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STANDARDIZED MEASUREMENT OF THE MODIFIED EARLY WARNING SCORE RESULTS IN ENHANCED IMPLEMENTATION OF A RAPID RESPONSE SYSTEM: A QUASI-EXPERIMENTAL STUDY

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ABSTRACT

Objectives. To study the effect of protocolized measurement (three times daily) of the Modified Early Warning Score (MEWS) versus measurement on indication on the degree of implementation of the Rapid Response System (RRS).

Methods. A quasi-experimental study was conducted in a university hospital in Amsterdam between September and November 2011. Patients who were admitted for at least one over-night stay were included. Wards were randomized to measure the MEWS three times daily ('protocolized') versus measuring the MEWS 'when clinically indicated' in the control group. At the end of each month, for an entire seven-day week, all vital signs recorded for patients were registered. The outcomes were categorized into process measures including the degree of implementation and compliance to set monitoring standards and secondly, outcomes such as the degree of delay in physician notification and Rapid Response Team (RRT) activation in patients with raised MEWS (MEWS ≥ 3).

Results. MEWS calculations from vital signs occurred in 70% (2513/3585) on the protocolized wards versus 2% (65/3013) in the control group. Compliance with the protocolized regime was presents in 68% (819/1205), compliance in the control group was present in 4% (47/1232) of the measurements. There were 90 calls to primary physicians on the protocolized and 9 calls on the control wards. Additionally on protocolized wards, there were twice as much RRT calls per admission.

Conclusions. Vital signs and MEWS determination three times daily, results in better detection of physiological abnormalities and more reliable activations of the RRT.

INTRODUCTION

Rapid Response Systems (RRS) have been implemented without unequivocal evidence regarding their effectiveness.[1,2] The goal of RRS is to identify clinical deteriorating patients in hospitals to prevent cardiopulmonary arrests, unplanned admissions to the Intensive Care Unit (ICU) and unexpected deaths.[3] Up to 80% of patients have vital signs abnormalities in the 24 hours prior to adverse events (AE).[4-6] Presence of suboptimal care and lack of clinical urgency are suggested as significant contributors.[7,8] To aid in the detection process of patients at risk for AE, Track and Trigger Systems have been developed.[9] One commonly used is the Modified Early Warning Score (MEWS), whereby nurses allocate points to the measurement of vital signs resulting in a summary score.[10,11] Upon reaching a predefined threshold, either the primary physician and/or a Rapid Response Team (RRT) is activated. In general the RRT consists of an ICU physician and nurse who respond within 10 minutes after activation.[12,13] This system combined with educational and organizational components is called a RRS.[14] The MERIT trial measured the effect of a RRS but was unable to show a significant clinical benefit.[15] Post hoc analyses identified a high rate of afferent limb failure, i.e. failure to respond to patients with signs of deterioration.[16] Although the face-validity of RRS is high, universal spread and acceptance of the system is hampered by the lack of robust evidence.[17] Current research is focused on afferent limb failure and causes for the delay in identifying deteriorating patients in hospitals where these systems are already implemented.[8,18] It is clear that monitoring of patients on general wards is not uniform in nature and unreliable even in hours prior to AE.[19] Even after major surgery, measurements of vital signs might be incomplete or absent,[20] while evidence is present that increased monitoring is associated with improved outcome.[21,22] In the Netherlands the implementation of a RRS has recently been dictated by the Health Care Inspectorate. We studied the effect of a protocolized measurement (three times daily) of the MEWS versus measurement on indication on the degree of implementation of the RRS.

METHODS

Study design

A quasi-experimental study was conducted from the 1st of September to the 31st of November 2011 in a University Hospital in Amsterdam, the Netherlands. We implemented a RRS on 18 adult general wards. Ten wards were randomized to the protocolized arm to measure the MEWS minimal three times daily and eight to the control arm, i.e. MEWS measurements when clinically indicated. Randomization was performed after stratification according to surgical or medical ward. Patients with at least one overnight stay were included.

