Early warning score challenges and opportunities in the care of deteriorating patients

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Early Warning Score

Challenges and opportunities in the care of deteriorating patients

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THE THREE ORIGINAL PAPERS ARE

1. Petersen JA, Mackel R, Antonsen K, Rasmussen LS. Serious adverse events in a hospital using early warning score – What went wrong? Resuscitation 2014;85:1699-1703
2. Petersen JA, Rasmussen LS, Rydahl-Hansen S. Barriers and facilitating factors related to use of early warning score among acute care nurses: a qualitative study. Accepted for publication.
3. Petersen JA, Antonsen K, Rasmussen LS. Frequency of early warning score assessment and clinical deterioration in hospitalized patients: A randomized trial. Resuscitation 2016;101:91-96

1. INTRODUCTION

Serious adverse events (SAE) in hospitalized patients, such as cardiac arrest (CA), unanticipated ICU admission (UICU), or unexpected death (UD), are often preceded by deteriorating vital signs[1–4]. In 51 – 80 % of in-hospital cardiac arrests (IHCA) one or more aberrant vital sign were reported up to 24 h before the event[5–7]. For the combined outcome of IHCA, death, and ICU admission signs of deterioration prior to the event were found in 60 % of cases[8]. If detected early and treated effectively, it is conjectured that further deterioration can be prevented and SAEs avoided[9–11]. To achieve this, many hospitals in the UK, Australia, USA, and Europe have implemented rapid response systems (RRS)[12–15]. The systems consist of an afferent limb to detect at-risk patients on general wards, and alert the efferent limb, usually a medical emergency team (MET), staffed with experts in critical care, for assistance[9]. Despite wide dissemination of RRSs potentially preventable SAEs continue to occur among hospitalized patients[7,16–19]. One reason for this is the complex nature of the process that leads from detection of physiological deterioration to triggering a staff response and initiating an appropriate treatment. A successful system requires monitoring of relevant physiological parameters at the right intervals, and trigger appropriate actions based on proper thresholds for escalating care. Furthermore, the system must be simple to use in order to routinely achieve reliable scores on busy hospital wards and ensure adherence to the escalation protocol[10].

EARLY WARNING SCORE

A variety of track-and-trigger systems (TTS) exists to aid detection and direct appropriate escalation of care, mostly based on changes in vital signs. These systems vary according to the number of vital signs and related observations, monitoring frequencies, trigger thresholds, and responses[20–22]. They can be broadly categorized into single- and multi-parameter systems. In the former, MET calls are triggered when a single vital sign exceeds a predefined threshold, and in the latter, points are allocated for each measured physiological parameter according to how much it deviates from a predefined normal range and aggregated to a single score – these aggregated weighted TTS (AWTTS) are also known as early warning scores (EWS). EWS reflects the degree of deterioration, with higher scores indicating greater severity[23]. Ideally, this allows adapting the urgency of the clinical response as well as the provider's level of expertise to patients' needs. The overall performance of an AWTTS depends on its ability to detect deterioration early and trigger a timely appropriate clinical response[23]. One study identified no less than 56 different AWTTSs, of which 33 were based on physiological parameters and 23 had additional parameters such as the presence of pain and need for respiratory support[22]. The performance of these AWTTSs to predict hospital mortality ranged from 0.567 to 0.782 in the area under the receiver operating characteristic curve (AUROC). Subsequent work led to the Vitalpac™ EWS (ViEWS) which was found to be superior to the other EWSs in predicting short term mortality in acutely admitted medical patients (AUROC 0.888 (0.880–0.895, 95 % CI))[24]. A slightly modified version, the national early warning score (NEWS)(table 1), is endorsed by the Royal College of Physicians for use in the UK and a similar system based on these recommendations was implemented at hospitals in the Capital Region of Denmark in 2013[23].

Vital sign	3	2	1	0	1	2	3
Respiratory rate pr min	<9		9-11	12-20		21-24	>24
Aterial oxygen saturation	<92%	92-93%	94-95%	>95%			
Supplemental oxygen		Yes		No			
Temperature (°C)	<35.1		35.1-36.0	36.1-38.0	38.1 – 39.0	>39.0	
Systolic blood pres-	<91	91-100	101-110	111-219			>219

sure mmHg							
Heart rate pr min	<41		41-50	51-90	91 – 110	111-130	>130
Level of consciousness				A			V, P, U

Table 1 – early warning score (EWS)

NEWS gives reduced weighting for supplemental oxygen from 3 to 2 points, and reduced threshold for elevated systolic blood pressure from 250 mmHg to 220 mmHg, in comparison to ViEWS. The ability of NEWS to predict the combined outcome of short term in-hospital mortality, CA, and ICU admission was tested on the ViEWS derivation cohort, and compared to the previous 33 physiology based AWTTSs. The AUROC for the combined outcome was 0.873 (0.866 – 0.879, 95% CI) and superior to the other systems (0.736 to 0.834). However, its ability to predict CA was only moderate with an AUROC of 0.722 (0.685 – 0.745, 95 % CI), but good for predicting ICU admission and death 0.857 (0.847 – 868) and 0.894 (0.887 – 0.902), respectively[25].

MONITORING

While it is fairly well established which vital signs and related parameters to measure, it still remains to be determined how often vital signs should be taken. Detecting at-risk patients early in their disease course requires regular and systematic assessment. Accordingly, monitoring can be defined as: "the ongoing assessment of a patient with the intention of 1) detecting abnormality, and 2) triggering a response if an abnormality is detected"[11]. Ideally, this should be done frequently enough to identify at-risk patients at a time when intervention can make a clinical difference. Theoretically, automated continuous surveillance would be best suited for this purpose, but current technology is not advanced enough to reliably measure all required parameters in ambulatory patients on general wards. Furthermore, there is no evidence of positive effect of continuous surveillance of general ward patients. In fact, an observational study found an increased rate of afferent limb failure in continuously monitored vs unmonitored ward patients (81 % vs. 53 %, $p < 0.001$) despite better documentation of vital signs (96 % vs. 74 %, $p < 0.001$) in the 6 h prior to MET activation[26]. Likewise, a randomized controlled trial of 402 high-risk patients showed no effect of continuous surveillance between intervention and control group in regard to morbidity and mortality[27]. However, another study showed a doubling of MET calls on wards randomized to use mandatory intermittent monitoring (three times daily) compared to control wards, where monitoring was based on indication. The increased MET activity did not translate to differences in serious adverse event rates, which decreased equally in both groups during the study period[28]. Creating a balance between frequency of observation and disruptions in work flow is a key concern. It is intuitively clear that increased monitoring leads to increased detection rates, but does so at the expense of augmented workload[29]. The ideal cut-off point must strike a balance between patient safety and available resources, and it is presently recommended to monitor low risk patients at least twice daily and to increase monitoring frequency with increasing EWS[11,23] .

