Do early warning track and trigger tools improve patient outcomes? A systematic synthesis without meta-analysis

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ABSTRACT

Aim: To determine the effect of Early Warning Track and Trigger Tools on patient outcomes

Design: A systematic review: synthesis without meta-analysis

Data sources: Electronic databases were searched from 1 January 2013 - 1 August 2018 and 221 papers identified.

Review methods: A systematic review and narrative synthesis supported the identification of synthesised findings named and reported according to outcome measure.

Results: Five international papers representing over 74,000 patients were included in the analysis. Seven key findings were identified, the impact of NEWS on: i) cardiopulmonary arrest; ii) mortality; iii) serious adverse events; iv) length of hospital stay; vi) hospital admissions; vii) observation frequency; and viii) Intensive/High dependency Unit admission. Papers identified statistically significant improvements in mortality, serious adverse events, hospital admissions, observation frequency and intensive care unit/high dependency unit admission when an Early Warning Track and Trigger protocol is in use. There were conflicting results regarding length of stay and cardiopulmonary arrest data.

Conclusion: Early Warning Track and Trigger Tools can aid recognition of deteriorating patients. Further research is required in relation to hospital length of stay and cardio-pulmonary arrests

Impact: Early warning track and trigger tools have been implemented nationally and to a lesser degree internationally. There is evidence to suggest improved clinical outcomes following their use. Further research needs to combine the use of the National Early Warning Score with an agreed set of measured outcomes, then subsequent study data could be combined to provide much stronger levels of evidence.

Key words: systematic review, deteriorating patient, early warning score, recognition and response, nurse, nursing

INTRODUCTION

There is evidence of clinical deterioration in approximately 80% of hospital in-patients who suffer cardiac arrest (Resuscitation Council (UK), 2010; National Confidential Enquiry into Patient Outcome and Death (NCEPOD) 2012). A lack of knowledge, skill, clinical urgency and delay in seeking expert advice are all factors which contribute to poor outcomes for the deteriorating patient (McQuillan et al. 1998). Failure to recognise physiological deterioration, undertake prompt clinical assessment and instigate timely intervention, results in increased rates of cardiac arrest and unplanned intensive care admissions (Smith et al. 2006). More recently Hogan et al (2012), in a review of 1000 deaths in acute hospitals across England, found that one in twenty patients died due to medical error, with one death in 20 having a greater than 50% chance of being preventable and 31% of preventable deaths being due to poor clinical monitoring. The inclusion of five international papers suggests a global interest in the topic.

Background

Several key historical reports have highlighted deficits in the care of patients discharged from Intensive Care Unit's (ICU) and in those at risk of deterioration on general wards (Goldhill et al. 1999; Mc Gloin et al. 1999; Garrard et al. 1998; Mc Quillan et al. 1998). Reasons for such failures include inadequate ward based critical care knowledge, sparsity of resources and increasing volume and acuity of patients which all contribute to the inability to detect deterioration (Welsh, 2000; Goldhill, 2000), McGloin et al. 1999; Franklin and Matthew, 1994).

Early Warning Scores were first introduced into acute hospitals in 2000 (Department of Health (DoH) 2000a). The National Early Warning Score (NEWS) and more recently NEWS (2) is a standardised EWS for use nationwide (Royal College of Physicians (RCP) 2012; 2017) and their use in UK hospitals is mandated as a standard of care by the National

Institute for Health and Clinical Excellence (NICE 2007). Once an EWS has been calculated the score relates to a graded escalation response. Ward nurses are expected to identify deteriorating patients and refer them expediently to rapid response teams (Odell et al. 2009). Specialist rapid response teams with core competencies in the assessment and management of deteriorating patients were formed following the Audit Commission's document Critical to Success (Audit Commission, 1999) and with the publication of Comprehensive Critical Care (DoH, 2000a). Rapid Response Teams (RRT), often called Critical Care Outreach, whose input is instigated through the EWS, can offer advanced system assessment and rescue of deteriorating patients before irretrievable deterioration and cardiac arrest occurs.

