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Review article

The impact of the use of the Early Warning Score (EWS) on patient outcomes: A systematic review☆

N. Alam[a,b], E.L. Hobbelink[a], A.J. van Tienhoven[a], P.M. van de Ven[c], E.P. Jansma[d], P.W.B. Nanayakkara[a,b,*]

[a] Department of Internal Medicine, VU University, The Netherlands
[b] Department of Section Emergency Medicine, VU University, The Netherlands
[c] Department of Epidemiology and Biostatistics, VU University, The Netherlands
[d] VU University Medical Centre, Medical Library, VU University, The Netherlands

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ABSTRACT

Background: Acute deterioration in critical ill patients is often preceded by changes in physiological parameters, such as pulse, blood pressure, temperature and respiratory rate. If these changes in the patient's vital parameters are recognized early, excess mortality and serious adverse events (SAEs) such as cardiac arrest may be prevented. The Early Warning Score (EWS) is a scoring system which assists with the detection of physiological changes and may help identify patients at risk of further deterioration.
Objectives: The aim of this systematic review is to evaluate the impact of the use of the Early Warning Score (EWS) on particular patient outcomes, such as in-hospital mortality, patterns of intensive care unit admission and usage, length of hospital stay, cardiac arrests and other serious adverse events of adult patients on general wards and in medical admission units.
Design and setting: Systematic review of studies identified from the bibliographic databases of PubMed, EMBASE.com and The Cochrane Library.
Selection criteria: All controlled studies which measured in-hospital mortality, ICU mortality, serious adverse events (SAEs), cardiopulmonary arrest, length of stay and documentation of physiological parameters which used a EWS on the ward or the emergency department to identify patients at risk were included in the review.
Data collection and analysis: Three reviewers (NA, AT and EH) independently screened all potentially relevant titles and abstracts for eligibility, by using a standardized data-worksheet. Meta-analysis was not possible due to heterogeneity.
Main results: Seven studies met the inclusion criteria. The results of our included studies were mixed, with a positive trend towards better clinical outcomes following the introduction of the EWS chart, sometimes coupled with an outreach service.

Six of the seven included studies used mortality as an endpoint: two of these studies reported no significant difference in in-hospital mortality rate; two found a significant reduction of in-hospital mortality; two other studies described a trend towards improved survival. Although, both ICU mortality and serious adverse events were not significantly improved, there was a trend towards reduction of these endpoints after introduction of the EWS. However only two studies looked respectively at each endpoint.

There were conflicting results concerning cardiopulmonary arrests. One study found a reduction in the incidence of cardiac arrest calls as well as in the mortality of patients who underwent CPR, while another one found an increased incidence of cardio-pulmonary arrests. Neither study met all methodological quality criteria.
Conclusion: The EWS itself is a simple and easy to use tool at the bedside, which may be of help in recognizing patients with potential for acute deterioration. Coupled with an outreach service, it may be used to timely initiate adequate treatment upon recognition, which may influence the clinical outcomes positively. However, the use of adapted forms of the EWS together with different thresholds, poor or inadequate methodology makes it difficult in drawing comparisons. A general conclusion can thus not be

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* Corresponding author at: Section Acute Medicine, Department of Internal Medicine, VU University Medical Centre, PO Box 7057, 1007 MB Amsterdam, The Netherlands.
E-mail address: p.nanayakkara@vumc.nl (P.W.B. Nanayakkara).

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generated from the lack of use of a single standardized score and the use of different populations. In future large multi-centre trials using one standardized score are needed also in order to facilitate comparison.

Contents

1. Introduction

Acute deterioration in patients is often preceded by subtle changes in physiological parameters such as pulse, blood pressure, respiratory rate and level of consciousness.[1–4] Both prospective and retrospective chart reviews as well as a recent report published by the NCEPOD show that evidence of clinical deterioration is often present for hours prior to the occurrence of serious adverse events (SAEs) such as cardiac arrest, death and intensive care unit admission, leading to the conclusion that many of these SAEs might be preventable.[3,5–8] Factors involved in 'preventable' SAEs frequently include poor clinical monitoring, inadequate interpretation of changes in physiological parameters and failure to undertake appropriate action.[9–12] Further, the inability to accurately recognize and initiate treatment of the critically unwell patient not only leads to higher levels of morbidity, but excessive utilization of costly resources, such as increased ICU usage and longer inpatient stay, a pressing issue in a climate of intense financial constraint.