AFFERENT LIMB FAILURE

Delayed or omitted MET calls are correlated with increased morbidity and mortality. As mentioned earlier, identification of at-risk patients and appropriate escalation of care is a stepwise, complex process. Detection is based on vital signs and to ensure efficiency, the response can be condensed to a simple escalation protocol that describes what actions are to be taken at different thresholds (table 2). To be successful, providers at every level in the chain of events have to execute their tasks properly, but this has been repeatedly shown not to be the case[16,17,30,31]. In a survey from the USA, omission to call MET was reported in 25 % of cases where patients fulfilled calling criteria. Reasons for non-adherence correlated with lack of knowledge and negative attitudes towards MET[32]. Conversely, an Australian study also showed a high non-adherence rate of 42 %, but here the main reason was staffs confidence in their own ability to be able to treat the patients[33]. Other often cited reasons for failure to call MET are: fear of reprimands by the team, and fear to appear incompetent[34,35]. A number of studies have addressed barriers to MET calls, but only few studies have specifically addressed compliance with EWS protocol[36–38]. In general, factors like: staffing, training, education, support by leadership, and professionalism are reported to correlate positively with adherence to guidelines, but it is difficult to draw firm conclusions about which factors are most important, because of conflicting results and heterogeneity in study designs[32–34,39–42]. So while it is well established that afferent limb failure occurs frequently, the reason(s) for this are less clear.

EWS	Frequency of monitoring	Clinical response according to escalation protocol
0 – 1	Minimum 12 hourly	• Continue monitoring minimum 12 hourly
2	Minimum 6 hourly	• Assess airway, breathing and circulation and intervene appropriately • With individual score = 2 inform nurse in charge about patient
3 – 5	Minimum 4 hourly	• Assess airway, breathing and circulation and intervene appropriately • Nurse in charge informs on-call physician, who assesses patient and lays out appropriate treatment and/ or diagnostic plan
6	Minimum 4 hourly	• Assess airway, breathing and circulation and intervene appropriately • Urgent assessment by on-call physician, who assesses patient and lays out appropriate treatment and/ or diagnostic plan
7 – 8	Minimum 1 hourly	• Assess airway, breathing and circulation and intervene appropriately • Emergency assessment (within 30 minutes) by on-call physician, who assesses patient and lays out appropriate treatment and/ or diagnostic plan • Consider to call medical emergency team (MET)
≥ 9	Minimum	• Assess airway, breathing and circulation and

	½ hourly	intervene appropriately • Emergency assessment (within 15 minutes) by on-call physician, who assesses patient and lays out appropriate treatment and/ or diagnostic plan • Patient must be conferred with specialist or medical emergency team (MET)

Table 2 – escalation protocol for EWS

OBJECTIVES

Ideally, SAEs on general wards would cease to occur in hospitals with fully implemented mature EWSs with an appropriate escalation protocol, since every at-risk patient would be identified early, and measures taken according to patients' needs: that is treat the underlying condition effectively, transfer patients to higher level of care if necessary, and/ or initiate end-of-life pathways when appropriate. This is clearly not always the case, and failure of the system must be attributed either to inherent flaws in the EWS, i.e. lack of sensitivity, or non-adherence to protocol by staff.

The studies included in the present thesis aim to explore different aspects of the EWS system implemented on all public hospitals in the Capital Region of Denmark in 2013 as well as qualitatively establish reasons for non-adherence to protocol among hospital staff.

Study 1 is a retrospective review of all CAs and UDs, and UICUs that occurred at Bispebjerg Hospital (BBH) during a 6 months study period. The aim of the study was to evaluate a newly implemented EWS, and explore to what degree failure of the system was due to lack of sensitivity, or non-adherence to the escalation protocol.

Study 2 is a qualitative study based on focus group interviews with acute care nurses. Its aim was to identify barriers and facilitating factors regarding: adherence to monitoring frequency, calls for junior doctors to patients with mildly elevated EWS, and call for MET to patients with severely elevated EWS. The choice of these three primary research questions was based on findings from study 1.

Study 3 is a randomized trial to explore whether EWS measurements at 8 h intervals was superior to 12 h intervals, in preventing deterioration among newly admitted surgical and medical patients with a low EWS on admission. Randomization was performed at ward level and the primary end-point was proportion of patients with an elevated EWS ≥ 2 at 24 h post-admission. Patients with an initial EWS of 0 or 1 on admission were included during two six-week study periods.

2. GENERAL METHODOLOGY

STUDY DESIGN

All three studies differ in methodology and design to properly investigate different aspects of EWS.

STUDY LOCATION

All studies were conducted at BBH that is part of Bispebjerg-Frederiksberg University Hospital. BBH is a 500-bed urban acute care hospital located in Copenhagen, Denmark with a catchment area of approximately 300,000 people. There are 300 medical and 200 surgical beds and an ICU with 10 beds. The hospital offers services in cardiology, neurology, pulmonology, endocrinology, geriatrics, medical and surgical gastroenterology, and orthopedics.

The surgical acute care ward has 20-beds and receives approximately 6500 patients annually. The medical acute care ward has 36 beds, and an annual intake of approximately 7500 general medical patients. Patients can be admitted either from the general practitioner, emergency department, other departments and outpatient clinics of the hospital, or transferred from other hospitals.

MEDICAL EMERGENCY TEAM

A fully implemented MET has been in place at the hospital since 2007, it is manned 24/ 7 with a specially trained intensive care nurse and a specialist in anesthesiology. MET covers all areas of the hospital except for the emergency department and radiology department. These departments request either the trauma team or CA team directly. All other staff on general wards can request a MET review by telephone directly to the ICU nurse on duty. Hospital policy states that all patients are eligible for MET review and staff is allowed to call MET, if they are concerned, regardless of EWS or existing limitations of treatment.

