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NURSE-LED proactive rounding and automatic early-warning score systems to prevent resuscitation incidences among Adults in ward-based Hospitalised patients

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ABSTRACT

Objectives: In this study, we investigated the impact of critical care outreach implemented to overcome the problem of rapid response system (RRS) activation. The aim was to evaluate the impact of nurse-led proactive rounding on the rate of adverse events in a hospital setting using an automatic early-warning score system, without a call-activated team.

Methods: This observational study was conducted at a university hospital in Japan. Beginning in September 2019, critical care outreach via nurse-led proactive rounding of the general ward was conducted, using an automatic early-warning score system. We retrospectively assessed the computerised records of all inpatient days (N = 497,284) of adult inpatients admitted to the hospital from September 2017 to 2020. We compared the adverse event occurrences before and after implementation of the critical care outreach program. The main outcome measures were: unexpected death in the general ward, code blue (an in-hospital resuscitation request code directed towards all staff via broadcast) for non-intensive care unit inpatients and unexpected intensive care unit admissions from the general ward. The secondary outcome was the proportion of patients who received respiratory rate measurement.

Results: The incidence rate ratios of the occurrence of unexpected deaths (0.19, 95% confidence interval: 0.04–0.57) and code blue in the general ward (0.15, 95% confidence interval: 0.025–0.50) decreased. There was no change in unexpected intensive care unit admissions from the general ward (1.25, confidence interval: 0.84–1.82). The proportion of patients who received respiratory rate measurement increased (10.2% vs 16.2%).

Conclusion: Our results suggest that in RRSs, drastic control of the failure of the mechanism to activate a response team may produce positive outcomes. Proactive rounding that bypasses the mechanism to activate a response team component of RRSs may relieve ward nurses of activation failure responsibility and help them overcome the hierarchical hospital structure.

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Abbreviations

CCNS	Critical Care Nursing Specialist
CCO	Critical Care Outreach
CI	Confidence Interval
EWS	Early Warning Score
ICU	Intensive Care Unit
ICULN	Intensive Care Unit Liaison Nurse
IQR	Interquartile Range
IRR	Incidence-Rate Ratio
MET	Medical Emergency Teams
NEWS	National Early Warning Score
NEWS2	National Early Warning Score 2
RRS	Rapid Response System
RRT	Rapid Response Teams

1. Introduction

The rapid response system (RRS) is aimed at the rapid detection and treatment of acutely and critically ill patients [1]. In this system, a team of emergency response specialists is activated by calls based on a set of activation criteria (i.e., the afferent component [2]).

RRS is effective in improving patient outcomes [3,4], and Japan has recognised the importance of RRSs. Although Japan's in-hospital emergency committee provides a descriptive summary of RRS data, including rapid response team (RRT) or medical emergency team activity data from 35 large acute-care hospitals [5], the prevalence of RRSs remains unclear. Hosokawa et al. [6] reported that 89% of 149 hospitals surveyed in western Japan had no RRS. It is standard to use the Early Warning Score (EWS) as an activation criterion for RRS [7]. A patient's acute decline is preceded by changes in vital parameters such as pulse, systolic blood pressure, respiratory rate and state of consciousness [8]. The EWS is used to assess a patient's degree of risk based on these parameters; vital parameters are measured, a score is generated and, if a threshold is reached, an escalating observation and care strategy is implemented [9,10]. Using the EWS could enhance the advance detection of patient deterioration [11–15]. EWS systems have evolved from manual monitoring to automation [16], and, thereafter, to the automation of staff alerts and RRT activation [17,18]. Additionally, even in systems that have proven to be effective with advanced automation, nurse rounding remains standard [17]. As nurses are professionals who are in constant contact with patients, they are important in detecting critically ill patients. In addition, nurses are vital in advanced systems, as they create an effective flow within the system, thereby making it function. However, Japan is lagging in the introduction of the EWS and standardisation. Barriers to introducing RRSs in Japan include staff shortages, which impede the creation of RRTs and contribute to insufficient administrative support [19,20]. Additionally, most patients in Japan are treated by one primary physician during their hospital stay. The attending physician usually decides whether a ward patient requires intensive care and requests their admission to the intensive care unit (ICU). Some doctors and patients are reluctant to let other doctors, such as members of the RRS team, provide treatment [19,20]. This cultural trait is also an obstacle to the introduction of RRSs; moreover, even after RRS introduction, this culture contributes to afferent component failures [19–23]. Nonetheless, such obstacles must be overcome. An RRS model that circumvents the problem of staff shortages and RRS activation are needed. Previous studies have shown that nurse-initiated RRSs reduce adverse events [24]. Positive results have also been reported using critical care outreach (CCO) via proactive rounds in addition to RRTs [23–25]. Hence, we hypothesised that without a traditional call-response team, implementing only nurse-led proactive rounding with an automatic EWS might reduce the incidence of adverse events. This study may be the first to examine the impact of nurse-led proactive rounding using an EWS on the rate of adverse events in a hospital setting in Japan.