Despite ninety nine percent of acute hospitals using an EWS to monitor patients (NCEPOD, 2015), there has been little improvement in the recognition and response to deteriorating patients over the last decade (Hogan et al. 2012) with sub-optimal care still evident on general wards (Credland, Dyson and Johnson, 2018).

EWS have been developed and widely implemented in developed countries countries with the aim of early identification of clinical deterioration (Smith et al. 2013). They are routinely used in the Netherlands, USA and Australia (Gerry et al. 2017). However, in developing countries critical care provision is variable (Haniffa et al. 2014). Hospital wards are often overcrowded, poorly resourced and understaffed, which hinders the effective monitoring of physiological parameters required for EWS implementation and validation (Burke et al. 2014). In lower income countries patients often differ in both presentation and pattern of disease. While data is limited, studies evaluating EWS in these settings show wide variation in performance (Beane et al. 2018).

THE REVIEW

Aim

This review aimed to examine international research relating to the relationship between Early Warning Track and Trigger Tools and outcomes. Outcomes of interest include cardiopulmonary arrest rates, admissions to intensive care, length of hospital stay and mortality. The research question guiding the review was:

What effect do Early Warning Track and Trigger Tools have on patient outcomes?

Design

The design is a synthesis without meta-analysis.

The review protocol was registered on Prospero (CRD42017074403, Credland, Dyson and Johnson, 2017). The search methods used throughout this review were according to the Centre for Review and Dissemination (2009). The Population, Intervention, Comparison, Outcome (PICO) acronym (O'Conner et al. 2008) was used to develop eligibility criteria (Table 1).

Search methods

A dated systematic review was published in 2014 which included papers up to 2013 answering the same research question (Alam et al. 2014). National Early Warning Scoring (NEWS) (Royal College of Physicians, 2012) was introduced in 2012 so it was deemed likely that there has been more recent research investigating track and trigger tools has become more prevalent since. Data bases searched were Medline, CINAHL and the Cochrane library. A date range of 2013 to current was set to identify literature published following the existing systematic review by Alam (2014). A snowball sampling approach was used to identify missed, non-indexed and unpublished material. Studies known to the researcher prior to the search were used for cross-checking. A search of the grey literature, citation and key author searching was also undertaken. A librarian checked the strategy to ensure a robust search.

The agreed search terms were:

track and trigger*" OR "early warning scor*"

AND

"patient outcome*" OR "cardiac arrest*" OR "ICU admission*" OR "intensive care unit admission*" OR "mortality" OR (length or long) "hospital stay*".

Screening against the inclusion and exclusion criteria was undertaken independently by NC and JD. MJ was available to support resolution of any disagreements in whether papers were appropriate for inclusion however, in all cases agreement was achieved.

Search outcomes

Of the 221 titles found by the search, 5 papers representing over 74,000 patients were included in the analysis. Reviews and Meta-Analysis diagram (PRISMA) (Moher et al. 2015) is provided in Figure 1. The included papers were of quantitative design published between 2013 and 2018 in English. Data were collected using either a pre-post intervention, point prevalence or prospective observational approach. Settings were all in hospital general wards, admissions units and accident and emergency. The five selected papers had worldwide origins (n=4 Europe, n=1 Asia) emphasising the global interest in the topic. Figure 2 summarises the design of the selected studies and their findings. The studies cover a range of interventions and are presented in accordance with the TIDieR Consort criteria (Hoffmann et al. 2014).

Quality appraisal

A Risk of bias assessment was undertaken for each included paper using the Cochrane Effective Practice and Organisation of Care guidance on assessing risk of bias in included studies (2017) (Figures 3 and 4). Due to the nature of the interventions (introduction of EWS) all papers were high risk of blinding as it would not be possible to blind either participants or personnel. We used the Grading of Recommendations Assessment, Development and Evaluation (GRADE) to assess the quality of evidence for each outcome (Balshem 2011, Guyatt 2011) (Table 4) considering study limitations (risk of bias, listed in Figure 3) and

imprecision. The quality of evidence could be graded from high to moderate, low, or very low quality.

