

Title: The Evolution of Critical Care Outreach

Author: Dr Sarah Marsh

Grade: ST6

Hospital: St James's University Hospital, Leeds

The Evolution of Critical Care Outreach

“Intensive care and its development is part of an evolutionary process in the general organisation of hospital medical practice.” Mushin et al 1964¹

A Short History of Intensive Care

Intensive care today is the composite of a cohort of critically ill patients nursed in one environment that facilitates the support of organs to maintain physiological normality. Although we think of intensive care as a modern concept, organ support dates back thousands of years. Egyptians had documented procedures resembling tracheostomies to treat airway obstruction from as early as 1500 BC, and Hippocrates had commenced a form of organ support by cannulating the airway to allow “air to be drawn into the lungs” one thousand years later.²

Florence Nightingale made a revolutionary step towards modern critical care during the Crimean War in the 1850s by separating wounded soldiers depending on the severity of their injuries. A key component to intensive care of a patient is the frequency and intensity of monitoring by a designated nurse, a system that Florence recognised by monitoring the sickest soldiers more regularly by more nurses.

Although she remained unconvinced about germ theory, her emphasis on cleanliness had a significant impact on reducing the mortality of the soldiers. Additionally her innovative data collection relating to hospital acquired infections allowed comparisons between hospitals and instigated the evidence based practice that we continue today.³

A pioneering event occurred in the 1950s, which heralded a new age for care of the acutely unwell. It occurred in Copenhagen in 1952, when the city's population experienced one of the world's worst polio epidemics. Many patients were dying from respiratory failure as the disease caused increasing muscle weakness and paralysis. Dr Bjorn Ibsen, a Danish anaesthetist, proposed a theory that the patient could be supported through their illness by inserting a tracheostomy, manually clearing their secretions and ventilating them with an oxygen/nitrogen mix using positive pressure. He also recognised the importance of carbon dioxide clearance and recommended that carbon dioxide absorbers were placed into the circuit. This led to the manual ventilation of up to 70 patients at any one time by a team of doctors, medical and dental students and resulted in a reduction in mortality from polio from 80 to 25%. Ibsen went on to open the first intensive care unit (ICU) in 1953, which was replicated around the world.⁴

Since the 1950s, intensive care has grown into a specialty in its own right. Significant technological advances have allowed us to develop sophisticated ventilators, renal replacement therapy and cardiovascular monitoring. Intensive care units can now even be supervised via tele or remote ICU systems, providing surveillance and support to a large number of ICUs in distant or remote sites by a centralised multi-disciplinary critical care team.⁵

ICUs exhibit much heterogeneity not only internationally but often locally. Germany leads the way with regard to the number of intensive care beds per unit population at 24.6 beds per 100,000, as compared with 3.5 ICU beds per 100,000 population in the

United Kingdom (UK) for example.⁶ Units may be specialty dependant or provide care with different levels of support. ICUs may be open or closed depending on the admitting rights and clinical lead for the patient on their admission. This concept of a truly “closed” critical care area has been challenged in recent years to enable access for patients outside of the unit to intensive care processes and personnel – “critical care without walls” is the theory applied to this idea, whereby intensivists and critical care nurses offer their help and expertise to those who are acutely unwell on the ward.⁷

Critical Care Teams

In this way, the role of intensive care has rapidly expanded over the last 20 years with critical care staff being involved not only in the care of critically ill patients within the ICU, but also of those on general wards before and after their critical illness and even following discharge. Of particular interest, and the beneficiary of significant financial investment over the last decade, has been the intuitively beneficial process of reviewing and treating patients early on in their acute illness, in order to prevent further deterioration and death. Multidisciplinary teams, consisting of experienced staff trained in intensive care, have been developed internationally over the last 15 years to review such patients. These teams have a number of formats and titles including Critical Care Outreach Service, Rapid Response and Medical Emergency Teams depending on the their geographical location.