Thus, this study aimed to evaluate the impact of nurse-led proactive rounding on the rate of adverse events in a hospital setting using an automatic EWS system, without a call-activated team.

2. Materials and Methods

2.1. Setting

We retrospectively assessed the computerised records of 1065 bedridden adult patients in a university hospital during September 2017–2020. There were six mixed ICU beds for adult patients and no high-care or step-down units in the university hospital. As a CCO service, nurse-led proactive rounding with automatic EWS was implemented in the hospital, starting in September 2019. The CCO service focussed on establishing a working relationship and facilitating communication with the ward nurses, attending physicians and ICU physicians in consideration of the cultural background. The shortage of staff made it difficult to create a 24/7 cal l-activated response team. Thus, a proactive rounding approach and an automated EWS system were employed to implement the CCO service even with limited resources.

2.1.1. Nurse-led proactive rounding with automatic EWSs

At this hospital, the critical care nursing specialists (CCNSs) are authorised by the Deputy Director and Nursing Director to take relevant decisions and implement the CCO activities at the hospital. In Japan, CCNSs have six primary responsibilities towards patients and families requiring complex care: 1) advanced practice; 2) consultation with medical professionals, such as nurses; 3) promotion of collaboration; 4) education; 5) ethical coordination; and 6) research. A CCNS has a master's degree and is trained to select and implement the best strategies considering the structure, size and culture of the organisation.

An EWS system was constructed prior to implementing nurse-led proactive rounding with an automated EWS. A literature review of existing EWSs was conducted, which focussed on healthcare resources and outcomes. After the analysis, as the hospital's previous medical records had used the MEWS and NEWS2, we selected the NEWS2 for its higher prediction capability for patients at risk. The NEWS2 includes parameters such as respiratory rate, oxygen saturation (SpO 2), body temperature, systolic blood pressure, heart rate, level of consciousness and presence of supplementary oxygen [10] (see Appendix A). A score is allocated to each parameter after it is measured, reflecting how significantly the parameter varies from the norm [10]. The score is aggregated, and patients' risk is categorised into one of four levels: low risk (0–4 points), low-to-moderate risk (3 or 4 points, with a 'red' score, namely three points for one individual parameter), moderate risk (5–6 points) and high risk (7 points or more [10]). Based on the NEWS2, we developed a system that extracts and scores inpatients' vital sign data (entered by ward nurses into the electronic medical record) and displays the patients' risk level. As the frequency and duration of vital sign measurements varied for each patient in the general ward, the most recent values were selected from the previous 24 h of data; subsequently, patients were classified into one of four levels. In cases of missing data for patients' vital parameters, the value from the preceding measurement of the parameter was input. The automatic EWS system was developed by the first and third authors, who possess advanced medical informatics skills.

