily and oxygen saturation and respiratory rate were not included in the standard observation protocol. **Intervention 2: (n=2410)** The introduction of a rapid response system which included the introduction of a medical emergency team (MET) and the use of a single parameter track and trigger system. The MET was doctor-led and included an intensivist and a critical care nurse and was accessible 24/7.	**Total costs (mean per patient-day):** Intervention 1: £463 Intervention 2: £484 Incremental (2−1): £21 (95% CI: NR; p=NR) **Currency & cost year:** 2009 Euros (presented here as 2009 UK pounds[(b)])] **Cost components incorporated:** Implementation, maintenance, training, nursing time, consultations, unplanned ICU admissions	**Cardiac arrests and/or deaths:** Intervention 1: 0.5% Intervention 2: 0.25% Incremental (2−1): -0.25% (95% CI: NR; p=NR) **Severity of disease (APACHEII score):** Intervention 1: 17.5 Intervention 2: 17.6 Incremental (2−1): 0.1 (95% CI: NR; p=NR) **ICU (length of stay) (Median):** Intervention 1: 3.5 Intervention 2: 3.0 Incremental (2−1): -0.5 (95% CI: NR; p=0.94) **Unplanned ICU admissions:** Intervention 1: 2.5% Intervention 2: 4.2% Incremental (2−1): 1.7% (95% CI: NR; p=NR)	**ICER (Intervention 2 versus Intervention 1):** NR **Analysis of uncertainty:** No sensitivity analysis is reported. A scenario analysis based on using lower APACHEII score (14) for identifying patients for admission to ICU showed that the mean cost per patient-day was reduced to £8.
Data sources				

Health outcomes: the health outcomes recorded included cardiac arrests and/or deaths and severity of disease measured using the APACHEII score. Data were collected for 1 year before and 2 years after the introduction of the RRS. The authors report that the RRS continued for 4 months. **Cost sources:** prices of personnel and ICU costs were retrieved from the Dutch guideline for cost analysis in health care (National unit costs).
Comments
Source of funding: NR. **Applicability and limitations :** the population is patients recovering from general surgery, not acute medical emergency. Some uncertainty regarding the applicability of resource use and costs from the Netherlands in 2009 to the current UK NHS context. QALYs were not used as an outcome. Costs and outcomes were not discounted. Longitudinal observational study with no adjustment for temporal variation or confounders. The follow-up was different in the before and after periods (1 year versus 2 years) and it is not clear whether this follow-up adequately captures all relevant costs and outcomes. Only 1 scenario analysis is reported.
Overall applicability[(c)]:partially applicable **Overall quality[(d)]:** potentially serious limitations

Abbreviations: CCA: cost–consequence analysis; 95% CI: 95% confidence interval; ICER: incremental cost-effectiveness ratio; NR: not reported; QALYs: quality-adjusted life years.

(a) For studies where the time horizon is longer than the treatment duration, an assumption needs to be made about the continuation of the study effect. For example, does a difference in utility between groups during treatment continue beyond the end of treatment and if so for how long?

(b) Converted using 2009 purchasing power parities.[127]

(c) Directly applicable/Partially applicable/Not applicable.

(d) Minor limitations/Potentially serious limitations/Very serious limitations.

Appendix F: GRADE tables

Table 6: Clinical evidence profile: Critical care outreach team versus usual care

Quality assessment							No of patients		Effect		Quality	Importance
No of studies	Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Critical care outreach team	Control	Relative (95% CI)	Absolute		
In-hospital mortality												
3	randomised trials	serious[1]	serious[2]	no serious indirectness	no serious imprecision	none	-	-	OR 0.95 (0.8 to 1.12)	See footnote[4]	⊕⊕OO LOW	CRITICAL
Length of stay (hazard ratio)												
1	randomised trials	very serious[1]	no serious inconsistency	no serious indirectness	no serious imprecision	none	-	-	HR 0.91 (0.84 to 0.99)	See footnote[4]	⊕⊕OO LOW	CRITICAL
Cardiac arrest												
1	randomised trials	serious[1]	no serious inconsistency	no serious indirectness	no serious imprecision	none	-	-	OR 0.94 (0.79 to 1.12)	See footnote[4]	⊕⊕⊕O MODERATE	CRITICAL
Cardiopulmonary resuscitation												
1	randomised trials	no serious risk of bias	no serious inconsistency	no serious indirectness	very serious[3]	none	-	-	OR 1.00 (0.69 to 1.45)	See footnote[4]	⊕⊕OO LOW	CRITICAL
Unplanned ICU admission												
1	randomised trials	Serious[1]	no serious inconsistency	no serious indirectness	no serious imprecision	none	-	-	OR 1.04 (0.89 to 1.22)	See footnote[4]	⊕⊕⊕O MODERATE	IMPORTANT