Components of RRS

Staff on the intervention (protocol) wards performed a full set of vital signs including a MEWS at least three times daily. Staff on the control wards performed vital signs when judged to be clinically indicated. In both groups, the RRS algorithm (Fig. 1) stipulated that upon reaching a MEWS of 3 points or more ('critical MEWS'), the patients' physician should be notified by the nurse. In accordance with the 'two-tiered' Dutch protocol the patients' primary physicians were instructed to attend to their patients within 30 minutes, perform an assessment and initiate treatment. The physicians' intervention could include activation of the RRT. If the patient did not improve after the primary intervention or if the physician was unable to assess the patient, the RRT had to be notified. The RRT operated 24/7 and consisted of an ICU physician and nurse who attended the patient within 10 minutes after notification.

Implementation process

Implementation of the RRS started in June 2011. Per ward three nurses were trained. Using a 'training the trainers' concept, these nurses educated their colleagues from June until August 2011. There were separate sessions for physicians during hand-over meetings. The RRS algorithm was distributed on pocket cards and advertised with posters, emails to staff and on the local website. From the 1st of September, the RRS was officially in use.

Definitions

Clinically indicated measurement of the MEWS was defined as when regular vital sign measurements led to a MEWS-sub score of 1 or more, this required the complete set of measurements to be calculated (Supplementary File 1). MEWS-sub scores refer to the MEWS applied to a single vital sign. The term 'MEWS' is used for the summation of all (available) sub scores. A MEWS of three or more was defined as a 'critical score'.[10,11]

'Retrospectively calculated MEWS' represent the MEWS calculated by the researchers based on the actual set (irrespective of completeness) of vital signs measured. 'Complete set of measurements' relates to the measurement of eight MEWS parameters and the MEWS summary score. Cardiopulmonary arrest was defined as an event in which respiratory and/or cardiopulmonary activity was absent and for which the cardiopulmonary arrest team was called and initiated cardiopulmonary resuscitation which included pharmacological, fluid, or mechanical resuscitation.[23] An unplanned ICU admission was defined as an admission that could not have been deferred without risk for at least 12 hours.[24] APACHE IV (Acute Physiology and Chronic Health Evaluation) scores indicate illness severity for those admitted to the ICU, whereby higher scores correspond to more severe disease and higher risks of death.[25]

