# Effectiveness of ways to improve detection and rescue of deteriorating patients

**A number of interventions has been introduced to improve recognition of and response to deterioration, but evidence for improved outcomes is mixed. Future evaluations need better articulation of intervention components and outcomes, longer run-in times and consideration of the interplay between concurrent interventions.**

Resuscitation teams are called to around 20 000 cardiac arrests in NHS hospitals in England each year, with a post-arrest survival to discharge of around 15% (Sandroni et al, 2007). A common antecedent is that deterioration is not recognized or not acted upon. A review in the UK found 75% of patients had clear warning signs before cardiac arrest and that these signs were inadequately acted upon in 56% of cases (National Confidential Enquiry into Patient Outcome and Death, 2012). Such failures account for up to a third of avoidable deaths in English hospitals as well as increased risk of serious harm (Hogan et al, 2012). In response to this problem, health-care organizations have adopted a multifaceted approach including four main categories of interventions to detect and manage deteriorating patients more effectively:

1. Rapid response teams (such as medical emergency teams (Lee et al, 1995) and critical care outreach teams (Baxter, 2006))
2. Early warning scores
3. Education programmes for junior doctors and nurses
4. Standardized approaches to patient handover.

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These are the interventions most commonly recommended in national guidelines and by professional bodies.

These interventions tackle different elements of what Smith (2010) has described as a 'chain of prevention' for the deteriorating patient. The chain relies upon:

> **'high-quality recording of vital signs; the education and mind-set of staff at the bedside to recognize pathological patterns; the reporting of abnormality to the efferent team; a timely and appropriate response by the latter.'**

In this model, the capacity of any one intervention is limited by weaknesses at other points in the chain. For instance, early warning scores rely upon staff having the ability to effectively escalate concerns to avoid the chart being limited simply to graphing a patient's decline. One consequence is that the effectiveness of any of the four categories of intervention will, to some extent, depend on the thoroughness with which the other three categories have been implemented (Subbe and Welch, 2013).

Previous reviews of the literature have focused on only one of the categories in the chain of prevention. In contrast, this review considered the evidence of the effectiveness of all four categories, taking into consideration the impact each can have on the others. Effectiveness was considered in four ways:

1. Outcome (preventing cardiac arrests, hospital deaths and adverse events)
2. Use of hospital beds (reducing unplanned admissions to critical care units and lengths of stay)
3. Vital sign recording
4. Improving staff confidence, communication and satisfaction.

## Method

Given the broad ambition of the review, the authors decided to make use of rigorous previously published systematic reviews of each of the four categories of interventions since 2010. Having scrutinized these reviews the findings were supplemented with primary research studies that had been published more recently (and in two instances, in studies previously overlooked).

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### Scope and search strategy for systematic reviews

Initial scoping searches were used to find the latest high quality systematic review of each of the four categories of intervention to use as the foundation for this search strategy. In the case of continuing education programmes, no suitable review was found so a de novo search strategy had to be created.

Searches were run in Embase and MEDLINE in October 2014 (see *Appendix 1* at www.bjhm.co.uk for search strategies). Results were limited to the English language and by date. Where a high quality review was the basis for the search strategy, that review was included in the study (*Appendix 2*). The sensitivity of each search was verified by checking its ability to find key papers identified during the initial scoping searches. The quality of each systematic review was assessed using the National Institute for Health and Care Excellence methodology checklist for systematic reviews (*Appendix 3*) which resulted in them all being rated 2++.

Data items based on the *Cochrane Handbook for Systematic Reviews of Interventions* were extracted from each review (*Appendix 4*). As the reviews identified were often broad in scope, data extraction was restricted to the primary research studies cited that were relevant for this study's aim. The exclusion criteria were specific to each of the four categories of intervention (*Appendix 5*). For each systematic review, the number of included papers that were relevant to the aim of this review is indicated in the first column of each of the summary tables.

### Scope and search strategy for additional studies

Searches for additional primary research studies were underpinned by population, intervention, comparison and outcome criteria (*Appendix 6*), tailored to each intervention and the available evidence. Studies were excluded if they had no comparison group, performed no statistical tests, were abstracts only or were already included in a systematic review.

Primary research papers were assessed for selection bias, attrition bias, performance bias and detection bias. All papers were then allocated an overall rating based on the study type and quality assessment, founded on the system used by the National Institute for Health and Care Excellence (2007) in Clinical Guideline 50 (*Appendix 5*). All studies were rated 2- except for one which was rated 2+.