Hospitals need tools to help them recognize patients at risk of deterioration in order to give the right care at the right moment before any SAEs arise The concept of the Early Warning Score (EWS), was developed in 1997 by Morgan et al.[13] It consists of a simple to use algorithm based on physiological parameters, such as heart rate, systolic blood pressure, respiratory rate, temperature and mental state. As this simple scoring tool can easily be utilized during the routine bedside observations, it is considered helpful in recognizing patients exhibiting signs of acute deterioration, but also obtaining timely assistance of a skilled clinician. The EWS is mostly coupled with a team (e.g. Critical Care Outreach Service (CCOS), Rapid Response Team (RRT), Patient at Risk Teams (PART)), consisting of experienced medical and/or nursing staff who can provide the support to timely manage the deteriorating patient [32] and thus help improving patient outcomes.

2. Objectives

In the last decade, several reviews have been carried out concerning critical outreach services using various scoring systems.[14–18] However, most of the studies reviewed the use of a CCOS or an RRT as an efferent limb together with different kinds of early warning systems (afferent limb) rather than the utility of the Early Warning Score and its derived forms.[19] Many studies have investigated some form of an EWS system with (or without) a coupled outreach service, finding positive results on clinical outcomes.[10,12,20] However most of these studies are observational in nature and lack a control group and thus not suitable for the drawing of general recommendations.

The aim of this systematic review is to evaluate the influence of the use of Early Warning Score (EWS) (and its modified forms) coupled with or without an outreach service in particular on patient outcomes such as in-hospital mortality, intensive care unit admission patterns, length of hospital stay, as well as number of cardiac arrests and serious adverse events of adult patients on general wards and in the emergency departments.

3. Search strategy

To identify all relevant publications, we performed systematic searches in the bibliographic databases PubMed, EMBASE.com and The Cochrane Library (via Wiley) from inception to April 8, 2013. Search terms included controlled terms from MeSH in PubMed, EMtree in EMBASE.com as well as free text terms. We used free text terms only in The Cochrane library. Search terms expressing 'Early Warning Score' were used in combination with search terms comprising 'hospital' and terms for 'hospital setting' and 'adults' (see appendix 1: EWS search strategy). The references of the identified articles were searched for relevant publications.

3.1. Selection process

Three reviewers (NA, AT and EH) independently screened all potentially relevant titles and abstracts for eligibility. If necessary, the full text article was checked for the eligibility criteria. Differences in judgments were resolved through consensus. Studies were included if they met the following criteria: (i) type of study should be a controlled study (ii) the study should answer the search question; (iii) studies should only include patients above 16 years of age.

We excluded studies if they were: (i) not a controlled trial (ii) if data was missing; (iii) if no full text was available; (iv) certain publication types: editorials, letters, legal cases, interviews etc. (v) studies which did not provide an answer our search question.

3.2. Data assessment

The full texts of the selected articles were obtained for further review. Three reviewers (NA, AT and EH) independently evaluated the methodological quality of the papers using an adapted version of the EPOC Data Collection checklist (see METHODS USED IN REVIEWS under GROUP DETAILS on *The Cochrane Library*). A standardized data-worksheet was used for data extraction, which included the following variables: type of study (randomized trial, retrospective or prospective, before and after controlled trial), patient characteristics, methodology (control for confounders), study outcomes (mortality, SAEs, LOS), conclusion, limitations, according to the 2009 PRISMA guidelines.[21]

3.3. Search results

The literature search generated a total of 637 references: 367 in PubMed, 249 in EMBASE.com and 21 in The Cochrane Library. After removing duplicates of references that were selected from more than one database, 532 references remained. The flow chart of the search and selection process is presented in supplementary Fig. 1. As we were interested in solely the effect of the EWS or its modified forms on patient outcomes, many studies were exempted from further analysis. This led us to a total of seven studies suitable for inclusion.