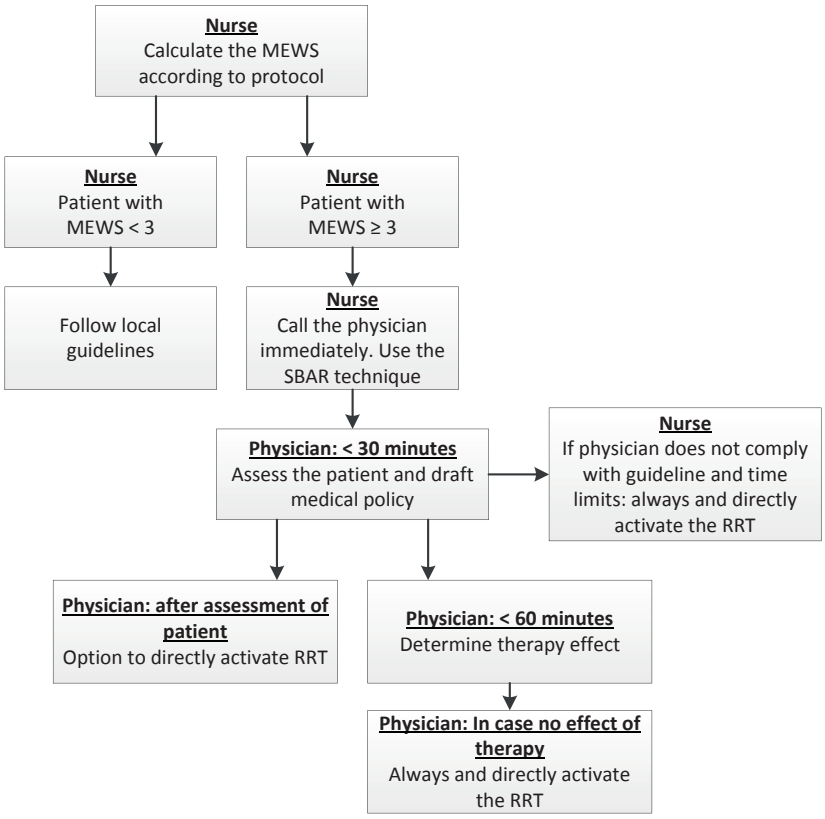

Figure 1. Algorithm for RRT activation which displays the protocol of handling critical MEWS values including all subsequent actions which either nurse or physician has to undertake together with set time limits.

Data collection

Two types of data were collected during a study period of three months: 1) all vital signs were recorded during a seven-day period at the end of each study month; 2) all AEs (i.e. cardiopulmonary arrests and unplanned ICU admissions) and the RRT activations were recorded during the whole three study months. MEWS was recorded on paper-based charts supported by a flowchart for RRT activation (Fig. 1). Measurements were excluded from data analysis when: 1) taken on non-participating wards e.g. delivery rooms; 2) taken during palliative care; 3) taken on days while the patient was significantly absent from the ward e.g. due to surgery; 4) predefined alterations on four protocolized wards were present (Supplementary File 2) which defined alternate frequency of measurement of MEWS; 5) deviations from the MEWS threshold (or sub scores) defined by the primary physician were recorded (Supplementary File 2). The presence of delay in notifying the physician was determined by measuring the time between the first critical MEWS (nurse documented and/or retrospectively determined) and the notification of the physician (Fig. 2). Dates and times at which the physician was notified including the critical MEWS were used and all subsequent first occurrences for these parameters were located. Patients were excluded when thresholds were uncertain (specific vital signs and/or MEWS) or if the physician raised the threshold for calling, e.g. MEWS of 5 instead of 3.

Data analysis and statistics

We applied an intention-to-treat analysis. Consequently, patients who were transferred to a different ward were analyzed in the original study arm (n=21). Continuous variables that were normally distributed were expressed as means with standard deviations and not normally distributed variables as medians and inter-quartile ranges (IQR). To test two independent groups of not normally distributed continuous variables, the Mann-Whitney U test was used. Categorical variables were expressed as percentages, numerators and denominators and were compared with the Chi-square test or Fisher's exact test or when appropriate as Relative Risk. Statistical uncertainty was expressed by 95% confidence intervals as appropriate, and statistical significance was defined at < 0.05. All data were entered into a Microsoft Access database and the analyses were performed using SPSS version 19.0 (Chicago, Illinois, USA) and confidence interval analysis software version 2.2.0 (University of Southampton, UK).

Ethics

This study conforms to the provision of the Declaration of Helsinki in 1975 (revised in 2008).[26] Given the observational nature of the study the hospital medical ethics committee waived the need for informed consent.

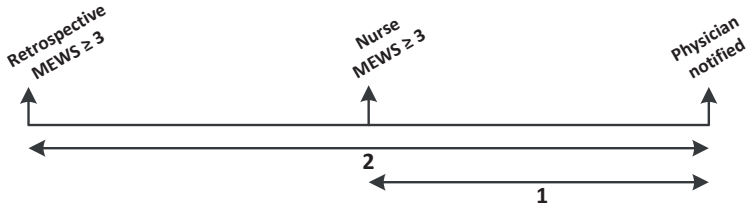

Figure 2. Time spans 'presence of delay'.

Time span 1, reflects the presence of delay between a registered critical MEWS by the nurse and the notification of the physician. According to the protocol, the physician should be notified immediately. Time span 2, reflects the theoretical 'window of recognition'. This is based upon registered vital signs and a retrospectively calculated critical MEWS. Thus, the critical MEWS could be derived by nurses and indicates the first moment at which the patient should be identified according to their vital signs.