Of the 20 additional papers included, three were on rapid response systems, five on early warning scores, ten on standardized handover and two on continuing education. A detailed breakdown of each sift can be found in the PRISMA flow diagrams in *Appendix 7*.



## Results

### Rapid response systems

Five systematic reviews incorporated relevant studies from Australia, North America and Europe, from 2000–2012 (*Table 1*). The interventions were mostly rapid response teams, either medically led or not.

The first review (National Institute for Health and Care Excellence, 2007) contained two randomized controlled trials and 16 uncontrolled before-and-after studies. One randomized controlled trial was a large cluster trial of a medically-led rapid response team alongside the use of an early warning score (a track and trigger system) and an education intervention (Hillman et al, 2005). They found no statistically significant impact on the cardiac arrest rate, unplanned intensive care unit admissions or hospital mortality. In contrast, a smaller randomized controlled trial (Priestley et al, 2004) reported a significant reduction in hospital mortality. The review authors suggested intervention variability as one possible explanation for the result in the larger cluster randomized controlled trial because although the calling criteria were uniform, the rapid response team make-up was not. In addition they noted the sample size was potentially inadequate. The results of the 16 uncontrolled before and after studies were mixed. While a majority found a significant decrease in cardiac arrest rate and unplanned intensive care unit admissions, less than half found a significant reduction in hospital mortality.

Chan et al (2010) also found no overall effect on hospital mortality in their meta-analysis of eleven studies but a 34% reduction in rates of cardiac arrest outside intensive care units (although less impressive in the high quality studies). A reduction in cardiac arrest rate was also reported by Massey et al (2010). Five of eight studies (all single-centre, observational studies) reported a significant reduction in arrests, ranging from 13% to 50%. Unlike the earlier reviews, they reported that half the studies also reported a reduction in hospital mortality. Despite this, the authors concluded that, overall, the evidence for the effectiveness of the rapid response team was inconclusive, suggesting underuse and lack of use of the teams as possible explanatory factors.

McNeill and Bryden (2013) tackled the issue of intervention heterogeneity by dividing their review into teams that were medically led (20 studies) and those that were not (23 studies). They reported that medical emergency teams reduced cardiac arrest rates and hospital mortality, and in addition unplanned intensive care unit admissions decreased. The evidence on hospital length of stay and intensive care unit mortality was unclear as the few studies measuring these outcomes showed conflicting findings. The evidence for non-doctor-led teams was not as strong, although such outreach services were effective in reducing readmissions to intensive care unit and hospital mortality. Winters et al (2013), the most recent review, reported a reduction in cardiac arrests and hospital mortality, although the latter was statistically significant in only seven studies.

Three additional studies not included in the five reviews are some of the largest reported and all found a statistically significant improvement in at least one outcome. All of the rapid response teams included a doctor and also introduced either a new early warning score or altered the escalation criteria for an existing scoring system.

Two were uncontrolled before and after studies which reported a 19% reduction in cardiac arrest rate and 15% reduction in mortality (Sabahi et al, 2012) and 36% reduction in intensive care unit admissions (Al-Qahtani et al, 2013). In contrast, Rothschild et al (2008) reported no change in cardiac arrest rates or hospital mortality which they attributed to underuse of the rapid response team and the short duration of the study. In addition, there was a concurrent 37% increase in critical care facilities which will have increased unplanned intensive care unit admissions.

A systematic review on rapid response teams published after this search was completed broadly concurs with these

**Table 1. Rapid response systems (five systematic reviews and three additional studies)**

| Reference, search period (no. of studies) | Setting | Intervention | Main results |
|---|---|---|---|
| National Institute for Health and Care Excellence (2007), 2004–2006 (*n*=20) | Hospital patients | Rapid response team | ■ Cardiac arrest rate: unchanged (cluster randomized controlled trial); decreased (5/8 before and after studies)<br>■ Unplanned intensive care unit admissions: unchanged (cluster randomized controlled trial); decreased (3/4 before and after studies)<br>■ Hospital mortality: unchanged (cluster randomized controlled trial); decreased odds ratio=0.52 (randomized controlled trial); decreased (4/9 before and after studies) |
| Chan et al (2010), 1950–2008 (*n*=11) | Inpatients (adults) | Rapid response team | ■ Cardiac arrest rate: decreased in non-intensive care unit patients (relative risk 0.66) (21.1% reduction in high quality studies)<br>■ Hospital mortality: unchanged (relative risk 0.96) |
| Massey et al (2010) 1995–2008 (*n*=8) | Inpatients (adults) | Rapid response system | ■ Cardiac arrest rate: decreased (13–50%) in five studies<br>■ Unplanned intensive care unit admissions: decreased (45 *vs* 29%) (one study)<br>■ Hospital mortality: decreased in three studies |
| McNeill and Bryden (2013), 1996–2012 (*n*=20) | Inpatients (adults) | Medical emergency teams (doctor-led) | ■ Cardiac arrest rate: decreased (14 studies)<br>■ Unplanned intensive care unit admission: decreased (14 studies)<br>■ Hospital mortality: decreased (14 studies) |
| McNeill and Bryden (2013), 1996–2012 (*n*=23) | Inpatients (adults) | Multidisciplinary rapid response team | ■ Unplanned intensive care unit admission: decreased<br>■ Hospital mortality: decreased |
| Winters et al (2013), 2000–2012 (*n*=28) | Inpatients | Rapid response team | ■ Cardiac arrest rate: decreased in non-intensive care unit patients (12/20 studies)<br>■ Hospital mortality: decreased (7/18 studies) |