EARLY WARNING SCORE

In 2012 the single parameter track and trigger score at BBH was replaced with an EWS based on NEWS (table 1) together with an escalation protocol (table 2). EWS includes measures for respiratory rate, arterial hemoglobin oxygen saturation, pulse rate, systolic blood pressure, level of consciousness according to AVPU score, temperature, and whether the patient receives supplementary oxygen. Each vital sign can be assigned from 0 to 3 points (supplementary oxygen 0 or 2) depending on how much it deviates from a predefined threshold; the values are added to an aggregated score from 0 to 20, higher scores indicating more severe disease. The escalation protocol directs the type of clinical response and competency of the provider according to EWS triggers and is an integrated part of the system. Scores 0 – 1 are considered low risk, and no actions are to be taken. In every patient with a score ≥ 2 staff must assess airway patency, breathing, and circulation and intervene appropriately according to a predefined ABCDE algorithm. Monitoring frequency is increased to every 6, 4 and 1 h for scores 2, 3 and 7 respectively, and to every 30 minutes for EWS ≥ 9.

Scores 3 – 5 mandate nurses to notify the junior doctor on-call, who must assess the patient, and document additional treatment and diagnostic plans. Patients with scores from 6 – 8 must be evaluated by a junior doctor immediately. Patients with EWS ≥ 9 must be seen by a senior doctor or MET without delay. The treating physician has the option to assign modified thresholds for individual vital signs in patients with chronically impaired physiology due to chronic disease, e.g. patients with chronic hypoxemia. In these patients the threshold for arterial oxygen saturation could be lowered to 92 % and the EWS will be calculated according to this new threshold. The escalation protocol, however, is the same, once the trigger score is reached.

Implementation of EWS at our institution was conducted through involvement of specially trained members of the nursing staff and physicians together with heads of departments. All new employees are introduced to the system and there is ongoing training for all healthcare providers on general wards in assessment and initial stabilization of acutely deteriorating patients.

STATISTICS

Median and interquartile range were used for reporting continuous data. Odds ratios (OR) were reported with 95 % confidence intervals (CI). Categorical variables, including primary and secondary outcomes, were compared using Chi square test or Fisher's exact test where appropriate. Continuous data were compared with unpaired t-test. RStudio, Version 0.98.501 software package (RStudio, Inc.) was used.

ETHICS

According to Danish law approval of the ethics committee is not required for observational studies or qualitative interview studies.

Study 1 and 3 were approved by the Danish Data Protection Agency (J. no. 2013-41-1944).

Study 3 was registered on ClinicalTrials.gov prior to patient inclusion (NCT0218054) and approved by the Danish Health and Medicines Authority (J. no. 3-3013-480/1). Ethics Committee approval was waived since all patients received treatment according to department standards (J. no. H-4-2013-FSP).

Participants in study 2 provided written confirmed consent after they were informed of the study goal. They were furthermore informed that participation was voluntary and consent could be withdrawn at any time, without stating any reason and without any consequences for the participant.

3. SUMMARY OF FINDINGS

STUDY 1

Methods

The study period was from 1st January – 30th June, 2013 during which data concerning all SAEs occurring on general wards at BBH were collected. SAEs included CA, UD, and UICU. SAEs occurring in the emergency department, psychiatric ward, ICU, operating theatre, and cardiology or post-operative high-dependency unit were not included, since EWS was not used in these departments, or patients were continuously monitored.

CA was defined as an event where a patient without prior do-not attempt resuscitation order (DNAR) either received chest compressions and/ or defibrillation by staff or was pronounced dead by the CA team. UD was defined as death without prior DNAR or if DNAR order was given less than 6 h before the patient died. Patients were exempted from the time limit, if the order was given on admission. Furthermore, all patients on palliative care wards were excluded. UICU was defined as an admission to the ICU of patients that had been admitted to the hospital for more than 24 h.

For all cases adherence to EWS protocol in the 24 h preceding an event was independently evaluated through chart review by two of the authors with knowledge about critical care and emergency medicine. In case of disagreement, the two reviewed the case together to reach consensus, and a third investigator decided if disagreement persisted.

Specifically, charts were evaluated in regard to the following points:

- Were patients monitored at least twice in 24 h prior to the event?
- Was monitoring frequency adhered to according to protocol?
- For scores ≥ 2, were patients appropriately evaluated and stabilized?
- For scores ≥ 3, was the (junior) doctor informed about the patient's condition?
- For scores ≥ 6, was the patient evaluated by the on-call doctor in a timely and appropriate manner?
- For scores ≥ 9, was the patient evaluated by a senior doctor or MET in a timely and appropriate manner?

Results

The principal findings are presented in table 3. Out of 852 screened events a total of 144 were included for final analysis; 77 cases of UICU and 67 cases of the combined outcome of CA (n = 51) and UD (n = 16).

A minimum monitoring interval of twice daily was adhered to in 87 % and 90 % of UICU and the combined outcome of CA and UD, respectively. For UICU, 13 % were monitored according to EWS protocol compared to 27 % of the combined outcome of CA and UD. Figure 1 shows the association between EWS and adherence to monitoring frequency. A higher EWS was significantly associated with lower likelihood to be monitored according to protocol.

In six cases, the maximum pre-event EWS was below 2 and no clinical response was needed according to the EWS protocol. Four of these experienced a CA, one died unexpectedly and one was admitted to ICU. Out of 138 cases with EWS ≥ 2 the clinical response was considered appropriate in 64 % of UICU and 58 % of CA and UD, respectively.

Junior doctors were notified about patients with EWS ≥ 3 in 75 of 130 cases (58%). An appropriate clinical response was documented for 44 of 106 patients (42 %) with EWS ≥ 6. Specifically, in only 19 % of patients with CA and EWS ≥ 6 a sufficient response was documented, compared to 49 % and 55 % of cases of UICU and UD, respectively.

A total of 71 patients had an EWS≥ 9, of these 22 had a CA or UD (31 %) and 49 had an UICU (69 %), the EWS protocol was adhered to in 36 % of CA and UD, and 53 % of UICU, respectively.

Conclusion

Poor adherence to the EWS protocol in regard to monitoring frequency and appropriateness of the clinical response was commonly found when SAEs occurred. Full compliance was only seen in 12 of 144 cases (8 %); five of these had an EWS < 2 and consequently, according to protocol, did not require further clinical intervention besides monitoring. Adherence to monitoring frequency was poor, with increased likelihood of non-adherence

with rising EWS. Junior doctors were rarely notified about patients with EWS ≥ 3. More than half of patients with an EWS ≥ 6 lacked a sufficient treatment plan, this was even more pronounced for patients with subsequent CAs. Patients with an EWS ≥ 9 who experienced a SAE were rarely seen by senior doctors or MET.