The teams were assembled in response to increasing evidence suggesting that unexpected mortality and morbidity may be prevented by early recognition of deterioration and prompt resuscitation of sick patients.^{8,9} Observational studies from a

number of authors demonstrated that physiological parameters including respiratory rate, blood pressure and conscious level were seen to deteriorate prior to a serious adverse event.¹⁰⁻¹² These changes were often missed or not acted upon correctly, leading to further clinical deterioration that resulted in an increase in unanticipated ICU admissions, increased hospital stay and even death.¹³⁻¹⁵

The Medical Emergency Team (MET) was the first of its kind, and was developed in the 1990s at Liverpool Hospital, Australia.¹⁶ The team, comprising of medical and nursing staff trained in critical care, replaced the traditional cardiac arrest team. The aim of the MET was to reduce the incidence and improve outcome of cardiopulmonary arrests by early recognition of deterioration and rapid institution of therapy. Specific calling criteria were developed for use by ward staff to alert the specialist team following abnormalities in the patients' physiological parameters. The criteria were formulated in order to pre-empt life threatening dysfunction of the airway, breathing and circulation. (Table 1)

Acute Change in:	Vital Signs:
Airway	Threatened
Breathing	Respiratory rate <5 Respiratory rate >36
Circulation	Pulse rate <40 bpm or >120 bpm Systolic BP <90 mmHg
Neurology	Fall in GCS >2 points Repeated or prolonged seizures
Other	Any patient who does not fit the criteria above who you are seriously worried about

Table 1: Single Scoring System. Liverpool Hospital, Sydney

Initial studies suggested that this resulted in a decrease in the incidence of unplanned ICU admissions, cardiac arrests and deaths.¹⁷⁻¹⁹ This led to an expansion of medical emergency teams across Australia and New Zealand – in 2008, approximately 60% of hospitals in Australia and New Zealand had a MET service in place.²⁰

The United States and the United Kingdom (UK) soon followed with critical care teams of their own. Rapid Response Teams (RRT) were implemented in the United States of America in 1996 and the Patient At Risk Team at the Royal London Hospital in 1997.^{21,22}

The rapid response team generally consists of a physician, a nurse and a respiratory specialist and is summoned prior to the “code” or cardiac arrest team. In 2004 the Institute for Healthcare Improvement launched the *100,000 Lives Campaign* - a national initiative with a goal of saving 100,000 lives amongst patients in American hospitals through improvements in the safety and effectiveness of health care. One of the campaign interventions was the deployment of RRT to initiate changes in patients’ care to prevent the arrest or by facilitating transfer to an intensive care unit.²³ Following the campaign, it was estimated that over one quarter of US hospitals had adopted some form of RRT, which continues today.²¹

The history of critical care teams in the UK was also born from the need to provide a national approach for the management of at risk patients. In 2000, the Department of Health published *Comprehensive Critical Care*. This document detailed the creation of “Outreach teams” to provide and support the care of sick patients on the ward.²⁴ Three essential objectives of an Outreach team were detailed by the Department of Health:

- To avert admission by identifying patients who are deteriorating and instituting treatment early, or by ensuring timely admission to an area where they can be treated to ensure the best outcome
- To support the continued recovery of previously critically ill patients discharged to the ward and after discharge from hospital
- To share critical care expertise and experience

The Department of Health recommended that this should be provided by a multi-disciplinary team that was led by a qualified critical care clinician. Examples of how

to achieve such a team were given using the “Patient At Risk Team” model instituted at The Royal London Hospital, and the use of an “Early Warning Scoring System” developed by Queen’s Hospital, Burton-Upon-Trent.²⁴

The Patient At Risk Team (PART) was piloted in 1997 and was contacted by ward staff with regard to patients with deranged physiology or who were causing concern. The PARTs aims were similar to the objectives set out by the Department of Health and were to improve care for these patients by providing support and advice to those responsible for them on the wards, as well as facilitating early intensive care admission when appropriate and preventing unnecessary ICU admissions.²⁵