| Reference, design | Setting | Intervention | Comparison periods | Results |
|---|---|---|---|---|
| Rothschild et al (2008), controlled before and after | Inpatients (adults and children) | Medical emergency team | Introduced in four wards over a 6-month period; compared with preceding 6 months and with six control wards | ■ Cardiac arrest rate: unchanged<br>■ Unplanned intensive care unit admission: increased (2% *vs* 3.1%), no change on control wards<br>■ Hospital mortality: unchanged<br>■ Mean length of stay: decreased (3.78 *vs* 3.46 days) |
| Sabahi et al (2012), uncontrolled before and after | General hospital, Iran (*n*=53 372) | Rapid response team (doctor, senior intensive care nurse, staff nurse) | One year before with 1 year after (after allowing 1 year) | ■ Cardiac arrest rate: decreased (431 *vs* 349; relative risk reduction 19%)<br>■ Hospital mortality: decreased (274 *vs* 231; relative risk reduction 16%) |
| Al-Qahtani et al (2013), uncontrolled before and after | Tertiary care academic hospital, Saudi Arabia (*n*=256 195) | Rapid response team (led by board-certified intensivist) | 2 years before with 3 years after | ■ Do not attempt cardiopulmonary resuscitation orders initiated by the intensive care unit team on the wards increased (relative risk 2.58)<br>■ Cardiac arrests: decreased in non-intensive care unit patients (relative risk 0.68)<br>■ Unplanned intensive care unit admissions: decreased (relative risk 0.84), readmission decreased (relative risk 0.77), intensive care unit length of stay decreased (9.9 *vs* 8.0 days)<br>■ Hospital mortality: decreased (relative risk 0.90) |

conclusions. Their meta-analysis of 29 papers reported a decrease in cardiac arrest rates and in mortality (Maharaj et al, 2015). The authors reported considerable heterogeneity for both outcomes, reflecting the variation in results across the included studies.

### Early warning scores

There were three systematic reviews, starting with National Institute for Health and Care Excellence in 2007, which included five studies of introducing aggregate weighted scoring systems (*Table 2*). The one randomized controlled trial reported a significant reduction in hospital mortality (but in combination with a rapid response team and continuing education). While one small single site before-and-after study confirmed a reduction in mortality without a concurrent rapid response team, another reported no impact on mortality. Only one of the three studies that assessed unplanned admission to critical care found a reduction and only one of four studies (a randomized controlled trial) reported a reduction in length of stay.

A more recent review by McNeill and Bryden (2013) reported decreases in cardiac arrest rates, unplanned intensive care unit admissions and hospital mortality. In addition, they concluded that early warning scores also improved documentation of vital signs. This was based primarily on a before-and-after study which replaced a single parameter score with an aggregate scoring system plus an education programme. This review found length of stay was unchanged.

“Only one of the three studies that assessed unplanned admission to critical care found a reduction and only one of four studies ... reported a reduction in length of stay.”

The latest review was limited to studies of poor methodological quality, with heterogeneous study populations (Alam et al, 2014). The impact on cardiac arrest was inconsistent. Of six papers assessing mortality, only two reported a reduction. One study reported unplanned intensive care unit admissions decreased but high dependency unit admissions increased.

The authors identified five additional uncontrolled before-and-after studies of which three assessed a form of Modified Early Warning Score (MEWS) and reported improved recording of one or more vital signs (Odell et al, 2007; De Meester et al, 2013a; Hammond et al, 2013). One of them also reported a decreased hospital mortality, incidence of re-operation and length of stay (De Meester et al, 2013a).

