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CARDIAC NURSING ROUNDTABLE

Early Warning Systems

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INTRODUCTION

Currently, medical general wards tend to have a higher number of severely sick patients with a long period of critical illness. In addition, there is a growing recognition that several indicators of acute deterioration are being missed by both nurses and doctors. The consequences of these are an increase in the number of adverse events, such as cardiac arrest[1] and in the number of patients admitted or readmitted in critical care units,[2] contributing undoubtedly to higher mortality rates. As a result, many initiatives have been designed trying to reduce such problems, including the development of early warning scoring systems with the perspective of timely medical response.

The aim of this project is to elucidate the dimensions of early warning systems (EWS), to raise discussion on their validity and to stimulate health leadership in introducing early warning systems into health care mechanisms. After having collected and presented data from several recent articles on the topic, this project intends to discuss about the introduction and function of EWS.

WHAT EARLY WARNING SYSTEMS ARE

The application of EWS is not a novel approach restricted solely to medical fields. These systems were first designed for the timely identification of ecological and financial risks. The need for gathering data and information on time, sharing information within different regimes and establishing models for calculation and analysis methods introduced the use of these "tools".[3] These systems were initially applied for the detection of economic weakness and vulnerability.

ABBREVIATIONS
EWS = early warning systems

An Early Warning System is defined as a systemic process for evaluating and measuring risks early in order to take pre-emptive steps to minimize its impact on the financial system. The above successful use of such systems has led to their further introduction in the field of medicine. An early warning system is now defined as: *a specific procedure for the early detection of any departure from normal frequencies of clinical cases or serological reactors of specific diseases by monitoring a sample of the population at risk.*[4]

EARLY WARNING SYSTEMS IN HEALTH CARE

Effective observation of patients is the first key step in identifying the deteriorating patient and effectively managing his/her care. It is vital to have a better nursing

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observation practice so as to produce an enhanced impact on the outcome of patients and prevent deterioration leading to critical illness, intensive care unit admission, and/or death.[5] A prospective study regarding the quality of care for patients admitted to intensive care units, defines it as suboptimal.[2] Causes for providing suboptimal care include: failure of organization, lack of knowledge, failure to appreciate urgency, non-availability of equipment. Fatigue due to increased medical and nursing workloads leading to reduced continuity of care and inadequate communication are also thought to contribute to suboptimal care. Studies in the Unites States of America have also shown that in many cases detectable physiological signs and symptoms of deterioration can be overlooked, neglected or poorly managed.

Acute deterioration in most cases is reported to be an unintended injury caused by medical management rather than the disease process itself. This is referred as 'adverse incidents' which are sufficiently serious to lead to prolongation of hospitalization or to temporary / permanent impairment or disability of the patient at the time of discharge.[6] Moreover, it is remarkable that admissions to intensive care units occur more frequently in the evening and at night. Early warning systems were developed following the publication of several studies suggesting that there was often a delay in the response to the deterioration of a patient's condition. An early warning score was proposed to be calculated for all patients at nurses' concern, giving a reproducible measure of the patient's risk. As tools, they were designed to trigger a response when changes in key physiological data were noted.

Early warning systems assign scores to patients' observation based on careful routine physiological measurement of vital signs. An early warning score is calculated for a patient using five simple physiological parameters: mental response, pulse rate, systolic blood pressure, respiratory rate, temperature, and urine output (for patients with a urine catheter). Each parameter has an upper score of 3 and a lower score of 0 points from which a total score is calculated.[7] Table 1 describes the width of parameters and the way the score is approached. The central idea is that small changes in these parameters will be earlier appreciated using EWS than waiting for obvious changes in individual parameters such as a marked drop in systolic blood pressure, which is often a pre-terminal event. An increasing score normally indicates deterioration, and can even predict subsequent mortality (Fig. 1). However, an EWS is not a panacea for accurate patient assessment and should be used as an adjunct to meticulous clinical assessment.