	UICU	*CA*	*UD*	**Combined outcome (CA & UD)**	p*
Monitoring frequency					
No. of events with at least two recorded EWS 24 h prior to event per total no. of events (%)	**67/ 77 (87%)**	*48/ 51(94%)*	*12/ 16 (75%)*	**60/ 67 (90%)**	0.64
No. of events with correct monitoring frequency 24 h prior to event per total no. of events (%)	**10/ 77 (13%)**	*16/ 51(31%)*	*2/ 16 (13%)*	**18/ 67 (27%)**	0.04
Clinical response					
No. of events with a clinical response according to trigger per total no. of events with EWS ≥ 2 (%)	**49/ 76 (64%)**	*24/ 47(51%)*	*12/ 15 (80%)*	**36/ 62 (58%)**	0.44
No. of events with a clinical response according to trigger per total no. of events with EWS ≥ 3 (%)	**45/ 75 (60%)**	*22/ 40(55%)*	*8/ 15 (53%)*	**30/ 55 (55%)**	0.53
No. of events with a clinical response according to trigger per total no. of events with EWS ≥ 6 (%)	**33/ 68 (49%)**	*5/ 27 (19%)*	*6/ 11 (55%)*	**11/ 38 (29%)**	0.05
No. of events with clinical response according to trigger per total no. of events with EWS ≥ 9 (%)	**26/ 49 (53%)**	*4/ 14 (29%)*	*4/ 8 (50%)*	**8/ 22 (36%)**	0.19

Table 3. Monitoring frequencies and clinical responses according to escalation protocol for 24 h preceding event. *for UICU and combined outcome of UD and CA.

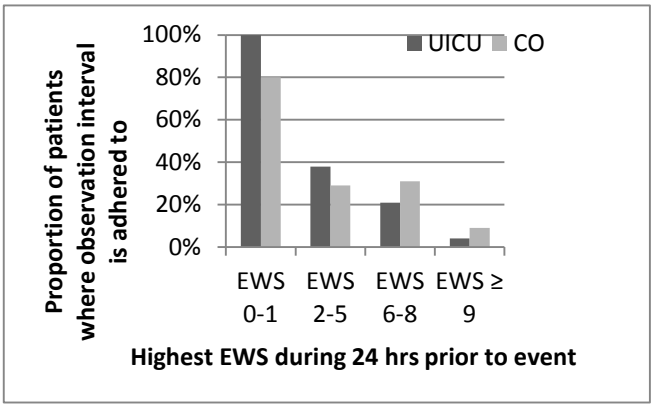

Figure 1. Association between highest Early Warning Score (EWS) and observation interval. Chi-square test for trend p = 0.0002 for UICU and p = 0.0058 for combined outcome (CO) of UD and CA.

STUDY 2

Methods

Based on the findings from study 1, the following key features were identified as problem areas in regard to nurses' adherence to EWS protocol:

- compliance with monitoring frequency
- notification of junior doctors about patients with EWS ≥ 3
- call for MET review to patient with EWS ≥ 9

To identify barriers and facilitating factors regarding these aspects, five semi-structured focus group interviews with nurses from the medical and surgical acute care wards were conducted from 20th July – 29th October 2014. To ensure familiarity with EWS, participants were selected among nurses with at least three months employment on the ward. Interviews were always conducted with nurses from both departments and moderated by the main author together with a research nurse with experience in qualitative interview technique. An interview guide was used to facilitate semi-structured discussion among participants about the research questions (figure 2).

All interviews were recorded and transcribed verbatim and analyzed based on Krippendorff's components of text driven content analysis[43]. This was performed through immersion in the text by reading it several times, in order to get a sense of the participants' perspectives. Secondly the text was divided into meaningful units in relation to the original research questions. And finally, codes with corresponding contents were merged into subcategories and formulated into meaningful main categories in relation to the research questions.

Validity of findings was sought throughout the research process through methodological coherence, appropriate sampling, collecting, and analyzing data in order to answer the research questions[44]. Briefly, this was ensured by conducting interviews until data saturation was achieved, and no new information emerged. Furthermore, only nurses with experience in using EWS were recruited for the interviews, and proper coding and categorization was assured through immersion into the transcripts and continuously relating text units, codes and categories to the research question[45,46].

Results

Research question 1: Barriers and facilitating factors related to monitoring frequency

Two forms of non-adherence to monitoring frequency emerged during the interviews: over-monitoring, i.e. monitoring more frequently than per protocol, and under-monitoring, i.e. monitoring less frequently than required. The former was primarily described in positive terms, while the latter was viewed as objectionable and considered bad nursing practice.

The main reasons to deviate from protocol were gut-feeling, lack of resources, and concern about patients' sleep. The decision to measure EWS or not, was not exclusively protocol-driven, but relied heavily on what was labeled gut-feeling by the interviewees. On further scrutiny this emerged to encompass a number of clinical and diagnostic cues not included in EWS, like: skin color, patients own perception of distress, respiratory pattern, and subtle changes in level of consciousness or cognition not reflected by the AVPU-score. Nurses reported to use these cues when they decided to deviate from monitoring standards. Reasons for under-monitoring included both time constrains and a prominent concern about sleep deprivation. There was broad consensus that sleep was important, and it was generally accepted to omit monitoring if the patients were asleep and appeared in no distress.

Research question 2: Barriers and facilitating factors in relation to inform doctors of EWS ≥ 3

Generally, nurses did not notify junior doctors about patients with an EWS of 3 – 6. Mainly, this was considered unrealistic and disruptive to work-flow due to the large number of patients with these scores. Also, nurses considered themselves competent to handle these patients without assistance, and many nurses considered it superfluous, because it rarely lead to changes in patient management.

Nurses from the surgical ward had a lower threshold for notifying doctors, and saw their role more limited in regard to initiating treatments. Their primary goal was to expedite patients to surgery, or to another unit, when an underlying surgical condition was ruled out.

Research question 3: barriers and facilitating factors in relation to MET call

MET calls were never initiated based on EWS protocol, but almost exclusively when nurses considered their patients in need of a higher level of care, than could be provided on their own ward. And often, only after all other options to treat the patient were exhausted. The main barrier was a feeling of anxiety towards MET, and while it was acknowledged that collaboration with MET generally was good, most interviewees had experienced frustrating, intimidating, or distressing encounters with members of the MET. Nurses valued the know-how and expertise members of the MET could provide, but they often found them lacking in non-technical and communicative skills.

Conclusion

A number of barriers and facilitating factors regarding the use of the EWS protocol were identified. Generally, nurses participating in this study did not consider it mandatory to follow EWS protocol, but merely regarded it as one among several options for clinical assessment and treatment of patients. Likewise, collaboration with doctors and MET was based on subjective judgement, personal preferences, and cultural norms, rather than protocol-driven.