Data extraction

Data were independently extracted and checked by a second reviewer using a bespoke data collection sheet. The data extracted contained study design, participants, interventions, measured outcomes and results.

Data synthesis

As our intervention of interest was consistently track and trigger tools and all papers were quantitative in nature, we considered selection of a "standardised metric" (Campbell et al, 2020). However, the diversity of approaches to track and trigger intervention have an impact on evaluation, the context and the available data were too diverse for this to be possible even within outcome categories (Table 3). It is recognised that often the best that can be achieved in reviews of complex interventions (those with several interacting components, dependent on the behaviours of those delivering or receiving and with a range of possible outcomes (Craig et al 2008)) is a non-quantitative synthesis (Higgins et al, 2019). This has been defined by the Cochrane Consumers and Communication group as "investigation of the similarities and the differences between the findings of different studies, as well as exploration of patterns in the data" and can be used to integrate qualitative, quantitative or both qualitative and quantitative data (Dixon-Woods, 2008). We followed the Centre for Reviews and Dissemination (2009) guidance for the synthesis of quantitative studies when a meta-analysis is not possible. We have produced narrative summaries of the quantitative studies based on the theory illustrated in our background section, that is, the NEWS intervention is designed to work by early identification of a physiological deterioration allowing timely intervention and subsequently improved patient outcomes. We have described and tabulated each included study and presented findings themed by patient outcomes.

Results

Seven outcomes were identified, and each is reported in turn. These are i) hospital admission, ii) length of stay (LoS), iii) observation frequency, iv) serious adverse incidents, v) Intensive Care Unit (ICU)/High Dependency Unit (HDU) admission, vi) mortality and vii) cardiopulmonary arrest. The development of groupings according to paper can be found in Table 2.

i) Hospital admission

Alam et al. (2015) was the only study which identified that hospital admission from the ED was significantly correlated with an elevated NEWS. The authors considered three time-points (T0 on arrival to ED, T1 hour after arrival to ED and T2 transfer to the ward/ICU) and for all time-points $p<0.001$. The AUROC's (95% CI) for NEWS for admission at T0, T1 and T2 were 0.664 (0.599-0.728), 0.687 (0.620-0.754) and 0.697 (0.609-0.786) respectively.

ii) Length of stay

Two studies identified a positive correlation between elevated EWS and length of hospital stay (LoS) (De Meester et al. 2013; Alam et al. 2015). The pre-and post-implementation of EWS intervention study by De Meester et al. (2013) identified that in-hospital LoS was significantly shorter in the post-intervention period decreasing from 4.55 days (95% CI, 4.34-4.76) in the pre-intervention to 4.11 days (95% CI 3.92-4.30; $p= 0.004$) in the post-intervention period. Length of stay significantly correlated with NEWS, at all the measured time points and the median length of stay more than doubles for a score >7 compared with a score of 0–4 (Alam et al. 2015).

iii) Observation frequency

One paper considered this outcome as a proxy measure of good care and noted an improvement in vital sign documentation after implementation of an EWS chart with an increase in the mean patient observation frequency per nursing shift during the 6-day post

intervention period (0.9940 (95% CI), 0.9708-1.0172; p<0.001) compared with the pre-intervention period (0.9376 (95% CI), 0.8921-0.9231) (De Meester et al. 2013). The measurement of oxygen saturation, consciousness level and respiratory rate (almost absent in the pre-intervention period) increased in the post-intervention period by up to 27% of the observation sets for O_2 saturation, 23% for consciousness level and 18% for respiratory rate.

iv) Serious adverse events

This outcome was considered by only De Meester et al (2013) who found an association between high EWS and serious adverse events defined as re-surgery. Following implementation of an EWS nurse observations and escalation protocol, 6-day post- operative re-surgery decreased from 141 in the pre-intervention period to 78 in the post-intervention period (95% CI, 9.5-47.2; p=0.007) in a cohort of 4247 patients suggesting increased recognition of post-operative complications resulting in improved patient outcomes

v) ICU/HDU admission

Two studies examined ICU/HDU admission. Alam et al. (2015) found ICU admission significantly correlated with NEWS at their studied time point T0 (arrival in ED) (Fisher's exact test with NEWS above or below 7) (p=0.003) T1 (one hour after arrival to ED) (p<0.001 and at T2 (transfer to the general ward/ICU) (p<0.046). Smith et al. (2013) reported that NEWS has an increased ability to identify patients at risk of unplanned ICU admission (AUROC (95% CI) 0.857 (0.847-0.868)) compared with the other 33 EWS available (AUROC (95% CI) 0.827 (0.814-0.840).