ICU admission												
1	randomised trials	serious[1]	no serious inconsistency	no serious indirectness	very serious[3]	none	–	-	OR 1.15 (0.64 to 2.07)	See footnote[4]	⊕OOO VERY LOW	IMPORTANT
DNAR orders issued												
1	randomised trials	Serious[1]	no serious inconsistency	no serious indirectness	no serious imprecision	none	160/4161 (3.8%)	1.7%	RR 2.24 (1.61 to 3.1)	21 more per 1000 (from 10 more to 36 more)	⊕⊕⊕O MODERATE	CRITICAL

[1] Downgraded by 1 increment if the majority of the evidence was at high risk of bias, and downgraded by 2 increments if the majority of the evidence was at very high risk of bias.
[2] Downgraded by 1 or 2 increments because: the point estimate varies widely across studies, the confidence intervals across studies show minimal or no overlap, Heterogeneity, I2>50%, unexplained by subgroup analysis.
[3] Downgraded by 1 increment if the confidence interval crossed 1 MID or by 2 increments if the confidence interval crossed both MIDs.
[4] Absolute values could not be calculated as the papers reported adjusted analyses only without control event rates.

Appendix G: Excluded clinical studies

Table 7: Studies excluded from the clinical review

Study	Exclusion reason
Adelstein 2011[8]	Incorrect study design (not RCT, prospective cohort)
Aftyka 2014[10]	Incorrect study design (not RCT, before and after)
Aftyka 2014A[9]	Not relevant as it is not pertaining to in-hospital medical emergency teams
Al kadri 2010[11]	Incorrect population (obstetrics). not comparable to UK setting (Saudi Arabia)
Al-qahtani 2013[12]	Not comparable to UK setting (Saudi Arabia)
Aneman 2006[13]	Systematic review: literature search not sufficiently rigorous
Anon 2005C[2]	Incorrect study design (not RCT)
Anon 2005D[1]	Correction for Hillman 2005 (data not relevant for our analysis)
Anon 2006A[4]	Incorrect study design (not RCT)
Anon 2006F[3]	Incorrect study design (not RCT)
Anon 2008A[5]	Incorrect study design (not RCT, commentary)
Anon 2009B[6]	Incorrect study design (not RCT, commentary)
Anon 2013[7]	Incorrect study design (not RCT, commentary)
Anwar 2010[14]	Incorrect age group
Austin 2014[15]	Not comparable to UK setting (USA)
Ball 2003[16]	Incorrect study design (not RCT, before and after study)
Bannard-Smith 2016[17]	Incorrect study design (non-RCT; prospective observational cohort study)
Barbetti 2008[18]	Systematic review: literature search not sufficiently rigorous
Barnes 2015[19]	Incorrect study design (not RCT, before and after study)
Baxter 2008[20]	Incorrect study design (not RCT, audit)
Beckett 2009[21]	Incorrect study design (not RCT, cohort study)
Beitler 2011[22]	not comparable to UK setting (USA)
Bellomo 2003[23]	Incorrect study design (not RCT, cohort study)
Bellomo 2004[24]	Incorrect study design (not RCT, cohort study)
Blotsky 2016[25]	Non-RCT; before/after study
Bokhari 2010[26]	Incorrect study design (not RCT, cohort study n<200)
Bonafide 2014[27]	Incorrect age group
Boniatti 2014[28]	Not comparable to UK setting (Brazil)
Bosch 2008[29]	Incorrect study design (not RCT, before and after study)
Brilli 2007[30]	Incorrect age group
Bristow 2000[31]	Incorrect study design (not RCT, cohort study)
Buist 2002[33]	Incorrect study design (not RCT, cohort study)
Buist 2007[32]	Incorrect study design (not RCT, audit)
Cabrini 2009[34]	Incorrect intervention and comparison
Calzavacca 2008[37]	Incorrect study design (not RCT, prospective cohort)
Calzavacca 2009[35]	Incorrect study design (no RCT, poster of a retrospective observational study)
Calzavacca 2010[38]	Incorrect study design (not RCT, cohort study)