Themes	Interview questions
Briefing and introduction	• Introduction of the interviewers and aim of the interview • Briefing that participation in the interview is voluntary and data will be published anonymized • I ask the participants to briefly introduce themselves by name, place of employment, and how long they have been nurses and worked on the ward
General aspects of knowledge and understandings of acutely deteriorating patients	• In your opinion, what is an acutely deteriorating patient? o Try to describe your last acutely deteriorating patient. o What connections do you see between critical illness and patients' diagnosis? o What connections do you see between critical illness and patients' vital signs? o What connections do you see between critical illness and progression in patients' condition? o What connections do you see between critical illness and patients' co-morbidities? o In your opinion, are there any other findings that lead you to conclude that a patient is acutely deteriorating?
General aspects of handling acutely deteriorating patients on the wards	• Try to tell how you typically handle acutely deteriorating patients on your ward o What is the role of other nurses? o How do you delegate tasks between doctors and nurses on your wards? o How do you typically identify at risk patients on your wards? o How do you determine how close patients should be monitored on your wards? o How do you decide what interventions and treatments acutely deteriorating patients receive on your wards? o How do you determine if you need further assistance to handle acutely deteriorating patients on your wards?
General aspects of the role of early warning score in identifying and handling acutely deteriorating patients	• In your opinion, what is the role of EWS and the related algorithm in handling acutely deteriorating patients? o Try to describe if and when you use EWS in identifying acutely deteriorating patients. o Try to describe if and when you use EWS in monitoring acutely deteriorating patients. o Try to describe if and when you use EWS in stabilizing acutely deteriorating patients. o Try to describe if and when you use EWS to obtain necessary assistance in handling acutely deteriorating patients.
Specifically about barriers and facilitators in relation to	• Try to describe what issues make it easy or hard to adhere to the prescribed monitoring frequency of the

adherence to monitoring frequency	EWS algorithm. o In what circumstances would you typically deviate from the algorithm and monitor more or less frequently? o What issues in your daily work life impact on the adherence to the algorithm? • Do you consider it important to adhere to the prescribed monitoring frequency? • What could be done to make it easier to adhere to the prescribed monitoring frequency?
Specifically about barriers and facilitators in relation to inform junior doctors about patients with moderately elevated EWS (≥ 3)	• According to the algorithm junior doctors must be informed about every patient with a moderately elevated EWS of 2 – 3, what do you think of that? o How often do you inform junior doctors about these patients? o Under what circumstances do you inform junior doctors about these patients? o When do you decide not to inform them? o What issues in your daily work life impact on the adherence to the algorithm? • In your opinion, what is the most important issue that determines whether you do or do not inform junior doctors? • What could be done to make it easier to inform junior doctors?
Specifically about barriers and facilitators in relation to MET calls	• Try to describe when you last made a MET call? • In what circumstances do you use MET? o Are there specific categories of patients where you call MET? o Are there specific times of the day when you use MET? o What criteria do you use to determine whether to call for MET or not? o What issues in your daily work life impact on the adherence to the algorithm in regard to MET calls? • When do you not use MET? • What is the role of EWS in your decision to call MET? • In your opinion, what is the most important issue that determines whether you do or do not inform junior doctors? • What could be done to make it easier to use MET?
Debriefing	• Are there any important issues we need to talk about in regard to acutely deteriorating patients? • Thank you for your participation.

Figure 2. Interview guide used for focus group interviews with nurses

STUDY 3

Methods

This was a pragmatic, ward-level randomized, non-blinded, controlled trial to determine the effect of two vs three EWS measurements daily on clinical deterioration among acutely admitted surgical and medical patients. The trial was conducted from 1st September to 14th December 2014, and had two phases: in phase 1 (weeks 1 to 7) surgical patients were allocated to the intervention arm (8 h group) and medical patients to the control arm (12 h group) and vice versa in phase 2 (weeks 8 to 15). The first week of phase 1 and the first two weeks of phase 2, were adaption periods to avoid carry-over effect and no patients were included during these intervals. All patients with an initial admission EWS of 0 or 1, and without exclusion criteria were eligible for inclusion. Wards were randomized to monitor patients either three times daily (the intervention arm) or follow standard care with two daily measurements (control arm).

Exclusion criteria were:

- Initial EWS ≥ 2 on admission
- earlier inclusion to the study
- age < 18 years
- chronically elevated EWS
- transfer from another hospital, department, or outpatient clinic
- conditions that warranted closer observation according to hospital guidelines
- terminal disease

Primary outcome was the proportion of patients with an EWS ≥ 2 at 24 h post admission.

Secondary outcomes were:

- Proportion of patients with an EWS ≥ 2 at 48 h
- Proportion of patients with an aggregated score of EWS ≥ 5 or ≥7 at 24 h
- Proportion of CA, ICU admission or MET review during the first 72 h of admission
- Length of hospital stay (LOS)
- Mortality at 72 h and 30 days

Adherence to study protocol was assessed by calculating the intervals between EWS measurements in the two groups for all patients with LOS > 24 h.

Sample size calculation was based on the assumption that 30 % of eligible patients in the standard care group would have EWS ≥ 2 at 24 h post-admission. With an expected drop-out rate of 20 % enrolment of minimum 144 patients in each group would have a power of 85 to 90% (at a two-sided alpha level of 0.05) to detect a 50 % relative risk reduction (to 15%). Multiple logistic regression was performed on the primary endpoint with adjustment for the *a priori* chosen variables: age, gender, inclusion period, and ward-type.

Results

Out of 3185 patients screened for eligibility 1346 were randomized, of these 544 could be included to the final analysis of the

primary outcome. Reasons for exclusion of 802 subjects from final analysis were discharge within 24 h (82 %) and missing EWS at 24 h (18 %). Main results are presented in table 4.

Of subjects included in the final analysis a total of 267 (49 %) were allocated to the 8 h group vs 277 (51 %) to the 12 h group. A significantly larger proportion of patients in the 8 h group compared to the 12 h group had an admission EWS of 0 (71 % vs 62 %, p < 0.001).

Regarding the primary outcome no differences between the intervention and control group was found, with 23 % and 20 % progressing to an elevated EWS ≥ 2 at 24 h post-admission, respectively (p = 0.456), OR 1.17 (0.78 – 1.76).

Furthermore, no significant differences for the secondary outcomes could be found between the intervention and control groups, with 3.4 % and 2 % progressing to an EWS ≥ 5 (p = 0.391); one patient in each group to an EWS ≥ 7 (p = 1.0); 21 % and 23 % had an EWS ≥ 2 48 h post-admission (p = 0.738); one patient in each group died within 72 h; and 30 day mortality was 1.1 % and 1.8 %, respectively (p = 0.357). Time between EWS measurements were significantly shorter in the intervention vs control group, median 7.2 (4.2 – 9.3) h vs 9.4 (4.6 – 12.3) h (p < 0.001).