Less encouraging were the results of a large multinational study which examined the introduction of electronic vital signs monitors (Bellomo et al, 2012). The monitors used in every site were the same but the warning score and escalation were based on each hospital's pre-existing policy. There was no impact on cardiac arrest rates, frequency of rapid response team calls or hospital mortality. There was some international variation: American hospitals reported a decrease in length of stay and increase in the

**Table 2. Early warning scores (three systematic reviews and five additional studies)**

| Reference, search period (no. of studies) | Setting and participants | Intervention | Main results ($P$<0.05) |
|---|---|---|---|
| National Institute for Health and Care Excellence (2007), 1990–2006 (*n*=5) | Hospital patients (inpatients, emergency department and those in transition) | Track and trigger score (physiological parameters and neurological state) (three studies also introduced rapid response systems) | ■ Cardiac arrest rate: unchanged<br>■ Unplanned admission to intensive care unit: decreased in 1/3 studies (58 *vs* 43%) as did intensive care unit readmissions (5.1 *vs* 3.3%)<br>■ Hospital mortality: decreased in one randomized controlled trial (odds ratio 0.52) and one before/after (5.8 *vs* 3%); unchanged in one before/after study<br>■ Hospital and intensive care unit length of stay: decreased (hazard ratio: 0.90) |
| McNeill and Bryden (2013), 1996–2012 (*n*=4) | Inpatients (adults) | Early warning score (aggregate weighted scoring system) | ■ Cardiac arrest rate: decreased<br>■ Unplanned intensive care unit admissions: decreased<br>■ Hospital mortality: decreased<br>■ Mean intensive care unit and hospital length of stay: unchanged |
| Alam et al (2014), up until 2013 (*n*= 7) | Inpatients and emergency departments (adults) | Early warning scores | ■ Vital sign recording: increased in one study (7.0 *vs* 75.6%)<br>■ Cardiac arrest rate: decreased in one study; increased in one study (0.6% *vs* 2.3%)<br>■ Unplanned intensive care unit admission: decreased in one study (11 *vs* 5%) but high dependency unit admission rate increased (14 *vs* 21%)<br>■ Hospital mortality: decreased in two studies (5.8 *vs* 3%; 1.4 *vs* 1.2%); unchanged in three studies<br>■ Mean length of stay: unchanged |

*Continued overleaf*

proportion of rapid response team call patients transferred to a greater acuity ward. This suggested caution is needed when transferring results between countries.

The latest study focused on the impact on the knowledge and confidence of nurses (McDonnell et al, 2013). There were improvements in the number of staff concerns, reported levels of experience and knowledge, and staff confidence in recognizing deterioration, reporting abnormal observations and in knowing who and when to contact for help. However, these improvements were small and the improvements were greater among non-registered nurses. In addition, confidence in asking senior staff to attend, a key part of the chain of prevention, did not increase.

### Standardized handover tool

The majority of studies in the two systematic reviews found handover tools were associated with an improvement in at least one outcome (*Table 3*) (Foster and Manser, 2012; Robertson et al, 2014). Examples of improvements included decreases in the number of dropped tasks, number of preventable adverse events and length of stay. However, one study reported an increase in the number of unexpected changes in care and the number of errors attributed to handover. The most common benefit in the Robertson review was improved information transfer. Only six studies assessed outcomes of which one reported a decrease in adverse events and one found a reduction in length of stay.

In the 10 additional studies the authors identified, three used the situation, background, assessment and recommendation (SBAR) approach: Cornell et al (2013) found no significant difference in the time to complete shift reports although there was an increase in the percentage of time spent on shift report tasks; Moseley et al (2012) found no improvement in 12 of 16 measures, although