RESULTS

Demographics

Due to logistical issues, the haematology/oncology unit, randomized as a control ward, dropped out of the study. According to the exclusion criteria 5752 measurements were excluded from analysis. In total, 372 patients were included on the protocolized wards (3585 measurements) and 432 patients (3013 measurements) on the control wards (Table 1). Of the patients 49% (394/804) were male; the mean age was 56.7 years (SD 17.7) and 1% (11/804) of the patients died during their hospital stay.

Table 1. Demographics of patients who were hospitalized during the seven-day period at the end of each of the three study months.

	Protocolized wards	Control wards
Patients during the three study weeks, % (n/N)	46 (372/804)	54 (432/804)
Age in years, mean (SD)	55.0 (17.7)	58.3 (17.6)
Gender (male), % (n/N)	56 (207/372)	43 (187/432)
LOHS[a] (days), median (IQR)	10 (6 - 20)	8 (5 - 10)
Died during hospital stay, % (n/N)	2 (7/372)	1 (4/432)

[a] LOHS, length of hospital stay

Compliance with protocol and degree of implementation

Compliance with the MEWS and RRS protocol is described in Table 2. Nurses calculated a MEWS in 70% (2513/3585) of the measurements on protocol wards and in 2% (65/3013) on control wards. Compliance of vital sign measurements three times per day on the protocol wards was achieved in 68% (819/1205). The median number of measurements per day was 3 (IQR 2-3) on protocol wards and 2 (IQR 1-2) on control wards. On control wards, retrospective review of vital signs indicated abnormal observations warranting the need for calculation of a MEWS according to the protocol in 41% (1232/2977) of all measurements. In only 4% (47/1232) of the measurements, the score was actually determined. A critical MEWS was recorded by nurses in 9% (338/3585) on the protocolized versus 1% (35/3013) on the control wards. Comparing the actually documented MEWS with the retrospective MEWS calculations, a critical MEWS was identified in 11% (381/3585) on the protocolized versus 7% (217/3013) on the control wards indicating the presence of calculation errors. In 43% (1552/3585) of measurements on protocol wards, the complete set of vital signs including MEWS was measured compared to 1% (31/3013) on control wards. In the majority of the measurements taken on control wards, the 'routine' set consisted of temperature, blood pressure, and heart rate. A 'perfect' measurement of all vital signs, including MEWS without calculation errors, was present in 14% (483/3585) of protocolized measurements versus 0.3% (8/3013) of control measurements.

Delay in notification of the physician

The presence of delay was analyzed in 99 patients (Table 3). In 49% (28/57) of the patients in the protocol arm and 50% (2/4) in the control arm, delays were present in identifying deterioration. When critical MEWS were measured by nurses on protocolized wards, a delay of 20 hours (IQR 5.5-54.0) was observed between the first registered critical MEWS and the notification of the physician, versus 44 hours on control wards, (P=0.79). When analyzing the delay using the retrospectively calculated critical MEWS, the presence of delay was 16.5 hours (IQR 6.0-40.5) on protocolized wards versus 23.5 hours (IQR 23.5-23.5) on control wards, (P=0.79).

Table 2. Description of compliance to the RRS protocol.