Study	Exclusion reason
Calzavacca 2010[36]	Incorrect study design (not RCT, retrospective cohort)
Campello 2009[39]	Incorrect study design (not RCT, before and after study)
Chaboyer 2004[41]	Incorrect study design (not RCT, commentary)
Chan 2008[43]	Not comparable to UK setting (USA)
Chan 2010[42]	Systematic review: literature search not sufficiently rigorous
Chen 2009[46]	No relevant outcomes reported (original study Hillman 2005 is included)
Chen 2014[44]	Incorrect study design (not RCT)
Chen 2014[48]	Incorrect study design (not RCT, population based study)
Chen 2015[45]	Incorrect comparison (delayed call versus non-delayed call). Data from Merit study (already included) analysed, no new outcomes
Chittawatanarat 2013[49]	Incorrect study design (not RCT, retrospective review)
Dacey 2007[50]	Incorrect study design (not RCT, before and after study)
De 2016[52]	Letter
Dechert 2013[53]	Not comparable to UK setting (USA)
Devita 2004[55]	Incorrect study design (not RCT, before and after study)
Downar 2013[56]	Incorrect study design (not RCT, retrospective review)
Downey 2008[57]	Incorrect study design (not RCT, cohort study n<200)
Eliott 2008[58]	Study not relevant (not pertaining to outreach service)
Esmonde 2006[59]	Systematic review: literature search not sufficiently rigorous
Findlay 2011[60]	Incorrect study population (trauma)
Flabouris 2010[61]	No outcomes relevant to our protocol (original paper Hillman 2005 fully included)
Galhotra 2010[62]	Not comparable to UK setting (USA)
Gao 2007[63]	Incorrect study design (not RCT, interrupted time-series analysis)
Garcea 2004[64]	Incorrect study design (not RCT, observational study)
Georgeto 2011[65]	Incorrect study design (not RCT, before and after study)
Gerdik 2010[66]	Incorrect population (Trauma)
Gessner 2007[67]	Not comparable to UK setting (USA)
Gilman 2014[68]	Incorrect comparison (hospitalised versus non-hospitalised patients)
Goncales 2012[69]	Not comparable to UK setting (Brazil)
Gray 2011[70]	Incorrect study design (not RCT, poster of observational study)
Haji 2004[71]	Incorrect study design (not RCT, retrospective audit)
Hanson 2009[72]	Incorrect age group
Hanson 2010[73]	Incorrect age group
Harrison 2010[74]	Incorrect study design (not RCT, cohort study)
Hatler 2009[75]	Incorrect study design (not RCT, before and after study)
Hayani 2011[76]	Incorrect study design (not RCT)
Hourihan 1995[79]	Incorrect study design (not RCT, prospective cohort)
Howell 2012[80]	Not comparable to UK setting (USA)
Jaderling 2011[83]	Incorrect study design (not RCT, retrospective cohort study)
Jaderling 2013[82]	Incorrect study design (not RCT, prospective observational study)
Jolley 2007[85]	Incorrect study design (not RCT, quasi experimental)
Jones 2005[87]	Incorrect study design (not RCT, prospective controlled study)
Jones 2007[91]	Incorrect study design (not RCT, before and after study)