All seven selected articles reported trials examining the endpoints before and after implementation of EWS with a total of 486,237 patients. Three studies investigated the impact of the EWS with an already existing CCOS,[7,10,24] whereas two other studies[8,22] introduced the EWS, parallel with a new CCOS. Peris et al.[23] and Meester et al. (2012) were the only studies who solely focused on the impact of the EWS without an official CCOS (Table 1).

Five of the seven studies were performed in the United Kingdom, one in Belgium and one in Italy.

We initially planned to carry out a meta-analysis, but because of the heterogeneity of the studies this was not possible. Therefore, a careful narrative analysis was performed.

4. Results

4.1. Mortality

Of the seven included studies,[7,8,10,22–24] six evaluated mortality. Two studies[7,8] found that introduction of an EWS chart after an intensive staff education programme resulted in a significant reduction in overall mortality. Paterson et al.[7] found a reduction of in-hospital mortality of 2.8% ($p = 0.046$), from 5.8% before implementation of EWS to 3.0% after implementation. Moon et al.[8] found that the in-hospital mortality significantly reduced from 1.4% to 1.2% ($p < 0.0001$).

Three studies[22–24] investigated the impact of the EWS in specific patient populations. Bokhari et al.[22] focused on patients with haematological disorders, finding improved short- and medium-term survival. Although relatively modest, the long-term survival at 3 and 6 months was also improved. Survival to discharge from the hospital increased by 8%, from 37% to 45%. It must be noted however that specific significance levels were not mentioned and an adequate description of the methodology for comparing the proportion was missing from this paper. Comparing proportions by means of chi-square test and using the numbers of 10/27 and 47/105 as reported gives $p = 0.47$, which is not significant. It must be mentioned that the length of short- and medium-term survival was not mentioned in the article.

Patel et al.[24] looked at the impact of the Modified Early Warning Score (MEWS) in a busy trauma unit. There was a trend towards lower mortality rates, but this was not statistically significant. In the periods pre- and post-MEWS the decrease in-hospital mortality rate was 0.4% for males ($p = 0.214$; 95% CI: 0.003–0.81, pre-MEWS mortality: 1.8%, post-MEWS mortality: 1.4%); 1.5% for females ($p = 0.108$; 95% CI: 0.81–2.21, pre-MEWS mortality: 4.9%, post-MEWS mortality: 3.4%); and 0.9% in total ($p = 0.092$; 95% CI: 0.53–1.31%, pre-MEWS mortality: 3.2%, post-MEWS mortality: 2.3%).

Peris et al.[23] investigated the effect of implementing the EWS in emergency surgical patients and found no significant difference in intra-hospital mortality rate (control group: 8%, MEWS 7%), *p*-values and confidence intervals were not given. Comparing mortality by means of chi-square test and using the numbers of 48/604 and 32/478 as reported gives $p = 0.43$.

Subbe et al.[10] compared rates of in-hospital mortality and found no significant differences within the three risk-bands (EWS = 0–2, EWS = 3–4, EWS ≥ 5) considered.

One study[7] investigated whether in-hospital mortality was associated with the admission EWS score. Paterson et al.[7] found that mortality rose more than 8-fold for a score of ≥4, compared with a score of 0–3 (difference in proportions 15.3%; 95% CI 3.7–26.9).

4.2. ICU mortality

Subbe et al.[10] was the only study which looked at the ICU mortality rates. They found that ICU mortality was lower after introducing EWS (67% vs 33%), although this was not significant $p = 0.21$. It must be noted however that the relative risk might seem large, there is uncertainty regarding this estimate, as the number of included patients included in this sub-analysis was very small ($n = 15$).

4.3. HDU and ICU admission

Peris et al.[23] looked at HDU and ICU admission rates after implementation of the EWS in emergency surgical patients. HDU admission significantly increased from 14% to 21% ($p = 0.0008$) while a significant decrease of ICU admission was reported from 11% to 5% ($p = 0.0010$).