vi) Mortality

There is a positive relationship between decreased mortality and the use of EWS. In comparison with the 33 other EWS available Smith et al (2013) found NEWS the best in identifying patients at increased risk of mortality. The AUROCs (95% CI) for NEWS for death within 24 h was 0.894 (0.887–0.902) in comparison with between 0.813 (0.802-0.824)

and 0.858 (0.849-0.867) for the other 33 EWS available. Tirkkonen et al. (2014) reported that for an EWS of seven or is independently associated with a higher 30, 60 and 180-day mortality; odds ratios 11.4(4.40–29.6), 6.42(2.92–14.1) and 6.15(2.83–13.4) respectively at p<0.001. Alam et al (2015) demonstrated mortality was positively correlated with a high NEWS on arrival at an emergency department (p<0.0001). This correlation remained significant at one hour after arrival and on discharge to the ward/ICU. (AUROCs (95% CI) at T0 0.768 (0.618-0.919), T1 0.867(0.769-0.964) T2 0.767 (0.568-0.966). Patients who died had a higher NEWS score (mean 6.00:SD 3.6; Mann-Whitney *U* test p=0.002) compared with patients who survived. Of the physiological measures comprising the NEWS score, the respiratory rate the only parameter significantly associated with mortality at all measured time points. Pulse rate had a strong correlation with mortality if measured an hour after arrival in the emergency department. No correlations could be found for the other physiological parameters. De Meester et al. (2013) found that the number of 6-day post-operative deaths decreased in the pre and post implementation 19 in the pre-implementation of EWS period to 4 in the post-implementation period with a relative risk reduction of 73.7% (95% CI, 22.8-91.0; p=0.015) for 6-day postoperative in-hospital mortality.

vii) Cardiopulmonary arrest

Two included papers considered the relationship between EWS and cardiopulmonary arrests. Nishijima et al. (2016) found that cardiopulmonary arrests dropped significantly following EWS implementation from 5.21 (79/15,170) to 2.05 (43/17,961) (p=<0.01). Smith et al (2013) suggests that NEWs does not perform better than the other 33 available early warning scores for cardiac arrest alone. The AUROC (95% CI) for NEWS for cardiac arrest within 24 h was 0.722 (0.685–0.759) in comparison with 0.611 (0.568-0.654) – 0.710 (0.675-0.745) for the other 33 EWS available.

Discussion

In summary, the results of this review are varied but there is a positive correlation with improved outcomes (cardiopulmonary arrest, mortality, serious adverse events, length of hospital stay, hospital admissions, observation frequency, ICU/HDU admission) following use of an Early Warning Score protocol.This review supports and builds on the previously identified review by Alam et al. (2014) who identified that early warning track and trigger tools significantly decrease ICU/HDU admission with a positive effect on documentation of vital sign parameters. They showed reduced mortality rates, serious adverse events and hospital length of stay although the data did not reach statistical significance. Published data regarding the relationship between length of stay and cardiopulmonary arrest are conflicting. De Meester et al. (2013) demonstrated statistically significant positive outcomes in terms of hospital length of stay, frequency of observations recorded, post-operative re-surgery rates and post-operative mortality. Alam et al. (2015) concurred with De Meester finding statistically significant results in terms of length of stay and mortality. Tirkkonen et al. (2014) also identified a statistically significant relationship between a NEWS of seven or more and in hospital serious adverse events (cardiac arrest, medical emergency team activation, unplanned ICU admission and death). Hospital admission and emergency admission to ICU also significantly correlated with the EWS. Tirkkonen et al. (2014) found that NEWS was independently associated with a higher 30, 60 and 120-day mortality with Smith (2013) identifying that NEWS performs the best of all the 33 available EWS in this theme. Smith also produced statistically significant results in terms of unplanned ICU admission with NEWS performing the best in comparison to the other EWS available.