HISTORY OF THE APPLICATION OF EARLY WARNING SYSTEMS IN CLINICAL PRACTICE

In 1997 Morgan et al in the UK were the first to develop and publish an Early Warning System composed of five physiological parameters not only to predict outcome, but to serve as a track and trigger system to identify early signs of deterioration.[8] The EWS that were introduced across the UK were subsequently modified (MEWS, Modified Early Warning Systems), and a Standardized Early Warning System (SEWS) was developed in Scotland in 2003. In 2007, the National Institute for Health and Clinical Excellence (NICE) recommended that physiological track and trigger systems, which employ multiple-parameter or aggregate weighted scoring systems, should be used to monitor all adult patients in acute hospital settings to facilitate the recognition of patient deterioration and a timely escalation of care. NICE also recommended that the chosen system should measure heart rate, respiratory rate, systolic blood pressure, level of consciousness, oxygen saturation and temperature.[9] Most recently, in 2010, the European Resuscitation Council outlined the importance of EWS by including them in the guidelines for resuscitation and including them into the first link in the chain of survival.[10]

NURSE'S ROLE IN VITAL SIGNS' EVALUATION

Appalling deterioration of patients in hospital is frequently preceded by documented deterioration of physiological parameters. Failure of clinical staff to respond to deterioration

TABLE 1. Early warning scoring system

	3	2	1	0	1	2	3
Pulse (bpm)		≤40	41- 50	51- 90	91-110	111-130	≥131
RR (/min)	≤8		9- 11	12- 20		21-24	≥25
Temperature (0 C)	≤35.0		35.1-36.0	36.1-38.0	38.1-39.0	≥39.1	
Systolic BP (mmHg)	≤90	91-100	101-110	111-249	≥250		
CNS (AVPU scale)				Alert			Voice, Pain, Unresponsive

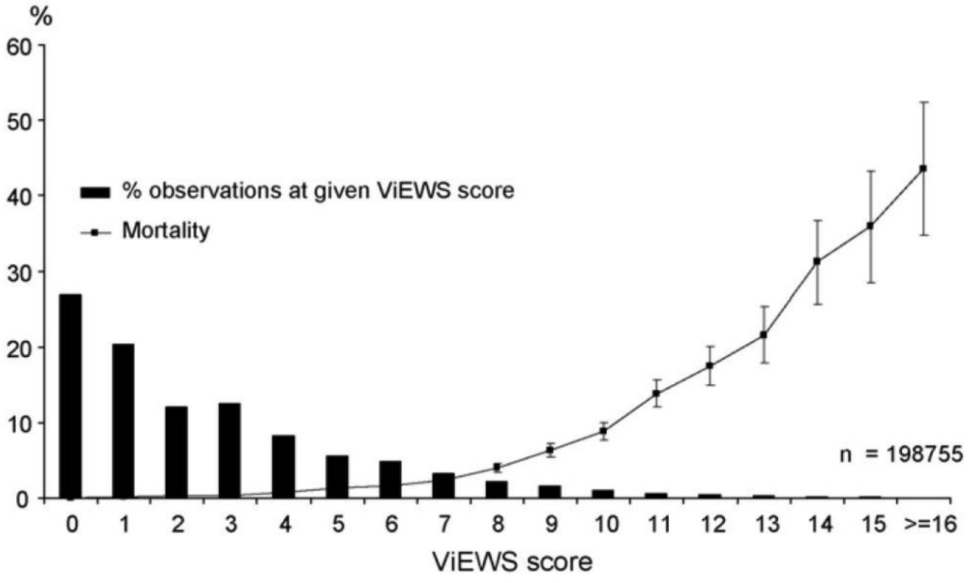

FIGURE 1. The distribution of EWS values and associated mortality within 24h of a given vital signs observation set.

of respiratory or cerebral function and a variety of medical interventions usually put patients at risk of cardio-respiratory arrest. Inappropriate action in response to observed abnormal physiological and biochemical variables might lead to avoidable death.[11] Because of resource limitations, the number of patients that can be monitored and treated in intensive care units or high dependency units is restricted. The selection of patients who might benefit from critical care is therefore crucial. Identifying medical in-patients at risk of deterioration at an early stage by means of simple protocols based on physiological parameters may reduce the number of pre-ICU resuscitation.[12]

A variety of vital sign monitoring tools that incorporate early warning scoring systems have been designed to 'track' signs of deterioration and 'trigger' a rapid response to improve patients' safety across UK and Australia. The modified EWS are based on physiological parameters recorded and graded in specific graphic boxes, according to predefined ranges. Points are allocated to abnormal values, to guide intervention and to monitor the effectiveness of interventions. These systems replace traditional charts which include values plotted on graphs and not specified intervention levels.[7]

To ensure that an early warning score is of a high quality, four data quality dimensions need to be considered (Fig.2):