4.4. Serious adverse events

The study of De Meester et al. (2012) was the only study, which investigated whether introducing a standard nurse observation protocol implementing the Early Warning Score, could decrease the incidence of serious adverse events (SAEs). SAEs were defined as the number of patients who died without an attempt at resuscitation (DNAR) and the number of patients readmitted to ICU 5 days after ICU discharge. The study reported that despite a substantial decrease in SAEs 120 h after ICU discharge, statistical significance could not be reached. An EWS of 4 or higher did however have a predictive value for SAEs in the 5-day period after ICU discharge (sensitivity of 61% and a specificity of 74% and AUC.703).

4.5. Cardiopulmonary arrest

Subbe et al.[10] found that there was an increased incidence of cardio-pulmonary arrests (2.3%) after introducing EWS in comparison with before (0.6%) ($p = 0.03$, computed by the authors of this

Table 1
Relevant papers.

Study	Patient group Type of study Year	Setting	Intervention	Outcomes	Results	Level of evidence (according to the Prisma guidelines)
Subbe et al.[10]	Total of 2354 patients; Historical cohort from earlier prospective study (before-group) and prospective cohort (after-group) Before $n = 659$; Mean age = 63 years (sd 19) Sex male/female: 45%/55% Year: 2001 After: $n = 1695$ Mean age = 64 years (sd 20) Sex male/female: 45%/55% Year: 2003	Medical Admission Unit (MAU) by general practitioners or the Accident and Emergency department (A&ED) Single centre	Before: administration of MEWS score, usual care was given. Critical care outreach service (CCOS) was already present. After: MEWS chart, threshold score of >4 (SBP, HR, RR, Temp, AVPU) coupled with the existing CCOS. *Nursing staff were trained prior implementation in collecting bedside observations and calculating MEWS score*	*Primary:* Rates of ICU and HDU admission, cardiopulmonary arrest, mortality *Secondary:* Time from hospital to ICU admission, length of stay on ICU and ICU mortality	- Results were stratified by MEWS risk bands for low, intermediate and high risk (0–2, 3–4, ≥5) - The rates of ICU and HDU admissions and in-hospital mortality were similar in the before- and after-groups for each of the risk bands defined. - The rates of cardiopulmonary arrests were found to differ significantly between before and after group, but only for intermediate risk group (MEWS 3–4): 16/348 (5%) in after-group and 0/117 (0%) in before group, $p = 0.016$). - ICU mortality was 33% (3/9) in the after-group and 67% (4/6) in the before group ($p = 0.21$).	Level B No reason is given for only performing stratified analyses. When analyzing the whole group, rate of cardiopulmonary arrests is significantly higher in the after-group: 40/1695 (2.3%), than in the before-group 4/659 (0.6%), $p = 0.03$. Presumably stratification is done to control for differences in MEWS scores between before- and after-group. In the discussion authors state that the increased CA rate may be caused by higher MEWS score in the after-group, but this does not explain the increased CA rate found in the intermediate risk band. Effect of missing data on study outcomes is unclear. Patients for which no outcome could be identified were excluded from analysis. Number of patients excluded is not mentioned. Statistical analysis concerning ICU mortality was based on 15 patients only (9 in the after-group vs. 6 in the before-group). Due to the small number of included patients there is large uncertainty around the estimated relative risk. Comparison may lack statistical power.
Paterson et al.[7]	Total of 848 patients Single prospective cohort Before $n = 413$; Mean age = 67 years (IQR: 44–80) Sex male/female: 45%/55% Year: 2003 (October) After $n = 435$ Mean age = 69 years (IQR: 43–79) Sex male/female: 45%/55% Year: 2003 (November)	Combined assessment area, all emergency referrals Single centre	Before: administration of conventional observation charts (no SEWS), usual care was given CCOS was already present After: SEWS chart, threshold score of >4 (HR, RR, BP, AVPU, Temp, SaO_2) coupled with the existing CCOS. *Introduction of the chart was after an standarised educational programme was followed by nursing and medical staff*	Completeness of documentation of physiological parameters, in-hospital mortality, hospital length of stay	- Significant increase in fraction of patients with all parameters reported: 29/413 (7.0%) versus 328/435 (75.6%), $p < 0.001$. - Significant increase in reporting for each of the physiological parameters separately ($p < 0.001$–0.005), except for SaO_2 $p = 0.069$. - Reduction in overall in-hospital mortality (before-group 5.8% (24/413), after-group 3.0% (13/434), $p = 0.046$). - SEWS ≥4 was (in the after-group) found to be associated with higher hospital mortality compared to SEWS ≤3 ($p < 0.001$) - Median LOS was (in the after-group) found to increase with increasing SEWS score ($p = 0.001$) - Staff thinks that scoring helps increase awareness of illness severity and prompts earlier intervention. - Incorporation of oxygen saturation improves the power of early warning scoring systems	Level B