Early warning scores were also first described in 1997 by Morgan and Wright, and comprised of a number of variables to which points were assigned.²⁶ The variables included heart rate, systolic blood pressure, respiratory rate, temperature and neurological status. Increasingly deranged variables were allocated a higher point score. Stenhouse added proportional deteriorations in the patients’s normal blood pressure and urine output to the scoring system in 1999, leading to the Modified Early Warning Score (MEWS). Ward staff could then grade “at risk” patients, and track their progress or deterioration. If the score did deteriorate sufficiently, it would trigger medical review including assessment by the intensive care team.²⁷ (Table 2)

Score	3	2	1	0	1	2	3
HR		<40	40-50	51-100	101-110	111-129	≥130
BP	>45% ↓	30% ↓	15% ↓	Normal	15% ↑	30% ↑	>45% ↑
RR		≤8		9-14	15-20	21-29	≥30
Temp		<35.0		35.0-38.4		≥38.5	
CNS				A	V	P	U
Urine	Nil	<1ml/kg/2hr	<1ml/kg/hr		>3ml/kg/2hr		

Table 2. Modified Early Warning Score, Stenhouse et al

In response to this document, outreach services and scoring systems were then introduced and developed across the country.

Along with the Department of Health, The Audit Commission published a document recommending the establishment of Critical Care Outreach Services (CCOS) – *Critical To Success*. This led to a £145 million investment into the development of outreach teams, redesignation of critical care beds and post-operative intensive recovery facilities.²⁸ The Intensive Care Society echoed the need for a multidisciplinary approach to the identification of patients at risk of developing or recovering from, a period of critical illness and to enable early intervention or transfer. They concluded that outreach should be a partnership aimed at prevention by both action and education.²⁹

A number of programmes based on the multidisciplinary education in the recognition and management of the critically ill have been developed over the years in order to address this issue. Acute Life-Threatening Events Recognition and Treatment (ALERT), Care of the Critically Ill Surgical Patient (CCrISP) and How to Evaluate and treat Life-threatening Problems (HELP) all use patient-based scenarios to aid the learning and development of the skills needed for identifying patients at risk. The courses have been run alongside locally based initiatives by critical care networks to attempt to improve education and performance.

Evidence Based Medicine

Considerable resources have been invested in outreach services worldwide over the last 15 years. This has led to questions being asked about the effectiveness of a system in which significant investments have been placed particularly in light of recent cluster controlled trials.

Intuitively, outreach teams seemed to be beneficial and indeed the first studies looking at the success of MET and outreach services were favourable. Publications in the early 2000's reported reductions in unplanned ICU admissions and readmissions following the introduction of a MET or Critical Care Outreach Team (CCOT)^{17,20,30} with other institutions noting reductions in the incidence and mortality of ward patients following cardiac arrest.^{17-20,30} Further studies showed a decrease in mortality in surgical patients alone as well as in the overall hospital rate.^{19,30,31}

Conversely during the same time period, other studies reported no change in cardiac arrest rates, unplanned ICU admission or mortality following the introduction of a critical care outreach team.^{20,32}

The National Confidential Enquiry into Patient Outcome and Death (NCEPOD) reviewed the care received by patients admitted to intensive care in 2003, and reported the findings in *An Acute Problem* in 2005. Five years had elapsed since the inception of Critical Care Outreach services into the National Health Service and the aim was to ascertain whether care had improved for at risk patients. It highlighted ongoing deficiencies in care with respect to the identification of deteriorating patients, poor provision of outreach services and lack of use of early warning scores.³³

The scoring system used in each institution was decided upon locally and therefore a number of EWS systems existed. This diversity has then in part impaired the ability to allow comparisons between systems and outcomes.¹⁵ Critics believe that the use of a scoring system is not infallible – the sensitivity of such a system is low, meaning that there are patients in need of treatment that are likely to be missed by ward staff despite the scoring systems being in place, and to date the scoring systems have not been validated. Track and trigger systems have further been refined by the use of large datasets and the application of regression analysis that allow us to predict those patients with a high likelihood of death.³⁴

This was also true of outreach services in that various models were developed.