- Timeliness: referring to the frequency of patient vital signs collection.
- Accuracy: referring to the interpretation of the collected patient vital signs and the calculation of the early warning score.
- Consistency: referring to a consistent approach of vital signs collection throughout the patient's stay in hospital.
- Completeness: referring to all vital signs parameters that should be collected.[13]

According to a study conducted in 2004, the parameters of abnormal blood pressure, neurological status or what the practitioner was 'worried about' were identified as the main causes of referrals to intensive care,[14] whereas a more recent study reported that an increase in respiratory rate was the most frequent trigger. Increased respiratory rate seems to be the most frequent physiological abnormality in patients prior to death, arrest or admission to intensive care.[6] There is a documented concern regarding misinterpretation of clinical data and little convincing evidence of timely response to signs of deterioration. The documentation and interpretation of vital signs along with the timely report of deterioration relies on nurses. It is the nurses' professional responsibility to understand the significance of patient observations and patient survival often depends on the decisions of nurses to call for assistance.[7]

In another study evaluating the factors which influence the experience of trained nurses taking care of critically ill patients in the ward setting, five key themes emerged: clinical environment, professional relationships, patient assessment, nurse's feelings and educational needs. Furthermore, studies in UK and Australian hospitals point out nurse's 'intuitive knowing' as a used process to recognize patients' vital signs of critical conditions. This intuition is a result of the nurse knowing the patient's condition and behavior when repeatedly exposed to similar patients with specific conditions. Nurses are proved to rely on past experience and knowledge to detect differences in patient condition leading to possible deterioration.[5] When nursing stuff feel intuitively concerned about a patient, they are likely to go on to confirm their suspicions by further assessment of the patient's vital signs, such as respiratory rate,

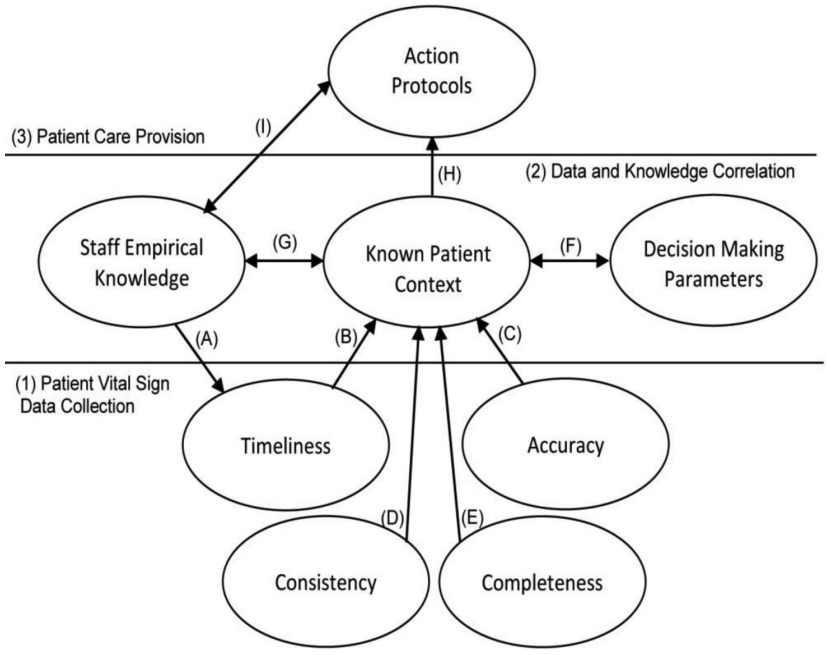

FIGURE 2. Patient vital sign data collection and decision- making process.

pulse and blood pressure. Finally, another study published in 2006 investigating the reasons behind the nurses' paucity in patient monitoring identifies the organization of nursing care activities, the development of nursing observation skills, clinical decision- making processes, and equipment management issues as the major factors.[15]

STUDIES EVALUATING THE UTILITY OF EARLY WARNING SYSTEMS

Several studies have shown that EWS are sensitive tools for identifying patients with high possibility of deterioration. An increased incidence of cardio-pulmonary arrest has been correlated with patients having a high score. Respiration rate is pointed out as the best discriminator to identify patients at risk. Relevant studies confirm the reliability of these systems, presented on Table 2.