Bokhari et al.[22]	Total of 132 patients Retrospective study, outcome data collection based on reviewing case notes, patient records and APACHE database Before $n = 27$ Mean age = 57 years (range: 22–79) Sex male/female: 74%/26% Year: 2004 After $n = 105$ Mean age = 60 years (range 17–84) Sex male/female: 50%/50% Year: 2006–2008	Department of clinical haematology and stem cell transplantation Single centre	Before: usual care was given (no EWS and no CCOS) After: MEWS chart, threshold score of >3 (HR, RR, BP, AVPU, temp, urine-output) coupled with the newly introduced CCOS. *No specific training was given before implementation*	LOS, survival to ICU, survival to discharge from ICU and hospital, proportion alive at 6 months, disease status at 6 months	- The median LOS for all patients increased from 3 to 4 days (no *p*-value reported), although that of level 3 (ICU) patients remained relatively static throughout the time period of the study at 5 days (no *p*-value reported). - There was an increase in the proportion of all patients surviving to discharge from hospital, and this also was reflected in level 3 patients, including those who underwent mechanical ventilation (no *p*-values reported). - Longer-term survival at 3 and 6 months also appeared to be improved, though the trend became more modest (no *p*-values reported).	Level C Small sample size and relatively large difference in percentage male between the before- and after-group. No statistical testing of primary endpoints (differences between before- and after group outcomes) – or at least no reporting of *p*-values. No statistical methods for comparing proportions between the two groups are mentioned in the methods section. Only statistical tests are for identifying factors associated with survival in the 2006–2008 cohort. Impact and benefits of introduction of EWS remain unclear as no formal before- and after-comparison is done (except for APACHE-2 score).
Patel et al.[24]	Total of 32 149 patients during the whole study period No specific subgroup description given Sex male/female: 55%/45% Year: Before; Jan 2002 till summer 2005 After; summer 2005 till 2009	Trauma and orthopedic wards Single center	Before: usual care was given (No MEWS) CCOS was already present After: MEWS chart, threshold score of >4(HR, RR, BP, AVPU, Temp, Urine-output) coupled with the existing CCOS *No specific training was given before implementation*	In-hospital mortality rate	- Observed trend towards reduction of in-hospital mortality. Estimated decrease was 0.9% (from 3.2% to 2.3%) ($p = 0.092$; 95% CI: 0.53–1.31%). - Estimated decrease in in-hospital mortality rate in the periods pre- and post-MEWS was 0.4% (from 1.8% to 1.4%) for males ($p = 0.214$; 95% CI: 0.003–0.81) and 1.5% (from 4.9% to 3.4%) for females ($p = 0.108$; 95% CI: 0.81–2.21); and	Level B
Moon et al.[8]	Total of 448.633 patients Retrospective study of prospectively collected data Before: $n = 213\ 117$ Mean age: 68 (range: 20–93) Sex male/female: 69%/31% Year: 2002–2005 After $n = 235\ 516$ Mean age = 69 (range: 31–91) Sex male/female: 57%/43% Year: 2006–2009	All referrals during two four year periods Multi center (two teaching hospitals, Freeman Hospital (FH) and Royal Victoria Infirmary (RVI)	Before: usual care was given (No MEWS and no CCOS) After: MEWS chart, threshold score of 5 (HR, RR, BP, AVPU, temp, SaO_2) coupled with the newly introduced CCOS *Specific education was provided in recognition of patients at risk and the use of MEWS chart.*	- Intensive care admission rates, - Cardiac arrest calls to adult care areas, - Admission to intensive care following in-hospital CPR and - Mortality rates (intensive care and in-hospital) of these patients.	FH: Reduction of emergency admissions 31% (66305/213117) to 28% ($n = 66457/235516$), $p < 0.001$. - Reduction in the proportion of cardiac arrest calls to adult care areas, relative to both total admissions and emergency admissions ($p < 0.0001$). - Reduction in hospital deaths from 750/year in 2002–2005 ($n = 3\ 001$) to 697/year in 2006–2009 ($n = 2789$), a 7.1% reduction. - Significant reduction of deaths rates per hospital admission (1.4% vs. 1.2%), per emergency admission (4.5% vs. 4.2%) both $p < 0.0001$. RVI: Reduction of emergency admissions 42% (103240/248260) to 41% ($n = 114003/281831$), $p = 0.8$. - Reduction in the proportion of cardiac arrest calls to adult care areas, relative to both total admissions and emergency admissions ($p < 0.0001$). - Reduction in hospital deaths from 952/year in 2002–2005 ($n = 3709$) to 906/year in 2006–2009 ($n = 3622$), a 2.3% reduction. - Significant reduction of deaths rates per hospital admission (1.49% vs. 1.29%, per emergency admission (1.49% vs. 1.29%, both $p < 0.0001$.	Level B