**Table 2. Early warning scores (three systematic reviews and five additional studies) (*continued*)**

| Reference, design | Setting (no. of patients) | Intervention | Comparison periods | Results |
|---|---|---|---|---|
| Odell et al (2007), uncontrolled before and after | Two UK hospitals (adults) (*n*=2638) | Reading-Modified Early Warning Score (R-MEWS) (one hospital also had a critical care outreach team) | 1 year before and 4 years after | ■ Respiratory rate recording: increased (6.0 *vs* 16.8, 57.2, 70.0, 77.9%)<br>■ Increased more in hospital with critical care outreach team (9.8 *vs* 28.9, 70.3, 83.8, 87.7%) |
| Bellomo et al (2012), uncontrolled before and after | Hospitals in USA (5), Sweden (2), UK (1), Netherlands (1), Australia (1) (*n*=18 305) | Paper track and trigger system converted to electronic version | 3 months before and 3 months after | Cardiac arrest rate: unchanged<br>Hospital mortality: unchanged<br>Rapid response team calls: unchanged; proportion for respiratory problems increased (21 *vs* 31%)<br>Number of abnormal physiological criteria present at time of rapid response team call: decreased<br>Proportion of rapid response team calls resulting in transfer: unchanged (41 *vs* 49%) – except in USA (54 *vs* 69%)<br>Mean hospital length of stay: decreased (4 *vs* 3 days) |
| De Meester et al (2013a), uncontrolled before and after | One general hospital, Belgium (postoperative adults) (*n*=4247) | Modified Early Warning Score (MEWS) | 4 months before and 4 months after | Vital sign recording: increased 1.81 *vs* 2.45<br>■ greatest during night shifts (1.94 *vs* 3.37)<br>■ increase in: oxygen saturation (27%); Glasgow Coma Scale (23%); respiratory rate (17%)<br>■ decrease in: temperature (68 v 63%); pulse rate (54 *vs* 49%)<br>Hospital mortality: decreased (19 *vs* 4; relative risk reduction 73.7%)<br>Re-operation rate: decreased (141 *vs* 78; relative risk reduction 30.9%)<br>Mean length of stay: decreased (4.55 *vs* 4.11 days) |
| Hammond et al (2013), uncontrolled before and after | Tertiary referral hospital, Australia (post-intensive care unit adults) (*n*=139) | Modified Early Warning Score (MEWS) | 1 month before and 1 month after | Vital sign recording in:<br>■ unplanned intensive care unit admissions: full set increased (44.0%); urine output increased (26.9%)<br>■ 24 hours post-intensive care unit: full set increased (210%): urine output increased (103%) |
| McDonnell et al (2013), uncontrolled before and after study | District general hospital, England Survey of 213 nurses and 15 interviews | Locally devised track and trigger system | 2 weeks before and 6 weeks after | ■ Number of staff concerns: decreased (4.3 *vs* 3.7) for 'lack of prior specific experience' and 'keeping calm'<br>■ Staff ability: increased (experience 7.5 *vs* 8.1; knowledge 7.3 *vs* 8.0)<br>■ Staff confidence: increased – recognize deterioration (7.5 *vs* 8.2); when to contact (8.8 *vs* 9.0); who to contact (8.9 *vs* 9.2); report abnormal observations (9.0 *vs* 9.3); ask senior staff to come (9.3 *vs* 9.4) |

medical residents reported an improvement in whether all the important data were transmitted during sign-out; and De Meester et al (2013b) reported an increase in the number of unplanned intensive care unit admissions and a decrease in hospital deaths (although concurrent educational interventions may have contributed).

**Table 3. Standardized handover tools (two systematic reviews and 10 additional studies)**

| Reference, search period (no. of studies) | Setting and participants | Intervention | Main results |
|---|---|---|---|
| Foster and Manser (2012), up until 2010 (*n*=7) | Hospital clinical staff | Standardized handover forms | ■ Interventions required, dropped tasks, preventable adverse events, mean length of stay: decreased (six studies)<br>■ Outcomes: improved (3/4 studies)<br>■ Dropped tasks, time to first intervention, 'undesirable actions', deviations from expected care, medical errors, adverse drug events: unchanged (three studies)<br>■ Unexpected changes in care: increased (odds ratio 7.16) (one study)<br>■ Errors attributed to handover: increased (odds ratio 7.68) (one study) |
| Robertson et al (2014), 2002–2012 (*n*=17) | Hospital clinical staff | Mnemonics, minimum datasets, standard operating procedures, IT | ■ Information transfer: improved (10 studies)<br>■ Adverse events: decreased 12% (one study)<br>■ Mean length of stay: decreased (one study) |