The proactive rounding was conducted once a week, on days when the CCNSs were working the day shift. At the beginning of the shift on the day of rounds, the CCNSs activated the EWS system on the terminal in the ICU and reviewed the patients listed in all wards (excluding those in the palliative and intensive care units, maternal-foetal care unit, paediatric ICU and neonatal ICU). The rounds targeted moderate-, high- and low-to-moderate-risk patients. The CCNSs made rounds to meet each listed patient ward and assisted with the appropriate delivery of care to at-risk patients. In addition, the CCNSs worked with the ward nurses, ICU physicians and attending physicians to determine patient management.

The ICU liaison nurse (ICULN) is known as the nurse responsible for CCO services [26–28]. The proactive rounding by CCNSs encompasses the role of an ICULN. In the proactive rounding, CCNSs provide care for patients with complex needs and work with interdisciplinary teams to ensure proper and timely management of patients with acute illnesses, including the timely admission of patients to the ICU. One of CCNSs' educational goals is to improve the ability of ward nurses in all acute care wards to manage more complex patients. In addition to providing patient-specific ward-based critical care expertise and skills, the CCNSs were informed in each round that ward nurses were an important source of respiratory rate information. Respiratory rate measurement is important for detecting the deterioration of patients, but it has been noted that such a measurement is often ignored or that the measurement is inaccurate and lacks reliability [29–31].

Ethical approval

This study was approved by the institutional review board of X (approval number: BLINDED). In this study, electronic medical record patient data were reviewed and collected, but no personally identifiable data were used for the statistical analysis. We posted the study protocol, containing information for patients' perusal, on the hospital's website during the study period. We informed patients that they could opt out if they wished to and provided them with our contact details.

2.2. Sample and data collection

The main outcome variables were: unexpected death of a patient in the general ward, code blue for non-intensive care unit inpatients and unexpected ICU admissions from the general ward. A code blue refers to an in-hospital resuscitation request code that all staff attend via broadcast. The secondary outcome was the proportion of patients who received a respiratory rate measurement.

The sample comprised all inpatient days (N = 497,284) during two time periods: baseline and post-implementation of the nurse-led proactive rounding. The baseline period was September 1, 2017 to August 31, 2019, which, prior to the implementation, was only a regular code blue operation (n = 338,763). The post-implementation period was September 1, 2019 to August 31, 2020 (n = 158,521). By using two time periods, we addressed seasonality that could affect patient severity, type of illness and staffing. We determined the post-implementation period considering the potential impact of COVID-19 on our hospital. The target population included inpatients aged 16 years and older; patients in paediatric wards, palliative care wards and ICUs were excluded.

Information on each variable was collected from several hospital department databases. Data on the EWS, level of risk and respiratory rate measurements were collected by an EWS system based on electronic medical records. Missing respiratory rate data in the previous 24 h were entered as a non-measured value. Data on code blue occurrences and unexpected death were collected from the database of the Department of Medical Safety and Management. There were no cases of code blues occurring incorrectly despite *do not attempt resuscitation* orders. Data on unexpected ICU admissions were extracted from the ICU database. Patient data were collected from computerised medical records.

2.3. Data analysis

Poisson regression models the incidence of count data or events per hour. Thus, Poisson regression was used to estimate the incidence rate ratio of the variables before and after implementation. Specifically, incidences of code blue, unexpected death and unexpected ICU admission from the general ward were analysed, including baseline/post-implementation and patient-days between months. Months were included as an interaction in the model to account for time and seasonal effects. The proportions of at-risk patients and of respiratory rate measurements (pre- and post-implementation) were compared using chi-square tests. The data were analysed and summarised by medians (interquartile range) or percentages, as appropriate. All analyses were conducted using JMP® Pro 15 (SAS Institute Inc., Cary, NC, USA). The confidence level was set to 95%; the significance level was $p < 0.05$.