	Measurements on protocolized wards (N=3585)	Measurements on control wards (N= 3013)	95% CI of % difference	*P*-value[e]
Demographics of measurements				
Number of MEWS registered by nurse[a], % (n/N)	70 (2513/3585)	2 (65/3013)	67.9 (66.3 to 70.0)	< 0.001
Critical MEWS registered by nurse, % (n/N)	9 (338/3585)	1 (35/3013)	8.3 (7.3 to 9.3)	< 0.001
Retrospectively calculated MEWS[b], median (IQR)	0 (0 - 1)	0 (0 - 1)	-	-
Retrospectively calculated critical MEWS, % (n/N)	11 (381/3585)	7 (217/3013)	3.4 (2.0 to 4.8)	< 0.001
Compliance to measurement regime				
Days present on which MEWS could have been measured 3 or more times per day[c], % (n/N)	44 (1205/2763)	56 (1558/2763)	-12.8 (-15.4 to -10.2)	< 0.001
Compliance of measurements taken ≥ 3 times per day, % (n/N)	68 (819/1205)	-	-	-
Measurements with retrospectively calculated MEWS ≥ 1, % (n/N)	59 (1745/2977)	41 (1232/2977)	17.2 (14.8 to 19.7)	< 0.001
Compliance of MEWS registered by nurse if retrospective MEWS ≥ 1, % (n/N)	-	4 (47/1232)	-	-
Completeness and errors in measurements of all 9 parameters during single measurement				
No missing parameters, % (n/N)	43 (1552/3585)	1 (31/3013)	42.3 (40.6 to 44.0)	< 0.001
1 missing parameter, % (n/N)	11 (391/3585)	1 (21/3013)	10.2 (9.2 to 11.3)	< 0.001
2 missing parameters, % (n/N)	5 (174/3585)	1 (19/3013)	4.2 (3.5 to 5.0)	< 0.001
3 or more missing parameters, % (n/N)	41 (1468/3585)	98 (2942/3013)	-56.7 (-58.4 to -55.0)	< 0.001
Errors in calculation[d]				
No errors, % (n/N)	20 (713/3585)	10 (309/3013)	9.6 (7.9 to 11.3)	< 0.001
1 error, % (n/N)	35 (1270/3585)	6 (175/3013)	29.6 (27.8 to 31.4)	< 0.001
2 errors, % (n/N)	14 (508/3585)	7 (203/3013)	7.4 (6.0 to 8.9)	< 0.001
3 or more errors, % (n/N)	31 (1094/3585)	77 (2326/3013)	-46.7 (-48.8 to -44.5)	< 0.001

Due to rounding, percentages do not always add up to 100%.

[a] This parameter describes if a nurse has registered a MEWS in the nursing chart, irrespective of correct calculation and/or based upon a complete set of measurements.

[b] Retrospective calculation of the MEWS is performed by the researchers by calculation of the sub scores based upon the registered vital signs and subsequent determination of the MEWS according to the vital signs registered (irrespective of complete set presence).

[c] The total number of nursing days per patient were calculated and cross checked if three or more measurements (irrespective of completeness and correctness) had taken place on the protocolized wards.

[d] For this parameter, allocation of the sub scores (for each individual vital sign) including MEWS was calculated. Of note, errors were defined as all vital signs missing as well as miscalculated and/or not recorded sub scores and MEWS.

[e] Chi-square test

Table 3. 'Presence of delay' between critical MEWS calculation and notification of physicians.

	Patients on protocolized wards (N = 90)	Patients on control wards (N = 9)	Relative Risk (95% CI)	*P*-value[c]
'Presence of delay'[a] when a critical MEWS was:				
Registered by a nurse or was retrospectively calculated, % (n/N)[b]	49 (28/57)	50 (2/4)	0.98 (0.36 to 2.71)	0.97
Registered by a nurse, % (n/N)[b]	22 (15/69)	20 (1/5)	1.09 (0.18 to 6.64)	0.93
Retrospectively calculated, % (n/N)[b]	39 (22/57)	50 (2/4)	0.77 (0.28 to 2.17)	0.65

[a] 'Presence of delay' is the time between a critical MEWS measurement and the notification of the physician.
[b] The 'presence of delay' could not be determined in case one of the following deviations from the RRS-protocol was found:
1) in case the critical MEWS calculated by the nurse and/or retrospectively calculated critical MEWS were absent, or;
2) one or both of these critical MEWS were present after primary notification of the physician, or;
3) the notified critical MEWS registered by the nurse turned out to be based upon a miscalculation.
[c] Fisher's exact test