Multiple logistic regression analysis showed an adjusted OR = 1.20 (0.79 – 1.82) for the 8 h group compared to 12 h group, with no significant interaction for the predefined interaction terms age, gender, ward type, and inclusion period.

	8 h group - N (%)	**12 h group - N (%)**	**p**
Randomized	656 (100)	690 (100)	0.13*
Surgical ward	362 (55)	409 (59)	
Medical ward	294 (45)	281 (41)	
Length of stay (LOS) < 24 h	314 (48)	340 (49)	0.61*
Surgical ward	194 (30)	210 (30)	
Medical ward	120 (18)	130 (19)	
Missing EWS at 24 h	75 (11)	73 (11)	0.62*
Surgical ward	56 (8.5)	49 (7.1)	
Medical ward	19 (2.9)	24 (3.5)	
Lost to follow up total	389 (59)	413 (60)	0.84*
Surgical ward	250 (38)	259 (38)	
Medical ward	139 (21)	154 (22)	
Intention to treat analysis for primary outcome (N = 1346)			
EWS ≥ 2 24 h post admission	61 (9.3)	56 (8.1)	0.44*
Surgical ward	27 (4.1)	34 (4.9)	
Medical ward	34 (5.2)	22 (3.2)	
Analysis including only patients with complete dataset (N = 544)	267 (100)	277 (100)	
EWS ≥ 2 24 h post admission	61 (23)	56 (20)	0.46*
Surgical ward	27 (24)	34 (4.9)	
Medical ward	34 (22)	22 (8)	
EWS ≥ 5 24 h post admission	9 (3.4)	6 (2.2)	0.39*
Surgical ward	1 (0.8)	2 (1.3)	
Medical ward	8 (5.2)	4 (3.1)	
EWS ≥ 7 24 h post admission	1 (0.4)	1 (0.4)	1.00**
Surgical ward	0	0	
Medical ward	1 (0.4)	1 (0.4)	
Transfers to ICU	1 (0.4)	0	0.49**
Surgical ward	0	0	
Medical ward	1 (0.4)	0	
Cardiac arrests	0	0	-
MET reviews	3 (1.1)	1 (0.4)	0.37**
Surgical ward	0 (0.0)	0 (0.0)	
Medical ward	3 (1.1)	1 (0.4)	
Data for patients admitted > 48 h (N = 338)			
	168 (100)	170 (100)	0.68*
Surgical ward	56 (33)	78 (46)	
Medical ward	112 (66)	92 (54)	
EWS ≥ 2 at 48 h post admission	36 (21)	39 (23)	0.74*
Surgical ward	11 (6.5)	19 (11)	
Medical ward	25 (15)	20 (12)	
Mortality data			
No. eligible for analysis (N = 1306)	642 (100)	664 (100)	0.078*
Surgical ward	354 (55)	394 (59)	
Medical ward	288 (45)	270 (41)	
72 h mortality	1 (0.2)	1 (0.2)	1.00**
Surgical ward	1 (0.2)	1 (0.2)	
Medical ward	0	0	
30 days mortality	7 (1.1)	12 (1.8)	0.36*
Surgical ward	4 (0.6)	6 (0.9)	
Medical ward	3 (0.5)	6 (0.9)	
Length of stay			
LOS (median +/- IQR) in days	1.0 (0.6 – 2.3)	1.0 (0.6 – 2.2)	0.89***
Surgical ward	1.0 (0.6 – 1.5)	1.0 (0.6 – 1.9)	
Medical ward	1.5 (0.6 – 4.3)	1.1 (0.6 – 3.0)	
Time between EWS scores			
H (median +/- IQR)	7.2 (4.2 – 9.3)	9.4 (4.6 – 12.3)	0.001***
Surgical ward	7.7 (4.9 – 9.6)	9.3 (4.7 – 12.3)	
Medical ward	6.8 (3.9	9.6	

	– 9.1)	(4.6 – 12.2)	

Table 4. Results of comparing two intervals for measuring EWS. * Chi-square test, ** Fisher's exact test, ****t*-test for continuous data.

Conclusion

No differences in the proportion of patients that progressed to an EWS ≥ 2 at 24 h post-admission could be found between two groups that were monitored at 8 h vs 12 h intervals. Included patients had an EWS of 0 or 1 on admission. Out of 544 patients eligible for final analysis, 23 % and 21 % met the primary endpoint (p = 0.46), respectively. Likewise, no differences in the secondary outcomes could be found. The group to 8 h intervals had significantly shorter monitoring intervals than the 12 h group, 7.2 (4.2 – 9.3) h vs. 9.4 (4.6 – 12.3) h (p = 0.001), respectively. EWS monitoring three times daily is not superior to twice daily in preventing clinical deterioration among acutely admitted, low-risk subjects without concomitant risk factors.

4. DISCUSSION

PRINCIPAL FINDINGS

Study 1

This observational study found one or more breaches of EWS protocol in the 24 h preceding an SAE in over 90 % of cases. Lack of adherence was prevalent at every level of the escalation protocol including: increasing monitoring frequency for higher EWS (EWS ≥ 2), call for junior doctors to patients with mild elevations (EWS ≥ 3), adequate evaluation and treatment plans for patients with moderate elevations(EWS ≥ 6), and review by experienced staff and MET for patients with severe elevations (EWS ≥ 9).

Study 2

Findings of this qualitative study suggest that nurses generally not considered the EWS protocol as mandatory, but often used several other strategies to evaluate patients and escalate care. Although a number of positive aspects of EWS and MET were acknowledged, monitoring, collaboration with doctors, and need for MET was often based on subjective judgement, personal preferences, and cultural norms, and not protocol-driven.

Study 3

This ward-level randomized study showed no differences among acutely admitted surgical and medical patients with an initial EWS of 0 or 1 monitored either 8 or 12 hourly, in regard to the primary endpoint, defined as progression to an elevated EWS ≥ 2 at 24 h post admission. Furthermore, no between group differences were found regarding the secondary outcomes: proportion of patients with an EWS ≥ 2 at 48 h, proportion with an aggregated score of EWS ≥ 5 or ≥7 at 24 h, proportion of CA, ICU admission or MET review during the first 72 h of admission, mortality at 72 h and 30 days, and length of hospital stay.