Table 1 (*Continued*)

Study	Patient group Type of study Year	Setting	Intervention	Outcomes	Results	Level of evidence (according to the Prisma guidelines)
Meester et al. (2012)	Total of 1039 patients Combination of retrospectively (before-group) and prospectively collected data (after-group). Before ($n = 530$), Mean age: 59 years (range 17–95) Sex male/female: 59%/41% Year: November 2008–February 2009 and June 2009–October 2009 After ($n = 509$) Mean age: 59 years (range 18–94) Sex male/female: 60%/40% Year: November 2009–June 2010	Patients transferred to a medical or surgical ward after ICU discharge Single center	Before: usual care was given. MEWS scores were available for the before-group for this study, but it is unclear whether MEWS was scored as part of routine clinical practice or retrospectively on the basis patient records. No CCOS. After: Standard nurse observation protocol implementing MEWS (HR, RR, BP, AVPU, temp, SaO_2) and color graphic observation chart, with threshold score of 5. Alert the physician responsible for the patient. No CCOS. *No specific training was given before implementation*	Prevalence SAE	- The incidence of SAE's during the 5-day period after ICU-discharge decreased with 38.6%: from 5.7% in the pre-intervention period to 3.5% in the post-intervention period. This was an absolute risk reduction of 2.2% (95% CI −0.4–4.67%). The Number needed to treat was 45, but not statistically significant. - Patients with MEWS ≥4 at ICU discharge had increased risk of SAE in the 5-day period following discharge ($p < 0.001$). - The number of unexpected deaths decreased from 4 to 0 patients. The number of SAE's within 56 h after ICU discharge decreased from 21 to 11 SAE's or a decrease of 47.6% (both not statistically significant)	Level B
Peris et al.[23]	Total of 1082 patients Before ($n = 604$) Mean age: 52 Sex male/female: 53%/47% Year: January 2008–March 2009 After ($n = 478$) Mean age: 50 Sex male/female: 36%/64% Year: April 2009–January 2010	Anesthesia and Intensive Care Unit of the ED and Emergency Surgical Open Space Unit Single center, tertiary referral center Emergency surgical patients, patients were divided into three groups (acute abdomen, non-complicated/nonscheduled surgery, blunt abdominal trauma)	Before: usual care was given (no MEWS, no CCOS) After: MEWS calculated by anesthetist on duty before surgical procedure and before discharge from operating room. (SBP, HR, RR, Temp, AVPU) Patients with a MEWS of 3 or 4 were transferred to HDU, whereas a MEWS of 5 or more was a criterion for ICU admission. No CCOS was used. Nurses of the surgical ward and HDU were trained in MEWS collection during the patient's routine evaluation	Hospital LOS, HDU admission, ICU admission, mortality	- HDU admission significantly increased from 14% to 21% ($p = 0.0008$; sensitivity 0.45, 95% CI 0.37–0.52; specificity 0.42, 95% CI 0.39–0.45) - Significant decrease of ICU admission from 11% to 5% ($p = 0.0010$; sensitivity 0.72, 95% CI 0.62–0.81; specificity 0.46, 95% CI 0.43–0.49) - Intra-hospital mortality rate did not show any significant difference (8% in the before-group en 7% in the after-group) Hospital length of stay did not differ between before and after-group (mean before-group 8 with sd = 11 and mean after-group 7 with sd = 10)	Level B The MEWS was used in order to choose the appropriate allocation of care (HDU/ICU) for surgical patients. Using the MEWS in this way, may be problematic as the shift in balance in patient admission can also be explained by using a higher threshold for admitting patients to the ICU.