LIMITATIONS OF EARLY WARNING SYSTEMS

Early warning systems are not always used to their full potential, raising the question of their impact in clinical practice. The impact of outreach teams and medical emergency teams has yet to be fully defined. For clinical practice, this means that care must be taken when developing and implementing EWS. The rigour of the development process needs to be considered along with reflection upon how to best meet local requirements.[6]

Early warning systems based on existing medical records suffer from the sparseness of measurements; in general hospital units, patients' vital signs are typically collected manually by a nurse, at a granularity of only a handful of readings per day. While real-time monitoring systems fill the gap in measurements, it is nevertheless impractical to intensively monitor all patients in general hospital units.[19] In general wards, older and more acutely ill patients are probably taken care by inadequate nursing staff facing fatigue or sleep deprivation, few qualified and most often inexperienced nurses who are not paid for post-registration education. Failure to comply with clinical protocols implies failure of the function of early warning systems. Confounding variables, such as clinical experience of nurses recording data on patients' charts also influence the effectiveness of clinical signs.

In addition, parameters being evaluated according to early warning scores are under controversy. Skin tone, sweating, nausea and other clinical signs, such as nurses' intuitive assessment of the patient being just 'not right' are documented but is unclear whether early warning scoring charts should be designed to include such clinical signs. The use of intuitive sense may not contribute to EWS if signs are picked up in the early stages of deterioration and this may cause confusion in the process.[5] Limitations of the parameters graded by EWS may also stem from the nature of the impending illness. If a

TABLE 2. Early Warning Scoring Systems subjected to evaluation of performance

Studies	Study objective	Outcome measures	Sample size	Findings
Prospective cohort Effect of introducing the MEWS on clinical outcomes, cardio-pulmonary arrests and intensive care utilization in acute medical admissions	Primary aim: to prospectively measure the effect of introducing the MEWS on the rates of ICU and high-dependency unit (HDU) admission, cardio-pulmonary arrest and mortality over a 3-month period Secondary aim: to collect physiological data {systolic blood pressure, heart rate, respiratory rate, temperature, neurological states (AVPU score)} from patients before critical care admission cardio-pulmonary arrest of death in order to improve the discrimination of the score	The ability of the MEWS to identify patients at risk	1695 study patients (medical admissions unit, medical HDU, ICU, following cardio-pulmonary arrest and death) 659 control patients (data from a 2001 study) Single- centre study	Overall, mortality was unchanged between the control group and the study group (patients with a MEWS) irrespective of risk band. There was an increased incidence of cardiopulmonary arrests in the study group in patients with a MEWS 3 of 4 (intermediate risk). A scoring system did not change outcomes in acute medical admissions. A MEWS of 4 triggered urgent medical referral aid critical care outreach team review. Respiratory rate was the best discriminator to identify patients at risk. The MEWS is suitable for identifying patient risk of deterioration[7].
Nurse-administered early warning score system can be used for emergency department triage. [has introduced a multidisciplinary team (MT) in the ED activated by the Bispebjerg Early Warning Score (BEWS). The BEWS is calculated on the basis of respiratory frequency, pulse, systolic blood pressure, temperature and level of consciousness].	To evaluate the ability of the Bispebjerg Early Warning Score System to identify critically ill patiets in the Emergency Department and to examine the feasibility of using the BEWS to activate an Multidisciplinary Team response	The BEWS is a simple scoring system based on readily available vital signs. It is a sensitive tool for detecting critically ill patients and may be used for ED triage and activation of an MT response.	This study is based on an evaluation of retrospective data from a random sample of 300 emergency patients. On the basis of documented vital signs, a BEWS was calculated retrospectively. The primary end points mere admission to an intensive care unit (ICU) and death within 48 hours of arrival at the ED. This study was registered at clinical trials	A BEWS ≥5 is associated with a significantly increased risk of ICU admission within 48h of arrival (relative risk (RR) 4.1; 95% confidence interval (CI) 1.5-10.9) and death within 48h of arrival (RR 20.3; 95% CI 6.9-60.1). The sensitivity of the BEWS in identifying patients who were admitted to the ICU or who died within 48 hours of arrival was 63%. The positive predictive value of the BEWS was 16% and the negative predictive value 98% for identification of patients who were admitted to the ICU or who died within 48h of arrival[16].
Long –term effect of introducing an early warning score on respiratory rate charting on general wards.	The short- and long- term effects of introducing a new patient vital signs chart and the modified early warning score (MEWS), which incorporates respiratory rate on the prevalence of respiratory	The study confirms he long-term beneficial effect of introducing the MEWS system on respiratory rate recording into the general wards of hospital	The six general wards of , which had been using the MEWS and the new chart system for almost one year	During the pre-introduction period, there was no difference in the prevalence of RR recording between the specialties (orthopedic, 26,9%; surgery, 32,9%; medicine 29,8%). During the second two audit periods, the prevalence of RR monitoring was consistently higher on medical wards than on surgical and orthopaedic wards[17].
Performance of the maximum modified early warning score to predict the need for higher care utilization among admitted emergency department patients	This investigation examines whether versions of the Modified Early Warning Score (MEWS) predict high level of care utilization among patient s admitted from the ED	The MEWS Max has moderate ability to predict the need for higher level of care. Addition of ED length of stay and other variables to MEWS Max may identify patients at both low and high risk of requiring a higher level of care	299 admissions from the ED were under the review. The final analysis contained 280 participants.	76 admissions (27%) met the composite endpoint of death of higher care utilization. The MEWS Max was associated with the composite outcome. Also the MEWS Max had moderate predictive ability but classified 82% of participants as intermediate (10-40%) risk. Inclusion of additional variables slightly improved the predictive ability and correctly reclassified 17% of patients as <10% risk[18]