The services in the UK varied from a single nurse providing advice and education within normal working hours, to a multidisciplinary team including physiotherapists,

junior and senior medical staff operating a 24-hour service. The trigger for review could be via an early warning scoring systems, or simply when ward staff were concerned. Commonly the outreach team was also involved when expert assistance and education was required, such as supervising non-invasive ventilation. The outreach team would then follow up those patients discharged from intensive care to the ward until they were no longer at risk of deterioration. NCEPOD acknowledged that the service would vary from hospital to hospital, but that it should be staffed by individuals with the skills and abilities to manage the critically ill.

In 2007 a national postal survey was completed identifying that many acute NHS trusts had no outreach service in place, and that the service was extremely diverse in those that did.³⁵ These findings suggested that many hospitals were not meeting the standards established by NCEPOD, which echoed reports from other bodies (Royal College of Physicians, Intensive Care Society, Department of Health) – that “every hospital should have a formal outreach service available 24 hours a day, seven days a week”.³³

The National Institute for Clinical Excellence (NICE) published *Acutely Ill Patients in Hospital* in the same year.³⁶ It further recommended that all hospitals should have a physiological “track and trigger” system, with multiple or aggregated weighted scoring systems that allowed a graded response. The recommendations did not specify a particular system due to lack of evidence, but suggested that the track and trigger system should be set up locally and have regular review.

NICE estimated that approximately 84% of hospital trusts used a track and trigger system at this stage. They suggested that 90% of all in-patients should be receiving 12 hourly physiological parameter measurements as a baseline standard, excluding well patients, palliative care patients and those already in critical care. The cost of performing these daily observations was estimated at an extra £3 million but was justified by NICE as being an opportunistic cost from diverting staff from other activities rather than as an additional cost.

In addition, the National Patient Safety Authority (NPSA) released a report following the analysis of 576 deaths over a one year period in 2005. Eleven percent of the deaths were as a result of deterioration that was not recognised or acted upon. The NPSA concluded that there were a number of areas where the process of recognising and responding appropriately could fail. Checklists and examples of good practice were offered to try and address the issues, with particular reference to communication and teamwork, training, monitoring and escalation procedures. Outreach services and examples of track and trigger scores were both cited again as examples of good practice. The NPSA further recommended that each acute trust should have a multidisciplinary “Deterioration Recognition Group” to lead and coordinate efforts to improve the safety of patients at risk of deterioration.³⁷

With a wealth of ongoing recommendations from various bodies, the Cochrane collaborative sought to systemically review the current literature in order to provide up-to-date, robust evidence on the impact of critical care outreach services on patient outcomes in 2009.¹⁵ A previous review in 2006 had failed to provide evidence to support CCOT due to poor methodological data.³⁸ Nearly 5000 studies were

identified as being potentially relevant with only 2 randomised controlled trials meeting the inclusion criteria.

The first study from 2005 was based in Australia and was one of the most significant studies into the effectiveness of a medical emergency team. The Medical Early Response Intervention and Treatment (MERIT) study undertook a randomised cluster-controlled trial to study the effects of the introduction of a MET. They found that the introduction of the MET did not significantly reduce the incidence of unexpected deaths, cardiac arrests and unplanned ICU admissions.³²

The second study was from the UK, reviewing critical care outreach teams. Priestly et al introduced a nurse led outreach service that ran 24 hours a day and focused on education, support and practical help for ward staff. The ward randomised trial resulted in reduced hospital mortality with possibly an increased length of stay.³⁹

The overall conclusion of the Cochrane collaborative however, was that the evidence to determine the effectiveness of such services was inconclusive.

Out of our reach?

