Nurse-administered early warning score system can be used for emergency department triage

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ABSTRACT

INTRODUCTION: Studies have shown that early warning score systems can identify in-patients at high risk of catastrophic deterioration and this may possibly be used for an emergency department (ED) triage. Bispebjerg Hospital 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. The aim of this study is to evaluate the ability of the BEWS to identify critically ill patients in the ED and to examine the feasibility of using the BEWS to activate an MT response.

MATERIAL AND METHODS: 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 were admission to an intensive care unit (ICU) and death within 48 hours of arrival at the ED. This study was registered at clinicaltrials.gov (NCT01243021).

RESULTS: A BEWS ≥ 5 is associated with a significantly increased risk of ICU admission within 48 hours of arrival (relative risk (RR) 4.1; 95% confidence interval (CI) 1.5-10.9) and death within 48 hours 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 48 hours of arrival.

CONCLUSION: 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.

Emergency departments and acute admission units receive critically ill patients every day. Studies have shown that rapid and effective initial treatment improves the survival of these patients [1-3]. Critically ill patients should therefore be identified quickly, so that relevant treatment can be initiated without delay. Different triage systems have been validated for use in emergency departments (ED) and acute admission units [4-6]. A recent Danish survey found that no acute medical admission units in Denmark are using a validated triage system [7].

Critical illness is frequently preceded by documented deterioration of physiological parameters [8-10]. To identify high-risk patients, a number of scoring systems have been developed. These are based on measurement of simple and readily available vital signs such as respiratory rate, heart rate, systolic blood pressure, temperature and level of consciousness [11-14]. These systems are known as Early Warning Score systems (EWS). EWS have primarily been validated for in-patients. However, a few studies suggest that EWS may also be used in the context of unselected medical admissions to identify patients with a high mortality in need of intensive care [11, 12]. The sensitivity and specificity of these systems have yet to be been examined.

To ensure a systematic triage and reception of critically ill patients in the ED, Bispebjerg Hospital has been developing a system for the reception of such patients since 2004. The system was termed emergency call (EC). The EC consists of a multidisciplinary team which is activated on the basis of a triage system. The current triage system was introduced in 2007 and relies on an EWS-based score, named Bispebjerg Early Warning Score (BEWS) in combination with "primary criteria" as described below.

The aims of the present study are: To evaluate the ability of BEWS to identify critically ill patients in the ED and to examine the feasibility of BEWS as an activation call trigger.

MATERIAL AND METHODS

Bispebjerg University Hospital is a 600-bed urban teaching hospital serving a population of 400,000 (surgical) and 270,000 (medical) citizens. A total of 38,000 patients visit the ED annually. ECs are activated approximately 30 times a month for patients presumed to be critically ill.

On arrival, ED patients are evaluated by trained triage nurses who have at least two years of experience at our ED. They allocate all patients into one of three categories (red, blue and white) based on the perceived severity of their injuries or illnesses according to common regional guidelines [15] and the nurse's clinical judgment. The most severely ill and injured patients are

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TABLE 1

Chart used for the calculation of the Bispebjerg Early Warning Score. Vital signs used for the calculation of the score are obtained when the patient arrives at an emergency department. Each vital sign is assigned a score of 0-3 points, and scores are then added to give a total score. A score ≥ 5 triggers an emergency call.

	Points						
	3	2	1	0	1	2	3
Respiratory rate	–	≤ 8	–	9-14	15-20	21-30	> 30
Heart rate	–	≤ 40	41-50	51-100	101-110	111-130	> 130
Systolic blood pressure, mmHg	≤ 70	71-80	81-100	101-199	–	> 199	
Temperature, °C	–	≤ 35	35.1-36	36.1-38	38.1-39	> 39	–
Level of consciousness	–	–	–	Awake	Responds to voice	Responds to pain	Unresponsive

marked as ''red". These patients need immediate or acute treatment.