STRENGTHS AND LIMITATIONS

Study 1

Strengths of the study include the prospective collection of events and completeness of outcome data. Deaths occurring at BBH were identified weekly from administrative data from the Capital Region of Denmark, and reviewed individually for study eligibility. Likewise, all ICU admissions were identified in the patient data management system of the ICU and reviewed weekly for eligibility. CAs were reported independently by two members of the CA team to the primary investigator for review. No patients were lost to follow-up, but in 22 cases EWS charts were missing, and could not be included in the data analysis. Furthermore, we applied precise, predetermined definitions for the different SAEs under study.

Limitations of the study include the retrospective, observational design and single center setting. Data extraction was based on chart review; this could bias the result due to missing, incomplete, or inaccurate documentation. Furthermore, evaluation of the appropriateness of the clinical response and adherence to protocol are observer dependent. To increase validity two researchers with extensive experience in critical care and emergency medicine reviewed each event independently, and in case of disagreement tried to reach consensus. A third researcher with extensive experience decided if disagreement persisted at this stage. The single center design of the study makes it difficult to infer results to other hospitals.

Study 2

Validity of the study findings was sought throughout the research process through methodological coherence, appropriate sampling, collecting, and analyzing data in order to answer the research questions. This was ensured by conducting interviews until data saturation was achieved, and no new information emerged during the interviews. Furthermore, an interview guide was used to facilitate discussion and ensure that all aspects about the research questions were covered. To encourage discussion and uncover norms and cultural values, participants were chosen among nurses with knowledge about EWS from two wards with a high proportion of at-risk patients. Content analysis was used to answer the research questions.

Again, limitations of the study include its single center design with recruitment of nurses from only two wards. This makes inferences of our findings to other settings difficult. Furthermore, focus groups harbor the risk of suppressing minority views through peer pressure. To minimize this, groups were kept at a small size of 3 – 6 participants and facilitators encouraged all participants to contribute.

Study 3

The strengths of the study include its randomized, controlled design, high adherence to study protocol assessed by difference in time between EWS measurements in the two groups, and inclusion of wash outs intervals during study periods, to minimize carry over effect.

Limitations of the study include randomization at the ward level instead of patient level. This design was chosen, because it was not considered possible to assign different monitoring regimes to different patients on the same ward without contaminating the intervention. To test for bias multiple regression analysis was performed on the primary endpoint with adjustment for: age, gender, inclusion period, and ward type. Other limitations include the higher than expected dropout rate of 60 % due to early discharge or missing EWS at 24 h. The clinical relevance of the primary endpoint can also be questioned, but a much larger study

would be needed to assess more infrequent endpoints like cardiac arrest. Furthermore, there were baseline differences between the intervention and control group, with a higher proportion of patients with an initial EWS of 0 in the former. This could introduce bias, since these subjects could be less prone to further deterioration. The study subjects were intentionally chosen among patients with low risk for further deterioration, and all patients with clinical conditions that warranted higher level of monitoring were also excluded; i.e. patients diabetic ketoacidosis, intoxication, hepatic coma, significant gastrointestinal bleeding. This leaves a highly selected group of patients with few risk factors, and care should be taken to infer the results to more severely ill patients. Finally, the single center setting makes it difficult to transfer the findings to other settings.

COMPARISONS TO OTHER STUDIES

Study 1

The individual parameters included in ViEWS and NEWS, and their weightings were calibrated to achieve the highest discriminative power in predicting short term in-hospital mortality in a data set of vital signs obtained from more than 35,000 acute medical admissions during 2006 – 2008 in the UK[24,25]. The performance of an abbreviated version, without scores for level of consciousness, was subsequently tested in a Canadian mixed patient cohort of acutely admitted medical and surgical patients, and found to perform equally well in predicting short term mortality[47]. However, none of these studies reported to what extent escalation protocols were followed, and what treatment, if any, patients received. This makes it difficult to evaluate, to what degree failure of the system can be attributed to lack of sensitivity of the score or suboptimal patient care. While a number of studies have evaluated performance of the afferent limb, to our knowledge, only one has reported where in the chain of events failure occurred[26,30,31]. Similar to study 1, results from this study showed that nurses failed to call for higher level assistance in 22 - 29 % of cases, and physicians failed to escalate care in 50 % of cases[48]. Comparison with our study results is difficult, since a single parameter TTS was used and monitoring intervals were not reported.

Results of study 1 did not allow to draw conclusions on the causes behind non-adherence to the escalation protocol, but identified where in the chain of events failures occurred.

Study 2

Failure of the afferent limb to detect deteriorating patients and escalate care properly is well documented, and a number of studies have tried to identify barriers and facilitating factors in relation to this. Regarding monitoring frequency, a study from a hospital using an EWS protocol similar to ours, found considerable variations in monitoring frequencies during the day. Out of 950,043 sets of observations of vital signs 22 % were measured during the two peak periods between 6:00 – 6:59 and 21:00 – 21:59, and only 12.81 % during nights from 23:00 – 05:59. The authors proposed a number of reasons for the variations, and suggested that nurses did not consider EWS the best way to asses patients' needs, it was unachievable to measure according to protocol, or vital signs could not be obtained because of other activities on the ward[36]. Many of these reasons were indeed mentioned by interviewees in our study, with the additional finding that nurses were reluctant to disturb patients at night out of fear of detrimental effects to sleep deprivation.

Similar to earlier findings, study 2 showed that a prominent barrier to escalate care was a prevalent belief among nurses in their abilities to handle at-risk patients without assistance. Earlier reports showed that a common reason for failure to escalate care, was that staff felt the situation was under control[33,49]. A Dutch study showed that staff on general wards often had overconfidence in their own performance. Specifically, they more frequently considered the SAEs they had been involved in as unavoidable, compared to expert opinion[49].

Similar to other reports, participants of study 2 also valued a number of features of the EWS, and found it a useful tool to evaluate and recognize deterioration early and communicate effectively inter- and intra-professioanlly[50].

Study 3

While it is well established that delayed intervention by MET, is associated with poorer outcomes, only few studies have tried to determine the optimum monitoring frequency. In a retrospective study of MET calls the authors reported a higher frequency of documentation of vital signs among continuously monitored patients compared to intermittently monitored patients, and found higher afferent limb failure among the former (81 % vs. 53 %; $p < 0.001$) that was independently associated with a higher risk of in-hospital mortality (OR 1.67, 1.02–2.72; $p = 0.041$)[26]. A randomized study of continuous vs standard monitoring of vital signs among high-risk surgical patients also found no benefit of continuous surveillance in regard to risk of experiencing a major event during hospitalization[27]. A recent randomized study comparing mandatory, intermittent monitoring with monitoring by indication, found doubling of MET calls in the first group, but no differences in unplanned ICU transfer, cardiac arrest rates or mortality among the two groups[51]. A minimum standard of 12 h for vital sign assessment has been suggested, and continuous monitoring was found desirable[11]. We found no support for increased intermittent monitoring more than twice daily for patients with low EWS in our study. There is generally very low risk of clinical deterioration in this population, yet they make up the majority of hospitalized patients, ranging from 50 – 65 %[24,47].