So why haven't the predicted life-saving and cost reducing benefits of a rapidly responding critical care team been borne out in the literature? There may be a number of explanations.

The EWTD has had a significant impact on the training of British junior doctors.

Working hours have been reduced from a maximum of 58 hours in 2003 to 48 hours

in 2009. Junior doctors now work a full shift system and in doing so spend less time in hospitals during the day. There are concerns that the restrictions to working hours are having a detrimental effect on training - learning opportunities have been reduced due to the reduction of time spent in hospitals during the day with an increased amount of time now spent on solitary out of hours shifts with little or no training value. Training time for the majority of specialties has not extended to compensate for the reduction in hours worked by junior doctors, but training schemes have become more competency based with a focus on ensuring that every training opportunity is taken in an attempt to readdress the balance. With the reduction in hours worked by junior doctors we expect our patients to be safer but is this necessarily true if they are less and less experienced?

Inexperience will almost certainly lead to an increased demand for a service that can be activated and led by nursing staff with direct access to experienced critical care physicians. As ward staff improve their ability to recognise the critically ill through education and protocol driven scoring systems, the workload of the critical care medical staff will increase. A nominated critical care physician for outreach has been developed in some units across the country. Direct consultant-to-consultant medical referral has been recommended by NCEPOD to avoid potentially inappropriate and excessive referrals being made by junior staff in an attempt to stream line the process - excessive referrals also have the detrimental effect of causing prolonged absences of the intensive care doctor away from the ICU itself.

The lack of standardisation of CCOS and the track and trigger systems used has been repeatedly identified as a barrier to attempting to further evaluate the service.

An international task force was set up in 2005 during the International Consensus Conference on Cardiopulmonary Resuscitation to develop core and supplemental data elements to allow standardisation to occur. This resulted in the publication of a data collection document in 2007, capable of being adopted by institutions around the world.⁴⁰ The data elements were agreed by international consensus and would allow direct hospital comparison with the ability to optimise systems and improve clinical outcomes. If this were to be implemented, it may be possible in the future to identify which of the varying calling criteria are the most useful, which composition of emergency team results in the best outcome or even whether an outreach system is cost effective.

The Department of Health has tried to address these issues by publishing guidance on indicators of effectiveness for critical care outreach services (including track and trigger systems, referral pathways, audit and education programmes) as well as issuing a non-mandatory framework of competencies designed to develop a multi-disciplinary team approach with a chain of response reflecting escalating levels of intervention. The areas concentrated upon are Airway and Breathing, Circulation, Transport and Mobility, Acute Neurological Care, and Teamwork and Communication.^{41,42} It recommends that organisations must ensure that their teams possess these competencies. The report reinforces that Outreach services have an important role, not only within the “Chain of Responders”, but also with the education of ward staff, collection of audit information and ongoing development of track and trigger systems.⁴²

The adoption of a National Early Warning Scoring system may go some way to

address this issue in the UK, as well as aiding in the identification of the acutely unwell by junior doctors moving from hospital to hospital. By implementing a systematic method to measure simple physiological parameters and defining the appropriate urgency and scale of the clinical response required, the speed and nature of the response to the acutely ill patient could be improved. It would then also assist in audit and planning of resource needs and as a powerful research tool to assess the impact of interventions and quality of care.⁴³

Reaching into the Future

There is no doubt that further research into the impact of critical care teams is needed. Due to the large variation of outreach services worldwide, evaluation is particularly complex. A true randomised controlled trial will be difficult to accomplish due to the requirement to look at the system of care, rather than an individual intervention.

Although the MERIT trial was essentially negative, there was a statistically significant 30% reduction in mortality in both the intervention and control hospitals over that period. This would suggest that something happened in these hospitals to improve patient care within a relatively short time span, but whether that event was education or pollution of the non-MET hospital arm with MET ideas for example, is unclear.