In ''red" patients, the triage nurses immediately perform a secondary evaluation to assess whether an EC is warranted. This is a two-step process. The first step determines whether an EC is to be activated or not. This assessment is performed on the basis of ''primary criteria", i.e. signs and symptoms presumed to be immediately life-threatening, like for instance upper airway obstruction, respiratory arrest or uncontrolled bleeding. If no "primary criteria" are present, the evaluation continues to step two, where vital signs are obtained and the BEWS is calculated (**Table 1**). Each vital sign is assigned a score of 0-3 points and the scores are then added to yield a BEWS. A BEWS ≥ 5 triggers an EC. A BEWS < 5 will normally not trigger the activation of an EC unless the receiving nurse or physician has concerns for the patient that are not expressed in steps one and two. In this study, we have defined a critically ill patient as a patient who is admitted to an intensive care unit (ICU) within 48 hours of arrival at the ED or who dies within 48 hours of arrival at the ED. See also **Table 2**.

TABLE 2

Definitions. We have defined a critically ill patient as a patient who is admitted to an intensive care unit within 48 hr of arrival at an emergency department or who dies within 48 hr of arrival at the emergency department.

Sensitivity	The ability of the BEWS to correctly classify critically ill patients, i.e. the prob-ability that a critically ill patient has a BEWS ≥ 5
Specificity	The ability of BEWS to correctly classify patients who are not critically ill, i.e. the probability that a patient who is not critically ill has a BEWS < 5
Positive predictive value	The probability that a patient is critically ill if the patient scores BEWS ≥ 5
Negative predictive value	The probability that a patient is not critically ill if the patient scores BEWS < 5

BEWS = Bispebjerg Early Warning Score.

To examine the ability of the BEWS to reliably identify critically ill patients at the ED, a random sample of 300 ''red" patients visiting the ED in the period from 1 April to 30 September 2009 were evaluated. The sample corresponds to a ninth of the population of ''red" patients seen in the ED in this time period. These patients are presumed to have a low prevalence of critical illness even though they are marked as ''red".

Retrospective data were collected including demographic data and vital signs on arrival or within the first 15 minutes of arrival. A BEWS was calculated retrospectively for all patients on the basis of their vital signs documented in the ED medical charts (by nurses or phys-icians) or ambulance records. Patients were subdivided into two groups: BEWS ≥ 5 and BEWS < 5. A BEWS ≥ 5 could be found if a minimum of two vital signs were documented. On the other hand, at least four vital signs had to be documented to ensure that the BEWS < 5 (Table 1).

Patients with insufficient data were excluded from the analysis. Patient outcome measures (death or ICU admission) were obtained through the hospital´s administrative system. No follow-up was made on patients who were transferred to other hospitals and these patients are counted as survivors. This study was registered at clinicaltrials.gov (NCT01243021).

Data are primarily presented descriptively. Age is reported as median and range. Relative risks (RR) are reported with 95% confidence intervals (95% CI).

RESULTS

Among the 300 randomly selected ''red" patients, 138 patients were excluded because of insufficient data. The study thus included 162 ''red" patients. A total of 24 patients from this randomly selected sample had activated an EC.

Demographic data, BEWS and outcome for the study population are summarized in **Table 3**.

Four patients were admitted to the ICU within 48 hours of arrival at the ED. Six patients died within 48

hours of arrival at the ED, including two of the patients who were admitted to the ICU. This means that a total of eight ''red" patients (5%) met our definition of critical illness.

A total of 32 patients had a BEWS ≥ 5, which was associated with a significantly increased risk of death within 48 hours of arrival (RR 20.3; 95% CI 6.9-60.1), ICU admission within 48 hours of arrival (RR 4.1; 95% CI 1.5-10.9) and of being critically ill according to our definition (RR 6.8; 95% CI 3.3-13.8) compared to a BEWS < 5.