AE incidence, RRT activations and ICU admissions

During the three-month study period 64 AE occurred of which 95% (61/64) were unplanned ICU admissions and 5% (3/64) cardiopulmonary arrests. In September the AE incidence on protocol wards was 13.4/1000 hospital admissions which reduced to 8.5/1000 in November (95% CI: -0.004 to 0.014). The AE incidence in the control arm also dropped in the same period from 9.1/1000 to 6.5/1000 (95% CI: -0.006 to 0.012) (Fig. 3). The total number of RRT activations in the protocolized arm (62/84) was significantly higher compared to the control arm (22/84) (X^2=8.79, df=1, $P < 0.003$). The number of RRT activations on protocolized wards increased from 11.8/1000 to 19.6/1000. The number of activations on control wards was unchanged with 8.0/1000 in September to 9.8/1000 in October and 6.5/1000 in November. The APACHE IV score of patients admitted to the ICU in both arms showed no statistically significant difference. APACHE IV scores in protocolized and control wards in September were 64 (IQR 58-82) and 63 (IQR 54-97) and in November 61, (IQR 47-83) and 73, (IQR 54-108). Following a RRT activation, patients from protocolized wards were taken less often to the ICU in November (26% (6/23)) compared to September (67%, (10/15)). On control wards a slight decrease was observed in November (50% (3/6)) versus September (57% (4/7)).

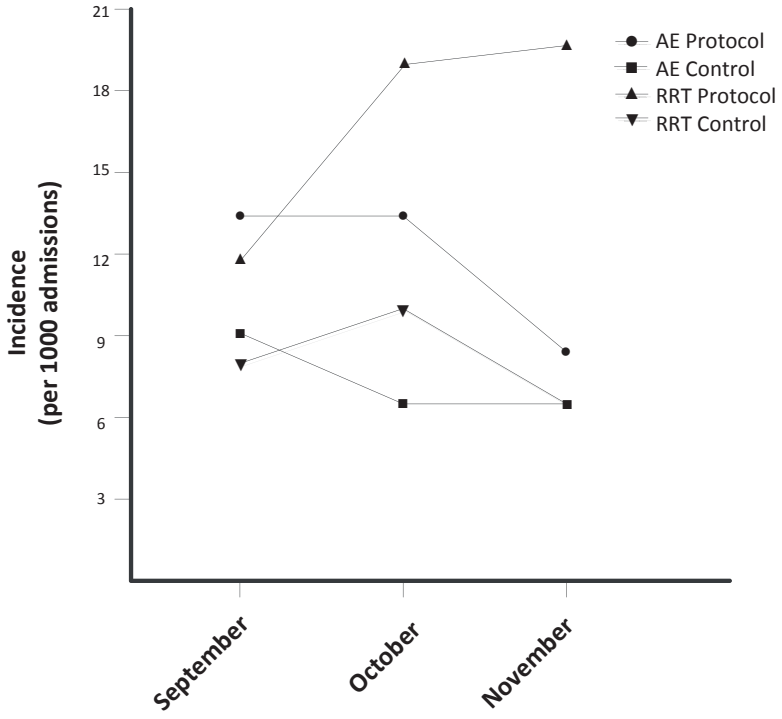

Figure 3. Incidence of AE and RRT activations per 1000 hospital admissions during the whole three study months.

DISCUSSION

Applying a protocol in which nurses have to measure the MEWS at least three times daily leads to better compliance and more reliable activation of the patients' own physician or the RRT compared to leaving frequency of measurement up to nurses themselves. Therefore, imposing regular measurements of the MEWS could actually lead to enhanced patient safety.

In this study, a multi parameter system was used to ensure more comprehensive measurements of vital signs and thus a greater chance in detecting deterioration. In theory the approach of a structured monitoring plan could also be applied to single parameter systems but their more extreme trigger points might lead to late alerts for physiological deterioration.[27]

To our knowledge, only one study has shown insight in the degree of implementation of the RRS protocol. Shearer *et al.* explored the causes of the lack of compliance to the RRS protocol using a mixed-method design.[28] In our study, we also give insight in the degree of implementation by describing the level of compliance of the MEWS measurements and the activations of the primary physician and/or RRT. Until now, data on effectiveness of RRS shows conflicting outcomes.[1,2] Effectiveness of any kind of intervention depends on the degree of implementation. The number of RRT activations has been directly linked to a decrease in incidence of AE[16]. However, effectiveness of RRS depends on more than only the dose of RRT.[14] Afferent limb failure and delayed detection of deteriorating patients is associated with worse clinical outcome.[29] Obviously, effectiveness also depends on compliance with the protocol,[30] and the degree of monitoring on wards,[20,31] both of which are in many studies not reported.[3] To date no trials have linked the reliability of measuring vital signs and MEWS to RRS performance. We show an improvement on protocolized wards, though reasons for the almost complete failure to calculate MEWS on control wards are not clear. Miscalculations of the MEWS[32], and incomplete 'routine sets' of observations in which respiratory rate is often not incorporated, may provide part of the explanation.[19] To which extend these factors and errors influence individual patient outcome, remains unknown. Despite the intense nature of the implementation process, unfamiliarity with the protocol may still have been present in our study. It is more likely though that there is a knowledge deficit regarding recognition of abnormal vital signs.[33,34]

