ORIGINAL PAPERS

Prediction of in-hospital mortality and length of stay using an early warning scoring system: clinical audit

R Paterson, DC MacLeod, D Thetford, A Beattie, C Graham, S Lam and D Bell

ABSTRACT – This aim of this study was to assess the impact of the introduction of a standardised early warning scoring system (SEWS) on physiological observations and patient outcomes in unselected acute admissions at point of entry to care. A sequential clinical audit was performed on 848 patients admitted to a combined medical and surgical assessment unit during two separate 11-day periods. Physiological parameters (respiratory rate, oxygen saturation, temperature, blood pressure, heart rate, and conscious level), in-hospital mortality, length of stay, transfer to critical care and staff satisfaction were documented. Documentation of these physiological parameters improved (P<0.001–0.005) with the exception of oxygen saturation (P=0.069). The admission early warning score correlated both with in-hospital mortality (P<0.001) and length of stay (P=0.001). Following the introduction of the scoring system, inpatient mortality decreased (P=0.046). Staff responding to a questionnaire indicated that the scoring system increased awareness of illness severity (80%) and prompted earlier interventions (60%). A standardised early warning scoring system improves documentation of physiological parameters, correlates with in-hospital mortality, and helps predict length of stay.

KEY WORDS: acute admissions, early warning scoring system, length of stay, mortality

At point of entry to care, emergency medical and surgical referrals are often at their least clinically stable.[1,2] Early indicators of serious illness may not be recognised or acted upon, leading to rapid subsequent clinical deterioration with important implications for critical care, morbidity, and mortality.[3,4] These concerns have been given fresh emphasis by the National Confidential Enquiry into Patient Outcome and Death (NCEPOD).[5] In response to recommendations from the Royal Colleges and the Department of Health,[6,7] the Emergency Medical Admissions Scoping Group of NHS Quality Improvement Scotland was convened. Thereafter, an Illness Severity Scoring Subgroup was given the remit to develop a patient observation chart incorporating a standardised early warning scoring system (SEWS). Physiological parameters contributing to SEWS are respiratory rate, oxygen saturation, temperature, systolic blood pressure, heart rate, and conscious level (Table 1). The inclusion of oxygen saturation, shown to have a significant relationship with short- to medium-term mortality in emergency medical admissions,[8] distinguishes SEWS from a previously described modified early warning scoring system (MEWS).[9] The SEWS chart was designed to be visually striking and simple to complete.[10] It incorporates an escalation policy prompting more frequent observations and urgent medical assessment. On the reverse there are simple patient management guidelines for first responders. The early MEWS experience was that a score of ≥5 was associated with an increased risk of in-hospital death. Accordingly, the SEWS threshold for medical review was set at a score of 4, the aim being to intensify treatment, prevent further deterioration, and potentially reduce mortality. To determine the impact of the SEWS chart, a clinical audit was performed on two cohorts of unselected emergency medical and surgical admissions to a combined assessment area (CAA).

Methods

We documented the observations made immediately on admission for all emergency referrals to the CAA during two separate 11-day periods in October and November 2003. Based on recent activity, these timeframes were selected in order to capture a minimum of 800 patient episodes. During the first period, data were obtained from existing conventional observation charts. The SEWS chart was the source of data for the second period, having been introduced following a standardised educational programme for nursing and medical staff. The education programme included the rationale behind the SEWS chart and emphasised the need to alert the appropriate medical professional if the patient triggered a score of 4 or more. Staff education was delivered in lecture format and through completion of a self-directed learning pack. There was no specific education on the management of the acutely ill patient, but staff were encouraged to refer to the guidelines on the reverse of the chart.

R Paterson MPhil, Practice Development Nurse

DC MacLeod PhD FRCP, Consultant, Departments of Acute Medicine and Cardiology[1]

D Thetford MRCP, Specialist Registrar

A Beattie MRCP, Senior House Officer

C Graham MSc, Statistician, Epidemiology and Statistics Core, Wellcome Trust Clinical Research Facility[1]

S Lam MCSP, Director of Allied Health Professions[2]

D Bell MD FRCP, Consultant, Department of Acute Medicine[3]

Department of Acute Medicine, Royal Infirmary of Edinburgh, Edinburgh

[1]Western General Hospital, Edinburgh

[2]NHS Education for Scotland (NES), Hanover Buildings, Edinburgh

[3]Imperial College, London

Clin Med 2006;**6**:281–4

Table 1. Standardised early warning scoring system (SEWS) parameters and scoring system.

Parameter	Score						
	3	2	1	0	1	2	3
Respiratory rate (breaths/min)	≥36	31–35	21–30	9–20			≤8
SaO_2 (%)	<85	85–89	90–92	≥93			
Temperature (°C)		≥39	38–38.9	36–37.9	35–35.9	34–34.9	≤33.9
Blood pressure (mmHg)		≥200		100–199	80–99	70–79	≤69
Heart rate (beats/min)	≥130	110–129	100–109	50–99	40–49	30–39	≤29
AVPU response				Alert	Verbal	Pain	None

Case example: patient presents in respiratory distress. Respiratory rate 32, SaO_2 90%, temperature 38.9, blood pressure 160/70, heart rate 105, AVPU verbal. SEWS score 6. Patient thus requires increased frequency of observations and urgent medical review. AVPU = alert/verbal/painful/unresponsive.