Table 4 shows the sensitivity, specificity and predictive values of BEWS in identifying death within 48 hours of arrival, admission to ICU within 48 hours of arrival and critical illness according to our definition. Among ''red" patients, a BEWS ≥ 5 identified 63% of the patients who were admitted to the ICU within 48 hours of arrival or who died within 48 hours of arrival, i.e. critically ill patients (sensitivity). The probability that a ''red" patient with a BEWS ≥ 5 would be admitted to the ICU within 48 hours of arrival or would die within 48 hours of arrival was 16% (positive predictive value). At the same time, there was a 98% probability that a ''red" patient would not be admitted to the ICU within 48 hours of arrival or would not die within 48 hours of arrival (negative predictive value) if the BEWS < 5. As can be seen in Table 4, the sensitivity and positive predictive value of the BEWS in identifying admission to the ICU within 48 hours of arrival are lower than in identifying death within 48 hours of arrival.

DISCUSSION

The BEWS is calculated on the basis of simple and readily available vital signs. The primary findings of this study are that the BEWS can identify with great certainty those patients who will be admitted to the ICU within 48 hours of arrival at the ED or who will die within 48 hours of arrival at the ED. The BEWS is therefore a safe tool for prioritizing resources to patients in need of rapid and intensive care.

In the literature, we have not been able to find a practicable definition of critical illness. As the BEWS is to be used for identification of critically ill patients on *arrival* at the ED, we have chosen a rather narrow definition: a patient who is admitted to the ICU within 48 hours of arrival or who dies within 48 hours of arrival. Naturally, this definition is arbitrary.

Our purpose was to exclude patients who deteriorated during admission, for *example* due to a hospital-acquired infection. Using this narrow definition, the prevalence of critical illness in our study population is low.

Studies have shown that mortality is significantly higher among patients who are admitted to an ICU from a hospital ward than among patients who are admitted to the ICU directly from the ED [3, 17]. To raise the quality of treatment given to critically ill patients on admission to the ED, early identification and rapid initiation of appropriate treatment is therefore important. If a EWS system is to be used for ED triage, it must be able to identify critically ill patients with a high sensitivity and a high negative predictive value.

We have shown that a BEWS ≥ 5 is associated with a significantly increased risk of death within 48 hours of arrival or admission to the ICU within 48 hours of arrival. The BEWS is thus capable of dividing emergency patients into low-risk patients and high-risk patients. We have shown that the sensitivity of the BEWS in identifying

TABLE 3

Demographic data, Bispebjerg Early Warning Score and outcome for the study population.

	''Red'' patients included in the study		
	BEWS ≥ 5 (n = 32)	BEWS < 5 (n = 130)	total (n = 162)
Proportion of men, %	50	49	49
Median age, years (range)	75 (39-92)	52 (2-98)	57 (2-98)
Presenting problem, n			
Neurological deficit	6	19	25
Respiratory problem	18	19	37
Cardiac problem	0	48	48
Intoxication/poisioning	1	12	13
Abdominal pain	0	10	10
Bleeding/hypovolaemia	1	9	10
Allergic reaction	0	4	4
Hypoglycaemia	0	2	2
Fall trauma	1	4	5
Other reasons	5	3	8
Outcome, n			
Deaths within 48 hr of arrival at the ED	5	1	6
ICU admissions within 48 hr of arrival at the ED	2	2	4
Critically ill patientsa	5	3	8

BEWS = Bispebjerg Early Warning Score; ED = emergency department; ICU = intensive care unit.
a) ICU admission within 48 hr of arrival at the ED or who die within 48 hr of arrival at the ED. Two of the ''red'' patients admitted to the ICU also died within 48 hr of arrival at the ED.

TABLE 4

Sensitivity, specificity and predictive values of Bispebjerg Early Warning Score greater than or equal to five in ''red" patients.

	''Red" patients included in the study (n = 162)		
	death within 48 hr of arrival at the ED	ICU admission within 48 hr of arrival at the ED	critial illness[a]
Sensitivity, %	83	50	63
Specificity, %	83	81	82
Positive predictive value, %	16	6	16
Negative predic-tive value, %	99	98	98

ED = emergency department; ICU = Intensive care unit.
a) ICU admission within 48 hr of arrival at the ED or death within 48 hr of arrival at the ED.