Early admission to the ICU is directly correlated with improved survival.[35] It is imperative that escalation of care and early notification of responders is without any delay. In our study, no delay in notification of the physician prior a RRT call was found in 51% (29/57) of protocol versus in 50% (2/4) of the patients on control wards. It should however be noted that on control wards delays were difficult to interpret due to omissions in the recording of measurements in vital signs. Therefore, comparisons between both study arms regarding the presence of delay are fraught with difficulty.

Although this study was not designed to analyze the effect on clinical outcomes, we did observe an interesting trend in a decrease of AE. Protocol wards and to a lesser extent control wards, showed increased utilization of the RRT, better compliance with the MEWS protocol and a decrease in AE. This may mirror the presence of a dose/response relationship between the dose of RRT calls and improved clinical outcomes found by others.[16] It is possible that observed differences between groups are influenced due to the so called Hawthorne effect. Since nurses from control wards might have been informed about the intervention. This in our opinion could have led to an underestimation of the observed differences. The fact that patients assessed by the RRT on protocolized wards

were able to stay on the ward more frequently in November compared to September (70% versus 27%), may substantiate this claim and could reflect earlier detection. A major strength of this study is the completeness of data acquisition from nursing charts during the weeks of measurement and thus the ability to review the actually provided care. As this study depends on records kept by nurses, some information bias may be present. However, this cohort represents all admitted patients and not a selection of patients that experienced an AE. This enables a realistic description of the alertness of nursing staff beyond the few hours preceding an AE.

An important limitation of this study is the single centre setting which possibly limits its external validity.[36] The exclusion of measurements in which the patient was absent from the ward for a significant part of the day, may have resulted in an underestimation of our findings since hypothetically speaking, a patient may have received an intervention due to clinical deterioration. Also the fact that we started collecting data shortly after having introduced the RRS may have led to an underestimation of our results since one can question if the RRS was already most effective at that point in time. Ideally, the implementation phase should have been longer; time and money constrains led to the decision for a three-month period. Another limitation is that measurement of vital signs, three times daily, without MEWS calculation might also lead to increased awareness of deteriorating patients. Finally, since stratification of wards was only for medical/surgical specialty and not for other possibly influencing factors such as severity of illness, our findings regarding clinical effectiveness have to be weighted accordingly.

The findings of our study have implications for future work and might favour changing to electronic medical record keeping. Recent evidence from the UK shows better completeness of vitals signs and scores with an electronic vital sign assessment chart.[37] Partial automation of responses and standard operating procedures as used in the VITAL care study may offer new opportunities to improve problems in the current system.[38] Opportunities to detect deterioration depend in many cases on recording vital signs. Automated systems will allow an even greater frequency, thus potentially further reducing the number of 'missed opportunities' due to lack of measurements. In order to understand conflicting scientific evidence of RRS processes measurements need to go beyond RRT activation rates to understand why clinical outcomes improve in some studies but not in others. Institutions with a RRS should describe local algorithms for measurements of vital signs and monitor compliance in order to understand the level of performance of their RRT.

CONCLUSIONS

Recording complete sets of vital signs and MEWS three times daily results in better detection of physiological abnormalities, a significant increase in call-out rates and a more reliable activation of the RRT, and are thus increasing opportunities to avoid AE.