3. Results

We included 497,284 patient-days in the analysis. All variables during the 24 months preceding and 12 months following the implementation were compared. No significant differences were found regarding gender, age and length of hospital stay between the pre- and post-implementation data (Table 1).

The differences in the number of at-risk patients targeted for CCO, EWSs and the proportion of respiratory rate measurements between the pre-and post-implementation periods are shown in Table 2.

The percentage of at-risk patients targeted for CCO was higher during the post-implementation period (3.4% vs 4.1%). The median (IQR) EWS for at-risk patients was 5 (5–6) points in both periods. The proportion of patients who received respiratory rate measurements was significantly higher in the post-implementation period for both general ward patients (10.2% vs 16.2%) and at-risk patients (33.7% vs 46.0%). Fig. 1 illustrates the smoothed changes in the proportion of respiratory rate measurements over the study period. The proportion of respiratory rate measurements followed an upward trend in the post-implementation period.

Table 3 shows the incidence rate ratios and 95% confidence intervals for the frequency of occurrence per 1,000,000 patient-days of unexpected death, resuscitation codes in the general wards and unexpected ICU admission from general wards.

After the start of the CCO service, the incidence rate ratios for unexpected death decreased by 0.19 (0.04–0.57) and code blue in general wards decreased by 0.15 (0.025–0.50). No CCO-intervened patients required code blue. The change in incidence rate ratios was 1.25 (0.84–1.82) for unexpected ICU admissions from general wards, showing an increasing trend, and 0.70 (0.37–1.23) for in-hospital resuscitation codes, showing a decreasing trend but not a significant difference.

4. Discussion

We evaluated the impact of nurse-led proactive rounding using an automatic EWS system as a CCO service in a hospital setting. In the post-implementation period, unexpected death decreased, along with resuscitation codes in the general wards. Establishing a semi-automatic system using novel technologies will allow patients to be monitored, while simultaneously enabling the alarm system's visual parameters to change regardless of the attending physician. One of the advantages of semi-automation is that the system is reproducible in any hospital worldwide and may help avoid automated proactive rounds by nurses. Prior research shows that the implementation of an RRS, including proactive rounding, reduces in-hospital mortality [32] and the incidence and mortality rates of non-ICU cardiac arrest [25,33]. Moreover, a proactive RRT approach guided by an EWS reduces unplanned ICU hospitalisations [23]. However, these were add-ons to 24/7 team activities with proactive rounds implemented, in addition to an RRT with manual activation [23,25,32,33].

Building an RRT requires correct, specialised and well-trained staff. It is expected that a team that is available 24/7 will produce better results than a team that works only once a week during the day. The CCO, as implemented in this study, was a very limited, restricted and non-ideal team. However, no impairment of the RRS afferent component was present as no team was present to respond to calls from the ward. Our results suggest that a drastic control of afferent component failure may produce positive outcomes in RRSs. For the afferent component, ward nurses are responsible for the team's activation. There are several barriers to the activation of a response team, such as incomplete vital sign records, nurses' lower perception of patient risk, disconnected escalation of appropriate patient care and delays in calling an expert response team [34–36]. These barriers place the blame on nurses, who are expected to overcome these barriers themselves. A recent systematic review examined such demands on ward nurses and demonstrated that the hierarchical structure of hospitals complicates the implementation of RRSs [21]. The hierarchical structure of the medical field, which is a barrier to RRSs, is a common problem in other countries as well. Hierarchical barriers include the attending physician's unwillingness to collaborate with other physicians or RRTs, as well as less experienced nurses' difficulty in having their opinion accepted by the physician; this inhibits ward nurses from activating RRTs [22,37,38]. This is also a barrier to implementing RRSs in Japan [19,20].

Table 1
Characteristics of study population: pre- and post-implementation.