The Bispebjerg Early Warning Score is calculated using simple and readily available vital parameters.

these critically ill patients is high. At the same time, the negative predictive value is also high, and, consequently, so is the risk of a patient being critically ill if the BEWS is < 5. The BEWS is therefore a safe tool for ED triage.

As resources in EDs are limited, a triage system also needs to have an acceptable specificity and positive predictive value in order to help prioritize the provision of rapid and competent care to the patients who need it the most. This is particularly true if the system is used to direct a considerable amount of extra resources to a particular group of patients, as is the case at Bispebjerg Hospital. The specificity of the BEWS is high and there is therefore a high probability that a person who is not critically ill according to our definition will have a BEWS < 5 and therefore will not activate a multidisciplinary team response. The relatively low positive predictive value of the BEWS among ''red" patients must be perceived in the light of the low prevalence of critical illness among the ''red" patients and our rather narrow definition of critical illness.

Developing a triage system that is both safe and ensures a rational use of the multidisciplinary team has been an ongoing process at our ED since 2004. Before we introduced our BEWS system in 2007, ECs were triggered by medical emergency team criteria (MET) [17] – a simple system triggered when a single extreme physiological value was reached. However, an evaluation of the MET showed that they were inexpedient for the activation of ECs and that, in turn, motivated the development of the BEWS [17].

Studies of other EWS systems have shown that mortality rises with rising EWS [11-13]. Selecting a higher cut-off value for activation of ECs, e.g. BEWS ≥ 6, would thus be expected to raise the specificity and positive predictive value, which means that fewer, but more severely ill patients would be identified. However, this would be at the expense of more false negatives, i.e. lower sensitivity and negative predictive value. The improved resource utilization must be weighed against the risk of insufficient and delayed care of critically ill patients who are misjudged by the system (false negatives). Due to poor documentation of vital signs in the ED charts, this study is unable to estimate the effect of raising the cut-off value for activation of ECs to e.g. BEWS ≥ 6.

In our opinion, the finding that 16% of ''red" patients with a BEWS ≥ 5 are admitted to the ICU within 48 hours of arrival at the ED or die within 48 hours of arrival at the ED makes the BEWS a feasible tool for activation of a multidisciplinary team response. Instead of raising the cut-off value for activation of an EC, we have tried to rationalize the use of resources by introducing two levels of EC, EC I and II, where the number and competencies of the team members depend on the BEWS score level [18].

A limitation of this study is that many patients had to be excluded because of insufficient documentation of vital signs, which made retrospective calculation of a BEWS impossible. We suspect that the excluded patients comprise a smaller proportion with BEWS ≥ 5 than the patients included (i.e. when patients are obviously not very ill, the ED nurses do not measure as many vital signs). This introduced a risk of selection bias which would lead to overestimation of the prevalence of critical illness among ''red" patients. This will affect the estimated sensitivity, specificity and predictive values in the study population.

We have evaluated the compliance with our triage system, i.e. documentation of vital signs and calculation of BEWS, and concluded that our triage system is not yet fully implemented. Poor documentation of vital signs is, however, not only a problem at Bispebjerg Hospital, but is known to be a wide-spread issue [14, 19]. The reasons why documentation of vital signs is poor are probably many: Work pressure, lack of knowledge about the importance of vital signs in the prediction of high-risk patients and overreliance on own experience and clinical judgment are possible explanations. Implementation of the BEWS will continue to play an important role in the ongoing process of improving the quality of our ED triage.

In our opinion, it is important that triage is performed on the basis of an objective and validated system in order to ensure uniformity and to achieve a high level of quality. Like previous studies [11, 12], our study indicates that EWS systems are safe triage tools in EDs and acute medical admission units. A recent survey [1] claimed that no Danish acute medical admission units use validated triage systems and that medical triage is primarily based on clinical judgment. The potential for the implementation of BEWS or other EWS-based systems in Danish EDs and acute medical admission units is thus considerable.

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CONFLICTS OF INTEREST: None

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