PERSPECTIVES FOR FUTURE RESEARCH

Despite its good ability to predict outcomes for cohorts of patients, the discriminative power of EWS to distinguish between deteriorating, and non-deteriorating patients is inadequate to form the basis for clinical decisions for individual patients. Furthermore, EWS only gives a snap-shot of the clinical state, and the dynamic nature of many disease processes, patients factors including frailty, presence of co-morbidities, and response to treatment are all important aspects EWS does not take into account. Future observational studies on outcome should take these factors into account, including organizational aspects, like nurse-to-patient ratio, and training of staff and performance of the separate limbs of the RRS and compliance with EWS protocol. When using death as an outcome, preventable deaths should be distinguished from natural deaths, since the former should be avoided, while the latter are a natural part of the end of life.

Also, doctors' roles, attitudes, and performances in regard to the afferent limb need further elucidation. Study 1 showed that an appropriate treatment plan was laid out by the doctor on call, in

less than half of the events with patients with an EWS ≥ 6, and doctors' delayed response has also been reported earlier[52]. Despite these findings, virtually no aspect of doctors' performances as part of the afferent limb has been investigated, although they form the front line in the care of deteriorating patients together with nurses. Furthermore, performance of the efferent limb merits further investigation, especially in regard to interventions aimed at improving non-technical skills[53].

Finally, monitoring constitutes a major research field in detecting and predicting deterioration. Technical developments in hardware and software hold many promises. Advances in the development of portable devices for remote continuous surveillance of physiological data in combination with automated alerts to staff about patients' condition, are exciting opportunities for improved care of deteriorating in-hospital patients[11,54].

5. CONCLUSION

The studies included in this thesis investigate different aspects concerning an EWS system to detect and treat patients at-risk of deterioration on general hospital wards. Findings from the first study confirmed that many SAEs are preceded by breach in escalation protocol, and it was possible to identify at what levels in the chain of events the afferent limb failed. Based on these findings a qualitative interview study was performed to find barriers and facilitating factors in relation to adherence to the EWS protocol by medical and surgical acute care nurses. A number of barriers and facilitating factors regarding the use of the EWS protocol were identified. In line with previous findings it was found that nurses did not consider the EWS protocol as mandatory, but regarded it as one of several other tools at their disposal to assess patients and direct care.

A third study explored the effect of EWS monitoring of acutely admitted patients twice vs three times daily. The primary outcome was progression to an elevated EWS ≥ 2 at 24 h post-admission. No difference between the groups could be found with 23 % and 20 % progressing to a higher EWS in the 8 h vs 12 h group respectively. To our knowledge this was the first randomized study on different monitoring regimes.

Results from the studies confirmed that afferent limb failure is prevalent and point towards reasons for this. These findings can form the basis for future interventions to increase adherence to protocol. In regard to monitoring frequency, it was shown that low risk patients rarely deteriorate and monitoring can safely be restricted to twice daily in the majority of patients with low EWS and without concomitant risk factors.

6. SUMMARY

Clinical deterioration of patients hospitalized on general wards is often preceded by worsening vital signs. If identified early and acted upon quickly, it is conjectured that further deterioration can be prevented. To this means the early warning score (EWS) was implemented in all hospitals in the Capital Region of Denmark in 2013. EWS consists of an aggregated weighted track-and-trigger system (TTS), to identify at-risk patients early, and a treatment protocol to escalate care appropriately and determine the level of competency of the provider. A similar system is endorsed by the Royal College of Physicians for use at hospitals in the UK. Despite wide dissemination of EWS and similar systems serious adverse events presaged by deteriorating vital signs continue to be a major source of morbidity. This is either due to inherent inadequacies of EWS, lack of adherence to the treatment protocol, or a combination of both.

All studies included in this thesis were conducted at Bispebjerg Hospital, an inner-city Hospital in Copenhagen, Denmark with 500 beds and a catchment area of approximately 300,000.

The aim of the thesis was to investigate the reasons for failure of the EWS by trying to answer the following research questions:

1. How often and why does the system fail?
2. What are the barriers and facilitating factors related to the use of the EWS protocol?
3. Is there a correlation between monitoring frequency and clinical deterioration?

To answer the first question an observational study was conducted, in which all unexpected deaths, cardiac arrests, and unintended ICU admission on general wards during a 6 months period were reviewed. A total of 144 events were recorded; in only 12 (8 %) of these the escalation protocol was adhered to strictly. Monitoring frequency was not adhered to in 81 % of cases; doctors were not notified about patients' condition in 42 % of cases, and the medical emergency team or senior doctors were not notified appropriately in 52 % of the cases. Leading to the conclusion that violations of the escalation protocol was common prior to serious adverse events on general wards.

To answer the second question semi-structured focus group interviews with nurses from the surgical and medical acute care wards were performed to investigate: 1) why monitoring frequencies are not adhered to, 2) why junior doctors are not notified about deteriorating patients, and 3) why review by the medical emergency team (MET) is often delayed or missed? The main findings from this study showed that time constraints and under staffing was mentioned as a main reason for non-adherence to monitoring frequencies. Confidence in their own abilities to take care of deteriorating patients, and the large number of patients with elevated EWS was mentioned as the main reason, for not notifying junior doctors. And fear of reprimands and lack of non-technical skills among members of the MET were mentioned among the main reasons for reluctance to call.

The third study investigated the role of monitoring frequency on clinical deterioration in a ward-level randomized study. It was hypothesized that 8 h monitoring intervals were superior to 12 h in preventing deterioration, defined as a rise in EWS to ≥ 2 after 24 h, among newly admitted patients with an initial EWS of 0 or 1. Of 3185 patients screened for eligibility, 1346 patients were included to the trial, and data from 544 patients were available for final analysis. Of these 49 % percent were allocated to the 8h group and 51% to the 12h group; of these, 23% and 20% had an elevated EWS≥2 at 24h, respectively (p=0.456), OR 1.17 (0.78-1.76). There were no significant differences in regard to the secondary outcomes: cardiac arrests, ICU admissions, review by MET, length of hospital stay, mortality, or elevated EWS at 48h.

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