review). Moon et al.,[8] on the contrary found that there was a significant reduction in the proportion of cardiac arrest calls as proportion of all adult admissions and emergency admissions in two hospitals ($p < 0.0001$ for all four groups before-after comparisons).

4.6. Length of stay

Length of stay in hospital was significantly correlated with a higher EWS score[7]; ($p = 0.001$). Bokhari et al.[22] found that the median length of stay for all patients admitted to the ICU or HDU increased from 3 to 4 days, but did not perform a statistical test to compare the distribution of the length of stay in the before- and after group. Peris et al.[23] did not find a significant change in length of stay (mean before = 8 days, mean after = 7 days, however there was a trend towards shorter LOS.

4.7. Documentation of physiological parameters

Two studies[7] (Meester et al., 2012) reported that implementing an EWS chart had a positive effect on the documentation frequency of vital parameters. Paterson et al. found that this was especially so for respiratory rate and consciousness level, two important prognostic indicators for critical illness.[10,11,25,26]

4.8. Cost effectiveness

None of the included studies assessed the cost effectiveness of interventions.

5. Discussion

In this systematic review we identified seven studies which met our inclusion criteria. These seven studies were all studies investigating patient outcomes before and after implementation of an Early Warning Scores, sometimes coupled with a CCOS. As all included studies were highly heterogeneous in study population, sample sizes and the use of different forms of Early Warning Scores with different alarm thresholds with or without a coupled CCOS, a meta-analysis for different patient subgroups could not be performed.

Also, it must be noted that before- and after-study designs may be prone to bias due to variations in the patient population and changes in ways of providing care at hospitals over time. The results of our included studies were mixed, but in general there was a positive trend towards better clinical outcomes (improved survival, lower ICU mortality, decrease in SAE) after the introduction of an EWS system.

However, there were some conflicting results concerning the length of stay and cardiopulmonary arrests, While both Paterson et al.[7] and Bokhari et al.[22] found that a higher score was associated with an extended stay, Peris and co-authors[23] could not reproduce this result, which could be due to the differences between the populations. Furthermore Moon et al.[8] found a reduction of incidence of cardiac arrest calls as well as a reduction of ICU- and in-hospital mortality of patients having undergone CPR. Subbe et al.[10] found an increased incidence of cardio-pulmonary arrests. This increase could be explained by the heterogeneity of the study group of Subbe et al., as it contained a higher number of sick patients compared with the control group. Despite the negative outcomes of the study of Subbe[10] the authors of this study were convinced that the EWS is a suitable score for identifying patients at risk. Subbe et al., along with the authors of the other included studies emphasize that a multitude of factors can contribute in not getting better results, amongst which are delayed or inadequate response, lack of organization or having too small sample sizes to obtain any significance.[19] Furthermore, the studies were retrospective analysis of prospectively collected data, leading to a possible variations in the control and study group.

Timely recognition of patients with deteriorating acute illness and adequate clinical response can be of great influence on improving clinical outcomes. However, recognizing patients in need of higher care can be quite challenging and is indeed dependent of many factors, such as the work experience of the healthcare provider as well as conscientious use of the given tools such as the EWS. Training to work with Early Warning Scores as well as familiarity with call-out algorithms is essential for being able to adequately understand the potential benefits of these scores. For correctly calculating the EWS, proper documentation of all vital parameters is required. Despite the importance of accurate documentation of physiological parameters, there is still a need for improvement as documentation is incomplete in most cases.[27] Foremost the importance of measuring the respiratory rate is not recognized, despite the fact that several studies have described the respiratory rate as one of the most accurate physiological parameters in predicting clinical outcome. Three of the included studies[7,10,22] emphasize the fact that adequate training can improve the outcomes. Through introduction of an EWS system, general awareness is improved and may lead to more frequent routine observation by nursing staff, as well as a more timely response to deteriorating vital signs. Nurses might be triggered earlier to call for adequate medical assistance. It should be noted however, that improving general awareness by training can cause a Hawthorne effect.