When considering this review within the context of the wider literature it is clear that recognition of the deteriorating patient and the instigation of a timely response is a complex challenge. Most (99%) of acute hospitals employ a track and trigger tool to identify deteriorating patients with 97.9% of these linked to an escalation protocol (NCEPOD 2015).

A lack of a standardised approach to EWS has introduced variation in methodology and approach resulting in lack of familiarity by clinical staff who may move between institutions and /or teams. The National Early Warning Scoring (NEWS) tool is the recommended track and trigger tool nationally (Royal College of Physicians, 2012; 2017) which should facilitate an increasingly standardised approach to the management of the acutely ill patient when in conjunction with improvements in education, communication and continuity of care (Alam et al. 2015). However, whilst the NEWS in the most highly sensitive score when detecting clinical deterioration, its impact on patient safety outcomes remains largely untested.

Although this review has shown that EWS can have a positive impact on outcomes use of EWS vary greatly and are often influenced by local need and resources (Credland, Dyson and Johnson, 2018). Early warning track and trigger tools have been described as a "quick fix" and a "band aid" for the failure to manage deteriorating patients in hospital (Litvak and Pronovost, 2010). Jones et al. (2009) suggests that inadequate education on the role and purpose of the EWS, a lack of clinical expertise, limited medical and nursing support, increased workload and ineffective patient advocacy are barriers to successful recognition and response.

There appears to be a difference between policy and practice. EWS are prevalent in most of NHS hospitals in the UK however there remains poor recognition and response to deteriorating patients (NCEPOD, 2015). Vital sign monitoring and completion of both the afferent and efferent arms of the EWS is important in the "Chain of Survival". This represents the illness trajectory from identification of acuity, through to timely, appropriate and effective response and ultimately survival. Failure to recognise the unwell patient will break that chain making deterioration more likely leading to increasing mortality, ICU admission and cardiopulmonary arrest (Hands et al. 2013). Compliance with the EWS protocol is a vital aspect in that chain of survival and it is important to investigate further if the research supports effective compliance with the protocol.

Limitations

All included papers in this review were single centre which limits external validity (Nishijima et al. 2016; Alam et al. 2015; Tirkkonen et al. 2014; Smith et al. 2013; De Meester et al. 2013). Both Tirrkonen et al. (2014) and Nishijima et al. (2016) added "concern" to the EWS system and attributed a score of 1. This element has not been validated and requires further exploration. There was a lack of accuracy in data collection in Alam et al. (2015), De Meester et al. (2013) and Smith et al. (2013) with a likely underestimation and incompletion of observations recorded. Tirrkonen et al. (2014) noted the hospital involved in the study had already implemented a medical emergency team (MET) associated with EWS. The use during the study period was highly suboptimal suggesting the staff have some experience of the EWS approach and have not actively engaged in its implementation. This decreases the external validity of the results to otherwise comparable institutions with no MET system or with well-established, mature systems. There are a dearth of studies exploring the effectiveness of EWS using robust design which makes it difficult undertake a meta-analysis and to generalise findings. Whilst the authors cannot guarantee that all papers were identified, the robust search strategy mitigates this issue.

Conclusion

Early Warning Track and Trigger Tools are bedside tools which can aid the recognition of deteriorating patients. There is preliminary evidence to suggest improved clinical outcomes with the use of such tools. Despite the evidence to suggest that EWS improves patient outcomes we continue to have suboptimal care and avoidable mortality (Hogan et al. 2012; NCEPOD, 2012). It would be prudent to explore if and to what extent, the EWS protocol is adhered to. If the National Early Warning Score were used along with an agreed set of measured outcomes, then subsequent study data could be combined to provide much stronger levels of evidence.

Conflict of Interest statement

There are no conflicts of interest

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