Considerable financial investment has been made into the development of outreach. In an international climate of financial difficulty, the need to rationalise services and obtain quality and value for money is evermore important. The practice of evidence based medicine is gold standard and so far it appears that the provision of outreach teams is lacking in this area. However medical and nursing teams have in part

become reliant on rapid access to experienced staff in critical care and dissolution of the service is likely to be unacceptable to many.

Recent literature suggests that using a systems-based approach to help coordinate the identification and treatment of patients with sepsis can lead to a reduction in mortality. By coupling critical care teams with early goal-directed therapy, patients with sepsis could be discovered earlier and have therapy instituted within the so-called 'golden hour'.⁴⁴

Technology is also advancing in the detection of the critically ill. There are now monitoring systems available that track the physiological parameters of patients and alert staff to abnormalities earlier and with greater accuracy using the process of data fusion. Increased detection will lead to increased demand for critical care review.

One further role that outreach may play in the UK is that of assisting in the rehabilitation of patients recovering from a critical illness. The recent publication by NICE, *Rehabilitation after critical illness*, outlines the need for follow up and support of patients who have been critically ill.⁴⁶ The “optimisation of recovery” as a therapeutic objective rather than mere “survival” is a key point in the guidelines. Outreach staff may be involved in the assessment of patients before discharge from critical care and in the immediate time post discharge to the ward to identify and facilitate particular areas of rehabilitation needed by the patient. NICE have also reviewed *The Acutely Ill Patient in Hospital* document from 2007. They found that all new evidence with respect to evaluation of outreach and MET services remained inconclusive. Also no data was available on its cost effectiveness to that date. NICE

concluded however that there was no current evidence to invalidate current guideline advice and so would continue to make Outreach Services a key recommendation.

In Conclusion

The development of rapidly responding critical care teams was in response to evidence that patients who were acutely unwell on the ward were often not being recognised or treated in a timely fashion. Various models for these teams have been devised internationally over the last 15 years and will respond to different calling criteria. The assessment of the services has been complex – only 2 high-level trials have been performed with inconclusive evidence for the benefit of the teams. Further clinical trials are warranted but this will be difficult to complete due to the Hawthorne effect.

In the future we may need to develop a scoring system that identifies those patients likely to benefit from critical care rather than those who are likely to die despite our efforts either due to overwhelming illness, co-morbidity or genetic makeup.³⁴

Outreach could continue to have a role in the care of such patients by allowing and supporting a natural death. Along with the variable they respond to, the optimum composition of the team needs further clarification. Is a sole nurse available during the working day comparable to a team composed of intensivists, physiotherapists as well as nursing staff? Therefore alterations in the team composition and modified scoring systems, identification of key inflammatory markers and even technological advances may allow a more efficient service with a better outcome profile.

Ultimately there needs to be the development of flexible frameworks to meet agreed standards of care which will allow a framework on which audit and quality improvement can be assessed. Educational programmes should be encouraged and their effect studied, as there are concerns that ward staff are becoming de-skilled (whilst the workload for intensive care personnel has increased). Shortened and more stream-lined training means that junior medical staff may lack certain skills and experience, which could result in patient compromise. The service provided by outreach may help to bridge the widening gap between the ward and inside the walls of critical care, as well as challenging the traditional hospital hierarchy with regard to communication between and within teams.

So, despite there being no clear evidence for outreach, the culture of critical care teams exists, and establishments in the United Kingdom as well as around the world are unlikely to accept their dissolution.