Despite the fact that most of the included studies found a positive impact on clinical outcomes, a definite conclusion about the usefulness in all wards cannot be drawn, as all included studies of specific subgroups of patients. Moreover some of the studies (Bokhari et al.[22] and Patel et al.[24] lacked adequate description of methodology and had relatively small sample sizes[10,22] (Meester et al., 2012). The usefulness of a hospital-wide EWS, whether or not with a coupled outreach service team remains unclear. Furthermore, data of the different studies might be influenced by the diversity of the studied population as the majority of the current patients admitted to hospital consist of an elderly population with multiple co-morbidities, many of which are not suitable or profited by higher levels of care. Also, patient characteristics (e.g. age, respiratory disease) and the use of medication (beta blockers) might give a bias in the EWS.

Since its development, the EWS has gone through much iteration and its modified forms have widely been used throughout many hospitals across the world.[28,29] However, one drawback is that the approach is not standardized, as many hospitals use their own modified version of the EWS scorings system. This variation in methodology and approach can result in a lack of familiarity with local systems when staff move between clinical areas and hospitals – the various EWS systems are not necessarily equivalent or interchangeable.[30] Because of the diversity of existing scoring systems, much effort has recently been put by the NHS in the United Kingdom to develop a standardized scoring system to be used across the National Health Service in England, Wales and Northern Ireland, the National Early Warning Score (NEWS). NEWS can be used to standardize the assessment of acute-illness severity not only when acute ill patients present to the hospital or as a surveillance system for all patients in hospitals, but potentially also in the pre-hospital assessment. It can be used for tracking clinical deterioration and alerting the medical team at the emergency department and triggering a timely clinical response. Also it must be noted, that thus far the NEWS is the most sensitive Early Warning Score available,[31] whereas single parameter systems and aggregated EWS have insufficient positive predictive value or perform inferiorly. Although the NEWS has shown its superiority in detecting deteriorating patients, its positive impact on patient safety outcomes remains to be investigated. The best approach for future research is a matter of debate, as conducting a big randomized controlled trial does not mean obtaining the highest level of evidence.[19] Another important aspect is that although the NEWS itself might be a simple and easy to use tool, the coupled outreach service however is not. In all future studies cost-effectiveness must be taken into account.

Successful implementation of an EWS in the hospital however must go hand in hand with proper education of staff and increasing awareness of the necessity of structural patient monitoring. This will eventually lead to a change in the mindset of healthcare providers to collaborate as a team thereby leading to a better organization of patient care. Every score should be used as an adjunct to the clinical judgement of the doctor.

6. Conclusion

Despite the fact that much effort has been put in the last decade in developing early warning scoring systems for recognizing patients at risk for deterioration, there still remains a need for improvement in recognition and response. The results of our included studies were mixed, but in general there was a positive trend towards clinical outcomes after the introduction of an EWS system. As the other available scoring systems are either too complex to use or only validated for specific patient populations, the EWS remains a simple and easy to use tool at the bedside, its simplicity being an advantage. However the lack of one standardized score and the use of different populations make it impossible to draw a general conclusion. Multi-centre trials using one standardized score (e.g. the NEWS) with more homogenous patient groups where clusters (comparable units from different hospitals) are randomized to either use or not use the EWS can be useful in order to facilitate comparison. Conducting a randomized controlled trial with the EWS however is difficult and not easily done. We think it is time to perform a study, which takes into account all the steps as stated before to investigate the usefulness of a standardized EWS throughout the hospital.

Conflict of interest statement

All authors have disclosed that they do not have any potential conflict of interest.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.resuscitation.2014.01.013.

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