	Pre-implementation	Post-implementation
Gender: female *n* (%)	11,348 (43)	5927 (45)
Age median (IQR)	69 (56–76)	69 (57–76)
Hospital length of stay (d) median (IQR)	8 (4–16)	8 (4–16)

Note: IQR = interquartile range; d = days.

Table 2
Comparison of the NEWS2 score, number of at-risk patients and proportion of respiratory rate measurements between the pre- and post-implementation periods.

	Pre-implementation n = 338,763	Post-implementation n = 158,521	Pre-implementation minus post-implementation (95% CI)
Number of patients receiving proactive rounding	0	944	
Median EWS in at-risk patients' (IQR)	5 (5–6)	5 (5–6)	
Proportion of at-risk patients (%)	3.4	4.1	−0.007 (−0.008, −0.006)*
Proportion of respiratory rate measurement in general wards (%)	10.2	16.2	−0.012 (−0.014, 0.012)*
Proportion of respiratory rate measurement in at-risk patients (%)	33.7	46.0	−0.12 (−0.13, −0.11)*

Note: At-risk patients were defined as having a single red score or a score greater than 5 on the National Early Warning Score 2; CI = confidence interval; *$p < 0.05$; IQR = interquartile range.

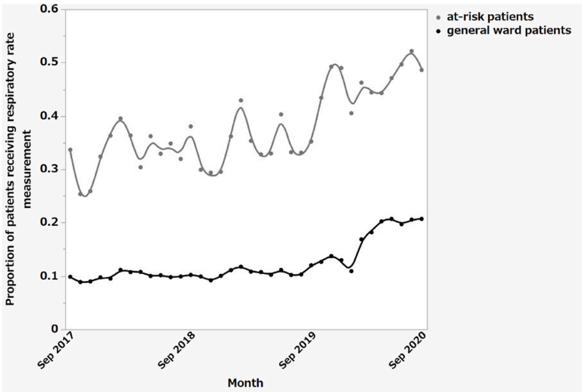

Fig. 1. Change in the proportion of patients receiving respiratory rate measurements over the study period. Each smoothed line represents the proportion of patients receiving respiratory rate measurements in general wards and the respiratory rate measurements of at-risk patients.

Table 3
Occurrence of adverse events in the pre- and post-implementation periods.

	Incidence of events per 1,000,000 patient-days		IRR (95% CI)
	Pre-implementation	Post-implementation	*p-value*
Unexpected death	1.25	0.17	0.19 (0.04–0.57) $p = 0.001$*
Code blue in general wards	2.13	0.34	0.15 (0.025–0.50) $p = 0.001$*
Code blue (on hospital premises)	2.93	2.03	0.70 (0.37–1.23) $p = 0.21$
Unexpected ICU admission from general wards	8.28	10.33	1.25 (0.84–1.82) p = 0.28
Unexpected ICU admission	25.65	28.47	1.11 (0.92–1.33) $p = 0.29$

Note: ICU = intensive care unit; IRR = incidence rate ratio; CI = confidence interval; *$p < 0.05$; code blue = an in-hospital resuscitation request code that all staff attended via broadcast.

In this study, the CCO focussed most on building stakeholder relationships when escalating the care of ward nurses for patients at high risk of sudden changes and bridging the gap towards intensive care. In studies where CCO rounds have shown positive outcomes, the initiative has been led by trained specialist nurses with specialised knowledge and experience [23,39]. CCNS play the role of innovators in establishing systems and advanced clinical practice capabilities [40]. Thus, we believe that the CCNS intervention can help circumvent some of the hierarchical barriers. CCNSs are present in 203 hospitals in Japan [41], and these facilities could introduce this style of RRS.

The goal of CCO is to reduce clinical deterioration leading to the need for resuscitation, reduce admissions to critical care areas and educate staff to enable effective recognition and management of deteriorating patients [42]. The results of this study showed no change in unscheduled ICU admissions. Our study did not reveal that unexpected ICU admissions were prevented. Additionally, the occurrence of code blues among in-hospital patients, including outpatients, other than ward patients, who were not the target of this intervention, did not decrease. The introduction of an automated EWS system for patients other than inpatients should be addressed in the future.