Study	Exclusion reason
Jones 2007[93]	Incorrect study design (not RCT, cohort study n<200)
Jones 2007[88]	Incorrect study population (surgical patients)
Jones 2008[89]	Incorrect study design (not RCT, retrospective cohort)
Jones 2012[92]	Incorrect study design (not RCT, prospective observational study)
Jones 2013[90]	Systematic review: literature search not sufficiently rigorous
Jones 2013[86]	Incorrect study design (not RCT, retrospective cohort study)
Karpman 2013[95]	Not comparable to UK setting (USA)
Karvellas 2012[96]	Not comparable to UK setting (Brazil)
Kenward 2004[97]	Incorrect study design (not RCT, cohort study)
Kim 2012[98]	Incorrect study design (not RCT, prospective observational study)
King 2006[99]	Incorrect study design (not RCT, before and after study)
Knott 2011[100]	Incorrect study design (not RCT, Retrospective cohort) Not relevant (pertains to effect of outreach teams on documentation of advance care directives)
Konrad 2010[101]	Incorrect study design (not RCT, prospective before and after trial)
Kotsakis 2011[102]	Incorrect age group
Kwak 2014[103]	Incorrect study design (not RCT, observational study)
Laurens 2010[105]	Systematic review: literature search not sufficiently rigorous
Laurens 2011[104]	Incorrect study design (not RCT, before and after)
Leary 2003[106]	Incorrect study design (not RCT, before and after study)
Lee 1995[107]	Incorrect study design (not RCT, observational study)
Lighthall 2010[108]	Not comparable to UK setting (USA)
Lim 2011[109]	Incorrect study design (not RCT, before and after study)
Maharaj 2015[111]	Systematic review (study designs are inappropriate)
Mailey 2006[112]	Not comparable to UK setting (USA)
Massey 2010[113]	Systematic review: literature search not sufficiently rigorous
Mcarthur-rouse 2001[114]	Systematic review: literature search not sufficiently rigorous
Mcfarlan 2007[115]	Not comparable to UK setting (USA)
Mcneill 2013[117]	Systematic review: literature search not sufficiently rigorous
Medina-rivera 2010[118]	Not comparable to UK setting (Puerto Rico)
Meredith 2005[119]	Incorrect study design (not RCT, before and after study)
Moriarty 2014[121]	Not comparable to UK setting (USA)
Moroseos 2014[122]	Not comparable to UK setting (USA). Incorrect study population (surgery patients)
Morris 2013[123]	Incorrect study design (not RCT, retrospective cohort study n<200)
Muchoki 2015[124]	Poster presentation of an observational study
Niven 2014[125]	Systematic review: literature search not sufficiently rigorous
Offner 2007[126]	Incorrect population (Trauma)
Orosz 2014[128]	Incorrect study design (not RCT, retrospective cohort)
Pirret 2008[129]	Incorrect study design (not RCT)
Pittard 2003[130]	Incorrect study design (not RCT, before and after study)
Ranji 2007[132]	Systematic review: literature search not sufficiently rigorous
Rashid 2014[133]	Not comparable to UK setting (India)
Reza 2015[134]	Incorrect study design (report on the implementation of a pulmonary

Study	Exclusion reason
	embolism response team)
Rothschild 2008[135]	Incorrect study design (not RCT)
Sabahi 2012[137]	Not comparable to UK setting (Dubai)
Salamonson 2001[138]	Incorrect study design (not RCT, retrospective review of hospital data)
Salvatierra 2014[139]	Not comparable to UK setting (USA)
Santamaria 2010[140]	Incorrect study design (not RCT, prospective cohort study)
Sarani 2011[141]	Incorrect study design (not RCT, retrospective review)
Sebat 2007[142]	Not comparable to UK setting (USA)
Segon 2014[143]	Not comparable to UK setting (USA)
Shah 2011[144]	Not comparable to UK setting (USA)
Sharek 2007[145]	Incorrect age group
Simmes 2012[148]	Incorrect study population (surgical patients)
Simmes 2013[147]	Incorrect study population (surgical patients)
Smith 2014[149]	Incorrect study design (not RCT, retrospective cohort)
Solomon 2016[150]	Systematic review (references screened)
Story 2004[152]	Incorrect study design (not RCT, cohort study)
Story 2013[151]	Incorrect study design (not RCT, audit)
Subbe 2003[153]	Conference abstract of RCT but looking at effect of physiological scoring system rather than outreach team
Tam 2014[154]	Incorrect study design (not RCT, retrospective chart review)
Tan 2014[155]	Systematic review: literature search not sufficiently rigorous
Tibballs 2005[156]	Incorrect age group
Tibballs 2009[157]	Incorrect age group
Tobin 2012[158]	Incorrect study design (not RCT, retrospective cohort study)
Vazquez 2009[159]	Not comparable to UK setting (USA)
Williams 2010[160]	Incorrect study design (not RCT, before and after study)
Winters 2007[161]	Systematic review: literature search not sufficiently rigorous
Winters 2013[162]	Systematic review: literature search not sufficiently rigorous
Young 2002[163]	Incorrect study design (not RCT, abstract of a before and after study)
Young 2008[164]	Incorrect study design (not RCT, retrospective analysis of audit forms)
Zorko 2013[165]	Incorrect age group

Appendix H: Excluded economic studies

No studies were excluded.