patient had an early warning score of 1 but was suffering from a myocardial infarction while the vital signs appear normal, death occurs due to arrhythmia which tends to occur suddenly, therefore the applicability of EWS would be of little use in this situation.[13] A study comparing early warning scoring systems to biochemical parameters (CRP/ albumin ratio) points out that the biochemical markers ratio appears to be of greater value in the elderly, especially in those with acute exacerbations of chronic disease as a predictor of patient outcome.[20] Additionally, a recent review showed either no evidence of the effectiveness of early warning systems or a reduction in overall mortality in patients receiving early warning scores.[21]

RECOMMENDATIONS FOR THE IMPROVEMENT OF EARLY WARNING SYSTEMS

Concern has been raised on the way EWS should be developed to make them more accurate and control their limitations. A recent systematic review of modified EWS concluded that a wide variety of scores was of poor sensitivity. The lack of sensitivity appears to stem from the high level of inconsistencies of early warning systems' deployment. This review recommends an electronical modified EWS designed to limit or avoid their reoccurrence. An electronic system used to monitor patient vital signs in a consistent and regular manner could counteract the paper based data limitations. This developed system is considered as a key element for patient-oriented healthcare services for the future, as it can provide a very effective way to collect, monitor and manage patient' s physiological parameters and improve its overall quality of care.[13]

Similarly, another study has shown that automated clinical alerts increase compliance with an early warning score protocol and improve patient outcomes. Electronic recording of patient observations linked to a computer system that calculates patient risk and then issues automatic graded alerts can improve clinical attendance to unstable general medical ward patients.[22] Moreover, the utility of monitoring systems along with EWS demonstrating excellent sensitivity in detecting signs of deterioration, and the inability of nurses caring for a large amount of patients in general wards, to manage a high number of false alarms are both recognized. It is concluded that adapted sample alarm settings appear to optimize false positive alarms with a better impact on nurse workflow.[23]

Furthermore, recommendations for improving nurses' competence in making the observations should be considered. Nurses are recommended to attend courses on acute life threatening events recognition and treatment and to develop further simulation exercises in both pre and post registration courses, which may foster EWS process and improve patients' outcome.[24] A combined early warning scoring system for the improvement of the sensitivity prediction is finally proposed. Adding a score for biochemical parameters (CRP, white blood count, platelets, henoglobin, albumin,) to basic early warning score has been proved to better predict outcomes of acute medical admissions.[25]

CONCLUSION

In recent years, there has been significant research within the medical community regarding the prevention of clinical deterioration among hospital patients. The detection and management of deteriorating ward patients is a highly complex process influenced by a variety of factors. Early detection and intervention through early warning systems (EWS) are essential to prevent serious, often life-threatening events, as they have already shown promising results in significantly lowering mortality rates. Among other factors, the perception of nurses plays a vital role in EWS. The context within deterioration is detected and reported as an important consideration that will influence the design and support the reliability of EWS with the potential of better administration of the bed availability of an intensive care or coronary care unit. The successful implementation of EWS requires support from hospital leaders, including senior medical and nursing personnel. Nursing managers of general wards in developing countries should consider implementation of early warning scoring observation charts validated at national level. However, early warning scoring systems must be viewed only as a major decision- making tool and should not be used to replace clinical judgment.

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