The CCO of this study was focussed especially on educating staff to conduct respiratory rate measurements. As a result, the frequency of respiratory rate measurement remained low; however, it increased in the post-implementation period. Besides the CCO rounding, the ward nurses followed standard practice, and there was no response team. The reduction in resuscitation codes in this study may be owing to ward nurses being more aware of respiratory changes as a precursor to acute changes, and possibly requiring earlier intervention. However, despite information being provided to ward nurses and measurement being promoted, less than half of at-risk patients had their respiratory rate measured in this study. Although automatic wearable continuous devices have been developed, including those that measure respiratory rate, there remains insufficient evidence regarding the detection of deterioration vis-à-vis standard care [43]. In capturing changes in patients' condition through breathing, rather than 'counting the number of breaths', respiration measurement becomes a meaningful act. Until contactless automated respiratory rate monitoring with minimal patient stress is realised in clinical practice, human nurses and doctors must conduct such measurements. Education is necessary for everyone involved in patient care, not just nurses and doctors. Although in this study, the EWS system was used primarily by the CCO side, the use of EWSs by ward nurses may motivate them to measure respiratory rate. This study on nurse-led proactive rounding using an automatic EWS system has some limitations that should be overcome in future research. However, our results show the possibility that supporting the continuation of activities can prevent the deterioration of patients, even with a simple system, as well as mitigate shortages of human resources that cannot be dealt with using the normal system, such as during a pandemic or disaster. We believe that saving a single life is sufficient justification for implementing this system or similar ones that enable rapid response in a variety of services, regardless of personnel training or the number of existing personnel.

4.1. Limitations

This study has some limitations. First, the CCO implementation and the responses of the relevant patients, ward nurses and physicians were not evaluated. Informal consultations by the ward nurses and attending physicians with intensivists, CCNS and ICU nurses were unprecedented; these occurred but were not recorded. Although they triggered ICU nurses, intensivists and CCNS towards outreach and intervention in ward patient care, they were not counted. Second, this study showed the possibility of preventing patients from becoming seriously ill, even with personnel who cannot respond 24/7. However, CCO services do not always have such staff, which complicates the analysis of the results. In addition, the system needs qualified personnel who can implement it and quickly analyse the results. Advanced practice nurses are important even in highly automated systems, as they create good flow within the system and are key to making the system work [17]. Therefore, in an environment lacking such staff, we cannot guarantee the implementation of this style of CCO and the reproducibility of the results presented in this study. It is also important to train advanced practice nurses to develop and implement an optimal system to prevent patient deterioration. Third, there were incomplete data on vital signs, almost all of which were manually entered. This caused problems such as the time of measurement differing from the time of entry, and mixed-text entry. It is important to have all vital sign data as nurses use these data to make decisions. Having incomplete data can generate obstacles in the service and may be acted on without the need or the other way around. Accurate and reliable recording of patients' vital signs is essential to ensure the accuracy of the EWS system, which contributes to an effective RRS. As this critical problem must be considered and assessed, further research is needed to improve and better define the project.

5. Conclusions

There are several obstacles to the afferent component of RRS. To date, nurses have been held responsible for these obstacles and have also been expected to overcome them themselves. We found that proactive rounding as a CCO to bypass afferent failures implemented with some limitations may have reduced the occurrence of resuscitation codes. This style of CCO has the potential to overcome the hierarchical context of the RRS afferent component. Saving a single life is sufficient justification for implementing a system that enables rapid response in a variety of services, regardless of personnel training or the number of existing personnel. This study provides valuable insights for future research and practice related to RRSs.

Ethical approval

This study was approved by the institutional review board of the Kyoto Prefectural University of Medicine (approval number: ERB-E−468).

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Data availability statement

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e17155.

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