| Reference, design | Setting, type of clinicians (no. of clinicians) | Intervention | Comparisons | Results |
|---|---|---|---|---|
| Payne et al (2012), controlled trial | Three teaching hospitals, USA, medical residents (*n*=124–251) | Structured web-based handover application (Wardmanager) | Part 1: 4 teams (intervention) *vs* 8 teams (controls)<br><br>Part 2: intervention hospital *vs* two control hospitals | Part 1:<br>■ Perceived patient harm: no difference<br>■ Perceived near-miss events: reduced or no difference<br>Part 2:<br>■ Patient information recorded: increased for code status (100% *vs* 55%), problem list (100% *vs* 48%), and medication lists (100% *vs* 11%)<br>■ Confidence in the quality of handover received: increased (93% *vs* 49%) |
| Moseley et al (2012), uncontrolled before and after study | Neurology department, USA, medical residents (*n*=20–33) | SBAR | 2 weeks before and 3 weeks after implementation | ■ Overall level of satisfaction: increased (6.2 *vs* 7.4)<br>■ All important data being transmitted: increased (49% *vs* 80%)<br>■ Sharing test results with patients: increased (69% *vs* 95%)<br>■ Night staff update electronic service list: increased (45% *vs* 75%)<br>■ Other 12 criteria: no improvement |
| Ahmed et al (2012), uncontrolled before and after study | Acute surgical admission unit, UK, junior doctors (*n*=unknown) | Computerized structured template | 4 weeks before and 4 weeks after | ■ Improvement in transfer of data on: date of birth (91% *vs* 98%), hospital number (61% *vs* 85%), history (91% *vs* 97%), past medical history (28% *vs* 48%), diagnosis (37% *vs* 50%), management plan (82% *vs* 94%), senior review (2% *vs* 91%)<br>■ No change in data on ward location or investigations |
| De Meester et al (2013b), uncontrolled before and after study | Tertiary referral hospital, Belgium, nurses (*n*=425) | SBAR | 9 months before and 9 months after | ■ Documentation of four SBAR elements: increased (4% *vs* 35%)<br>■ Communication score: increased (58 *vs* 64)<br>■ Unplanned intensive care unit admissions: increased (13.1 *vs* 14.8/1000 admissions)<br>■ Unexpected deaths: decreased (0.99 *vs* 0.34/1000 admissions)<br>■ Number of cardiac arrest team calls: unchanged |
| Yazici et al (2013), uncontrolled before and after study | Teaching hospital, USA, medical residents (*n*=48) | Standardized handover tool (Mercy 10-D) | Before, and 3 and 9 months after | ■ Frequency of morning handover: increased (59% *vs* 89%)<br>■ Overnight events that should have been communicated during handover: decreased (84% *vs* 50%)<br>■ Uncertainty about decisions as a result of poor handover: decreased (72% *vs* 37%) |

*Continued overleaf*

> **In the only study to use a parallel control group, users were more likely to report inclusion of key patient information and to be confident about the quality of the handover they received.**

Of the other seven studies, five tested a bespoke electronic handover tool. In the only study to use a parallel control group, users were more likely to report inclusion of key patient information and to be confident about the quality of the handover they received (Payne et al, 2012). Ahmed et al (2012) also found an improvement in data transfer, the biggest improvement being recording of senior review. Similarly, Graham et al (2013) reported improvements in the quality of written accounts of five of six measures. Yazici et al (2013) noted an improvement in five quality markers but this was sustained to 9 months for only three of them. Gonzalo et al (2014) also found limited benefits after 12 months, with no improvement in eight measures of communication and a worsening in communication of results of completed consultations.

The other two studies were of non-electronic handover approaches. One reported improvements in all self-reported measures of knowledge (patient diagnoses, hospital course, active concerns and treatment plans), as well in the overall helpfulness of the handover (Connor et al, 2013). The other found that the proportion of missing data decreased for 18 of the 36 criteria, including fall risk, pain status and home medication (Younan and Fralic, 2013).

### Continuing education

The one systematic review (Liaw et al, 2011) included three before and after evaluations of educational programmes aimed at doctors and nurses (*Table 4*). One reported improved confidence across several measures, including recognizing critical illness, keeping patients alive, remembering essential life-saving procedures and seeking out senior staff for help (Featherstone et al, 2005). Of the other two studies, one reported no change in mortality or staff awareness of patients at risk on general wards