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Conflict of interest statement

Dr. C. Subbe consulted for and received honoraria from Philips. On behalf of the remaining authors, the corresponding author states that there is no conflict of interest.

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Supplementary File 1

The Modified Early Warning Score (MEWS).

MEWS score	3	2	1	0	1	2	3
Heart rate		<40	40-50	51-100	101-110	111-130	>130
Systolic blood pressure	<70	70-80	81-100	101-200		>200	
Respiratory rate		<9		9-14	15-20	21-30	>30
Temperature		<35.1	35.1-36.5	36.6-37.5	>37.5		
AVPU score				A (Alert)	V (response to Voice)	P (reacting to Pain)	U (Unresponsive)
Worried about patient's condition: 1 point							
Urine production below 75 mL during previous 4 hours: 1 point							
Saturation below 90% despite adequate oxygen therapy: 3 points							

Upon reaching 3 or more points → call resident in charge
The MEWS instrument was implemented as a tool that ward staff can use to identify the patient at risk of deterioration. The described method was adapted from Subbe *et al.*[11]

Supplementary File 2

Description of included general wards.

Specialty/ward	Surgery (Yes/No)	Study arm	Pre-defined alteration of protocol, if applicable	Exclusion of patients
Pulmonology	No	Protocolized		Patients admitted for sleep apnoea registration.
Kidney diseases	No	Protocolized		All patients admitted for sleep apnoea registration, fluid deprivation tests for diabetes insipidus, synacthen tests or research patients in general.
Cardiology	No	Clinically indicated		
Internal medicine/ infectious diseases	No	Clinically indicated		
Internal medicine/ Rheumatology	No	Protocolized		
Internal Medicine/Gastro-intestinal diseases	No	Protocolized		
Abdominal surgery	Yes	Protocolized	After 'moments at risk': MEWS measured three times daily for subsequent five days after which the MEWS is determined as clinically indicated unless patient encountered a new moment at risk.	
General/oncology surgery and mouth/jaw surgery	Yes	Protocolized	Identical as previous ward 'abdominal surgery'.	
Urology and short-stay surgery	Yes	Protocolized		All patients other than those admitted for: radical cystectomy (Bricker) and cystectomy with orthotopic bladder construction, laparoscopic and open radical nephrectomy and laparoscopic and open radical prostatectomy including according to Millin.

Specialty/ward	Surgery (Yes/No)	Study arm	Pre-defined alteration of protocol, if applicable	Exclusion of patients
Cardiothoracic surgery	Yes	Clinically indicated		
Orthopaedics	Yes	Clinically indicated		
Trauma surgery	Yes	Protocolized	After 'moments at risk': MEWS measured three times daily for subsequent three days. After three days as clinically indicated unless patient encountered a new moment at risk.	
Vascular surgery and plastic surgery	Yes	Protocolized		All patients other than those admitted for: all post-ICU patients irrespective of primary diagnosis, all aneurysm of the aorta, surgery for stenosis of the carotid arteries and thrombolytic therapy.
Ear, Nose and Throat/ Ophthalmology/ Dermatology	Yes (two out of three are surgery)	Clinically indicated		
Neurology	No	Clinically indicated		
Neurosurgery	Yes	Clinically indicated		
Maternity and delivery ward	No	Protocolized	All surgery patients, MEWS three times daily. Remainder as clinically indicated.	
Gynaecology	Yes	Clinically indicated		All patients staying one night admitted for chemotherapy only.

A description of the 18 included study wards is shown. Primarily, all patients admitted for at least one night are eligible for inclusion. The specialties on the wards are described including whether the ward was primarily denoted as being a surgery type based ward. For ear, nose and throat, ophthalmology and dermatology, the ward was also denoted as surgery because two out of three are primary surgery based. Four wards indicated that some alterations were applicable for patients admitted to these wards. These primarily indicated that not throughout the entire admission, MEWS was to be determined three times daily. Five wards also defined patient groups specifically for in- or exclusion. 'Moments at risk' are defined as the period (specifically defined per specialty/general ward) after admission to the hospital, after receiving surgery and after discharge from ICU/high dependency wards.