Outreach must therefore, continue “to reach farther”

(Out-reach; transitive verb – “*to reach farther*”)

REFERENCES

1. Mushin WW, Lunn JN. The anaesthetist and intensive care. Br Med J. 1969 Jun 14;2(5658):683-4
2. Szmuk P, Ezri T, Evron S, Roth Y, Katz J. A brief history of tracheostomy and tracheal intubation, from the Bronze Age to the Space Age. Intensive Care Med. 2008 Feb;34(2):222-8
3. Munro, Cindy L. The "Lady With the Lamp" Illuminates Critical Care Today. Am J Crit Care 2010;19:315-317
4. Caroline Richmond. Bjørn Ibsen. BMJ 2007;335:674
5. Goran SF. A second set of eyes: An introduction to Tele-ICU. Crit Care Nurse. 2010 Aug;30(4):46-55
6. Adhikari NK, Fowler RA, Bhagwanjee S, Rubenfeld GD. Critical care and the global burden of critical illness in adults. Lancet. 2010 Oct 16;376(9749):1339-46
7. Hillman K. Critical care without walls. Curr Opin Crit Care. 2002 Dec;8(6):594-9.
8. Hillman KM, Bristow PJ, Chey T, Daffurn K, Jacques T, Norman SL, Bishop GF, Simmons G. Antecedents to hospital deaths. Intern Med J. 2001 Aug; **31(6)**: 343-8
9. Kause J, Smith G, Prytherch D, Parr M, Flabouris A, Hillman K.. A comparison of antecedents to cardiac arrests, deaths and emergency intensive care admissions in

Australia and New Zealand, and the United Kingdom--the ACADEMIA study.

Resuscitation. 2004 Sep; **62(3)**: 275-82

10. Franklin C, Mathew J. Developing strategies to prevent in hospital cardiac arrest: analysing responses of physicians and nurses in the hours before the event. *Critical Care Medicine*. 1994; **22**: 244-7

11. Hillman KM, Bristow PJ, Chey T, Daffurn K, Jacques T, Norman SL, Bishop GF, Simmons G. Duration of life-threatening antecedents prior to intensive care admission. *Intensive Care Med*. 2002 Nov; **28(11)**:1629-34

12. Smith AF, Wood J.. Can some in-hospital cardio-respiratory arrests be prevented? A prospective survey. *Resuscitation*. 1998 Jun; **37(3)**:133-7

13. Goldhill DR. Medical Emergency Teams. *Care of the Critically Ill*. 2000;16:209-12

14. McQuillan P, Pilkington S, Allan A, Taylor B, Short A, Morgan G, Nielsen M, Barrett D, Smith G, Collins CH. Confidential inquiry into quality of care before admission to intensive care. *BMJ*. 1998 Jun; **316(7148)**: 1853-8

15. 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 Syst Rev*. 2007 Jul; **(3)** CD005529.

16. Lee A, Bishop G, Hillman KM, Daffurn K. The Medical Emergency Team.

Anaesth Intensive Care. 1995 Apr;23(2):183-6

17. Bristow PJ, Hillman KM, Chey T, Daffurn K, Jacques TC, Norman SL, Bishop GF, Simmons EG. Rates of in-hospital arrests, deaths and intensive care admissions: the effect of a medical emergency team. *Med J Aust.* 2000 Sep;173(5):236-40.

18. 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 Feb 16;324(7334):387-90.

19. Bellomo R, Goldsmith D, Uchino S, Buckmaster J, Hart GK, Opdam H, Silvester W, Doolan L, Gutteridge G. A prospective before-and-after trial of a medical emergency team. *Med J Aust.* 2003 Sep 15;179(6):283-7.

20. Jones D, George C, Hart GK, Bellomo R, Martin J. Introduction of medical emergency teams in Australia and New Zealand: a multi-centre study. *Crit Care.* 2008;12(2):R46. Epub 2008 Apr 7