**Table 3. Standardized handover tools (two systematic reviews and 10 additional studies) (*continued*)**

| Reference, design | Setting, type of clinicians (no. of clinicians) | Intervention | Comparisons | Results |
|---|---|---|---|---|
| Graham et al (2013), uncontrolled before and after study | Teaching hospital, USA, medical interns (*n*=39) | Electronic handover template | 3 months before and 3 months after (following 9-month implementation period) | ■ Written handover quality: improved (5/6 measures)<br>■ Spoken handover quality: improved (4/10 measures)<br>■ Critical data omissions: decreased (23 *vs* 0)<br>■ Adverse events (including near misses) unchanged<br>■ Content of sign-out documents: improved (3/5 measures) |
| Connor et al (2013), uncontrolled before and after study | Military Medical Centre, USA, medical residents (*n*=15) | Structured mnemonic (IMOUTA) | 6 weeks before and 6 weeks after | ■ Knowledge of patient diagnoses: improved (3.96 *vs* 4.60)<br>■ Knowledge of hospital course: improved (3.49 *vs* 4.69)<br>■ Knowledge of active concerns: improved (3.49 *vs* 4.69)<br>■ Knowledge of treatment plans: improved (3.44 *vs* 4.60)<br>■ Overall helpfulness: improved (3.62 *vs* 4.71) |
| Cornell et al (2013), uncontrolled before and after study | Suburban hospital, USA, nurses (*n*=75) | SBAR (initially paper, then electronic) | Before and 1 month after | ■ Time to complete shift report: unchanged<br>■ Proportion of time on shift report tasks: increased with electronic version (54.6 *vs* 66.4%)<br>■ Proportion of time on spoken report: increased with electronic version (29.5 *vs* 42.1%) |
| Younan and Fralic (2013), uncontrolled before and after study | Hospital, Lebanon, nurses (*n*=32) | Standardized handover tool | One month before and 6 months after | ■ Omissions: decreased (18/36 measures) including risk for fall (24 *vs* 8%), pain status (10 *vs* 1%), abnormal laboratory results (90 *vs* 48%), abnormal radiology results (74 *vs* 30%), isolation precautions (100 *vs* 65%), level of consciousness (100 *vs* 65%), fall risk (95 *vs* 65%), pressure ulcer risk (95 *vs* 65%)<br>■ Interruptions of handovers: decreased (2.17 *vs* 1.26) |
| Gonzalo et al (2014), uncontrolled before and after study | Tertiary-care hospital, USA, medical residents (*n*=unknown) | Standardized electronic tool (eSignout) | Three weeks before and 12 months after | ■ Spoken communication: improved, including being complete and helpful (3.13 *vs* 3.44)<br>■ Communication of 'results of completed studies/consults: decreased (4.1 *vs* 3.9)<br>■ Eight other communication measures: unchanged, including provisional diagnosis, vital signs on arrival and upon transfer/trigger criteria at time of transfer |

*SBAR = situation, background, assessment, recommendation*

5–9 months post-intervention (Fuhrmann et al, 2009) whereas the other reported a reduction in unplanned admissions to intensive care unit and hospital deaths (Mitchell et al, 2010). However, in the latter the educational intervention was accompanied by greater use of a medical emergency team review, more vital signs documentation and a new track and trigger system.

One of the two additional studies was an interrupted time series analysis which observed reductions in unsatisfactory pain score charting and observations (in medical but not surgical patients) following an educational intervention (Kinsman et al, 2012). The other study found nurses' knowledge of failure to rescue events increased after exposing them to a deteriorating patient simulation scenario with a high-fidelity mannequin (Schubert, 2012).

## Discussion

### Main findings

Of the four interventions, the strongest evidence exists for rapid response systems where studies tended to have larger sample sizes and focused on a smaller number of patient outcomes. There is evidence that rapid response teams reduce cardiac arrest rates and, to a lesser extent, mortality. The introduction of new early warning scores (track and trigger systems) is also effective in improving the recording of one or more vital signs, although the sustainability of the impact is unclear as is the impact on patient outcomes.

Studies evaluating standardized handover tools, which have been weaker methodologically, have mostly reported improvements, in particular in information transfer. Whether this translates into better patient outcomes is not known – the studies that have suggested an improvement had limitations.

Continuing education is the most challenging of the four interventions to assess in terms of the quality and quantity of evidence available. There is some evidence of improved knowledge and self-reported confidence in a range of skills, as well as in process measures such as frequency of observations, but the evidence for improved patient outcomes is weak.

### Limitations

As other reviews of these topics have found, there is a mixed picture with regard to study results in all four interventions. There are three possible explanations for this. First, there is considerable diversity in the details of the interventions being used within each category: rapid response systems varied in their calling criteria, composition and the hours they covered; early warning scores varied in the

**Table 4. Continuing education (one systematic review and two additional studies)**

| Reference, search period (no. of studies) | Setting, participants | Intervention | Main results |
|---|---|---|---|
| Liaw et al (2011), 2000–2010 (*n*=3) | Hospital wards, doctors and nurses | Acute life threatening events recognition and treatment (ALERT): ABCDE approach, team problem-solving skills, communication skills, ethics of acute care<br>Multi-professional full-scale simulation (MFS): recognition of deterioration, criteria of abnormal physiological signs, ABCDE, teamwork and communication skills including situation, background, assessment, recommendation<br>COMPASS: physiology, Modified Early Warning Score, situation, background, assessment, recommendation, management plan and teamwork | ALERT:<br>■ Confidence: increased, including in recognizing critical illness, keeping patients alive, remembering essential life-saving procedures, seeking out senior staff for help and working as part of an interdisciplinary team<br>MFS:<br>■ Mortality rate: unchanged<br>■ Nurses awareness of patients at risk: unchanged<br>COMPASS:<br>■ Vital signs documentation: improved<br>■ Use of medical emergency team reviews: increased<br>■ Unplanned admissions to intensive care unit: decreased<br>■ Unexpected hospital deaths: decreased |

| Reference, design | Setting, no. of staff | Intervention | Comparison period | Results |
|---|---|---|---|---|
| Kinsman et al (2012), interrupted time series analysis | Rural hospital, Australia, 34 nurses | Programme (FIRST2ACT) for detection and management of clinical deterioration | 2 weeks before and 8 weeks after | ■ Unsatisfactory pain score charting: decreased (-0.179)<br>■ Unsatisfactory frequency of observations: decreased (-0.112)<br>■ Observation frequency: improved in medical but not in surgical patients<br>■ Administration of oxygen therapy: unchanged |
| Schubert (2012), uncontrolled before and after study | University medical centre, USA, 58 nurses | Deteriorating patient simulation scenario with a high-fidelity mannequin | Before, immediately after and 2 weeks after | ■ Failure to rescue knowledge: increased 0.73 points (immediate) and 1.76 points (2 weeks)<br>■ Critical thinking: improved (immediate) but no difference at 2 weeks |

## KEY POINTS

- Recognition of and response to deterioration requires optimization of care at a number of points along the chain of prevention from recording vital signs, to reporting an abnormality and triggering an appropriate response.
- Rapid response systems, early warning scores, standardized handover tools and focused education have been introduced to improve patient outcomes.
- Although all interventions show benefits, the strongest evidence for reducing in-hospital cardiac arrests and reducing mortality is associated with the introduction of rapid response teams.
- Future studies should be designed such that both the intervention and outcomes measured are clearly articulated at the start, there is adequate time allowed for implementation and to test long-term sustainability, and process evaluations are undertaken to determine the impact of concurrent interventions on outcome.

parameters they included, the thresholds for activation and the responses they triggered; continuing education interventions had different curricula and teaching methods; and structured handover tools varied in the information being conveyed.

Second, there is the challenge in many studies of concurrent interventions. Such an approach is pragmatic from the perspective of service providers as it tackles several aspects of the chain of prevention at once. However, it is difficult to attribute impact to any one of the interventions as each may have contributed all or nothing to the result.

Third, there was variation in the way interventions were implemented. For instance, Simmes et al (2013) reported that their medical emergency team was not consulted before a serious adverse event in 50% of cases, even though abnormal vital signs were observed and should have led to medical emergency team activation. A study of the same team would have returned different results had it been consulted 100% of the time. Many factors may have modulated the implementation of the interventions. Some studies had educational packages to accompany the roll-out of their rapid response scheme or early warning score, while others made no mention of this. In addition, the enthusiasm and teaching aptitude of the trainers in the educational interventions will likely have been key to their success or failure. Participants will also have influenced implementation. For instance, 50% of the learners in Schubert's (2012) study had just finished a night shift when they started the course, which could easily have affected their motivation and capacity to learn. There are also broader contextual factors at play, such as the support of hospital managers for the intervention or the financial support for its rollout.

Another potential moderating factor is the country the intervention was set in. Most of the studies took place in Australia, the UK and the USA, which have different health-care systems with different staffing, working hours and access to intensive care unit beds. Evidence to support the idea that the country of use could be introducing variability in results comes from Bellomo et al's (2012) study of electronic track and trigger systems in Australia, the USA and Europe. They found that American hospitals produced significantly different results on several key outcomes including hospital length of stay and the percentage of patients transferred to a greater acuity ward following the rapid response team being called.

Fourth, the majority of studies used an uncontrolled before and after design. There is, therefore, the risk of confounding affecting the results. The majority of these studies provided no reassurance that confounding had been adequately taken into account.

### Implications

While the existing literature provides a fairly consistent picture of the benefits of each of the four types of intervention, larger studies conducted over a longer period of time, to allow the intervention to become established and to assess sustainability, would be needed to strengthen the evidence base. Future studies should measure a core set of outcomes based on the chain of prevention and define more precisely the intervention being evaluated to facilitate inter-study comparability and pooling of the evidence. For instance, rapid response systems could be described in terms of four dimensions: team make-up, hours of operation, services provided and intensive care unit admission rights. This would reduce the problem of variability when synthesizing results from different studies and allow meaningful comparisons and conclusions to be drawn. Finally, there is a need to investigate the interplay between contextual factors such as facilitation strategies, staff engagement or quality monitoring and the success or failure of interventions. **BJHM**

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