21. Rapid Response Teams – A Bridge over Troubled Water. VHA. 2007

22. Goldhill DR, Worthington L, Mulcahy A, Tarling M, Sumner A. The patient-at-risk team: identifying and managing seriously ill ward patients. *Anaesthesia*. 1999 Sep;**54(9)**:853-60
23. Donald M. Berwick, MD, MPP, FRCP; David R. Calkins, MD, MPP; C. Joseph McCannon, BA; Andrew D. Hackbarth, BA . The 100 000 Lives Campaign - Setting a Goal and a Deadline for Improving Health Care Quality. *JAMA*. 2006;295(3):324-327
24. Comprehensive Critical Care: A review of Adult Critical Care Services. *Department of Health*. 2000
25. Goldhill DR, Worthington L, Mulcahy A, Tarling M, Sumner A. The patient-at-risk team: identifying and managing seriously ill ward patients. *Anaesthesia*. 1999 Sep;54(9):853-60
26. Morgan R, Williams F, Wright M. An early warning scoring system for detecting developing critical illness. *Clinical Intensive Care* 1999; 8: 100
27. Stenhouse C, Coates S, Tivey M, Allsop P, Parker T. Prospective evaluation of a Modified Earle Warning Score to aid earlier detection of patients developing critical illness on a general surgical ward. *British Journal of Anaesthesia*, 1999;84:663
28. Critical to Success. *London Audit Comission*. 1999

29. Guidelines for the introduction of Outreach services. Standards and guidelines. *Intensive Care Society*. 2002
30. Pittard AJ. Out of our reach? Assessing the impact of introducing a critical care outreach service. *Anaesthesia*. 2003 Sep;58(9):882-5.
31. Bellomo R, Goldsmith D, Uchino S, Buckmaster J, Hart G, Opdam H, Silvester W, Doolan L, Gutteridge G. Prospective controlled trial of effect of medical emergency team on postoperative morbidity and mortality rates. *Crit Care Med*. 2004 Apr;32(4):916-21.
32. Hillman K, Chen J, Cretikos M, Bellomo R, Brown D, Doig G, Finfer S, Flabouris A; MERIT study investigators. Introduction of the medical emergency team (MET) system: a cluster-randomised controlled trial. *Lancet*. 2005 Jun 18-24;365(9477):2091-7.
33. National Confidential Enquiry into Patient Outcome and Death. *An Acute Problem?* London. 2005
34. Fletcher SJ, Cuthbertson BH. Outreach, epistemology and the evolution of critical care. *Anaesthesia*. 2010 Feb;65(2):115-8.

35. McDonnell A, Esmonde L, Morgan R, Brown R, Bray K, Parry G, Adam S, Sinclair R, Harvey S, Mays N, Rowan K. The provision of critical care outreach services in England: findings from a national survey. *J Crit Care*. 2007 Sep;22(3):212-8.
36. Acutely Ill Patients in Hospital. National Institute for Health and Clinical Excellence. July 2007.
37. National Patient Safety Authority. Recognising and responding appropriately to early signs of deterioration in hospitalised patients . 2007.
38. Esmonde L, McDonnell A, Ball C, Waskett C, Morgan R, Rashidian A, Bray K, Adam S, Harvey S. Investigating the effectiveness of critical care outreach services: a systematic review. *Intensive Care Med*. 2006 Nov;32(11):1713-21.
39. Priestley G, Watson W, Rashidian A, Mozley C, Russell D, Wilson J, Cope J, Hart D, Kay D, Cowley K, Pateraki J. Introducing Critical Care Outreach: a ward-randomised trial of phased introduction in a general hospital. *Intensive Care Med*. 2004 Jul;30(7):1398-404.
40. Peberdy M, Cretikos M, Abella B et al. Recommended guidelines for monitoring, reporting and conducting research on medical emergency team, outreach and rapid response systems. *Resuscitation*. 2007 75:412-433.

41. Department of Health. Clinical indicators for critical care outreach services. 2007
42. Department of Health. Competencies for recognising and responding to acutely ill patients in hospital. 2009.
43. Acute medical care. The right person, in the right setting – first time. Report of the Acute Medicine Task Force. The Royal College of Physicians. October 2007
44. Funk D, Sebat F, Kumar A. A systems approach to the early recognition and rapid administration of best practice therapy in sepsis and septic shock. *Curr Opin Crit Care*. 2009 Aug;15(4):301-7.
45. Rehabilitation after Critical Illness. National Institute for Health and Clinical Excellence. March 2009.