Outcome measures were completeness of documentation of physiological parameters, in-hospital mortality, and hospital length of stay. The effect of the introduction of the SEWS chart on the standard of documentation was analysed using a binomial test for comparison of proportions using a normal approximation. A chi-squared test for trend was used to determine if there was any relationship between SEWS score and in-hospital mortality. The relationship between SEWS score and length of stay was examined using a Kruskal–Wallis test. Following implementation, a 12-point quantitative and qualitative questionnaire employing a Likert scale expressing agreement or disagreement with the statements was circulated to medical and nursing staff. They were asked to comment on the applicability and ease of use of the SEWS chart, and on whether they felt the chart improved the management of acute admissions.

Results

Patient population

Data were collated for a total of 848 patients, 413 pre-SEWS and 435 post-SEWS. Age, gender, length of stay, and frequency of admission to critical care did not differ following introduction of the SEWS chart (Table 2). One patient in the SEWS cohort was excluded from further analysis as only demographic data were available.

Table 2. Demographics, length of stay, and rate of admission of patients to critical care.

	Pre-SEWS (n=413)	Post-SEWS (n=435)
Median age (interquartile range)	67 (44–80)	69 (43–79)
Number of males (%)	186 (45)	197 (45)
Median LOS (interquartile range)	2 (1–6)	2 (1–6)
Number of critical care admissions (%)	11 (2.6)	11 (2.5)

LOS = length of stay; SEWS = standardised early warning scoring system.

Documentation

Physiological parameters were more completely documented following the introduction of the SEWS chart, in particular the recording of respiratory rate and conscious level. All improvements except those in oxygen saturation were significant, and the chart led to an increase in the proportion of patients for whom all parameters were recorded (Table 3).

Mortality

In the SEWS chart cohort, there was a significant linear relationship between in-hospital mortality and admission SEWS score (chi 34.3, P<0.001, Fig 1). Mortality rose more than eight-fold for a score of ≥4 compared with 0–3 (difference in proportions 15.3%; 95% confidence interval 3.7–26.9; P<0.01). Introduction of the SEWS chart was accompanied by a reduction in overall in-hospital mortality (pre-SEWS 5.8% (24/413), post-SEWS 3.0% (13/434), P=0.046).

Length of stay

Median length of stay extended significantly in relation to increasing SEWS score (P=0.001, Table 4). A score of ≥4 as opposed to 0–3 equated with more than a doubling of length of stay.

Staff opinion

Of 69 staff (37 nurses, 26 doctors, five clinical support workers, one allied healthcare professional) returning the questionnaire,

Table 3. Documentation of physiological parameters before and after the introduction of the SEWS chart.

	Pre-SEWS (%)	Post-SEWS (%)	Difference in proportions pre- and post-SEWS (95% CI)	P
Respiratory rate	63 (15.3)	376 (86.6)	71.38 (66.66–76.10)	
SaO_2	384 (93.0)	416 (95.9)	2.87 (0.22–5.97)	<0.069
Temperature	365 (88.4)	416 (95.9)	7.47 (3.86–11.09)	<0.001
Blood pressure	403 (97.6)	433 (99.8)	2.19 (0.64–3.74)	0.005*
Heart rate	387 (93.7)	430 (99.1)	5.37 (2.86–7.88)	<0.001*
AVPU	66 (16.0)	402 (92.6)	76.65 (72.34–80.95)	<0.001
All parameters	29 (7.0)	328 (75.6)	68.55 (63.82–73.29)	<0.001

*Results from Fisher's exact test due to small samples.
AVPU = alert/verbal/painful/unresponsive; SEWS = standardised early warning scoring system.

80% agreed or strongly agreed that the SEWS chart was useful in signalling illness severity, and 60% that it prompted earlier intervention.

Discussion

A standardised early warning scoring system improved the documentation of a range of physiological parameters. This was strikingly evident for respiratory rate and conscious level, two important indicators of illness severity.[11] For respiratory rate, this was facilitated by the relevant section being placed at the top of the chart, and for conscious level by the use of a simple AVPU (alert/verbal/painful/ unresponsive) scale as described in toxicology admissions,[12] and promoted in current resuscitation training.[13]

We found that inpatient mortality paralleled the admission SEWS score. Furthermore, an admission score of ≥4, our preset threshold for urgent medical assessment, was associated with a one in six risk of in-hospital death. These findings appear consistent with a previous report in which physiological abnormalities recorded during a 24-hour period in a cohort of adult inpatients correlated with 30-day mortality.[11] However, another group assessing the impact of a MEWS scoring system did not identify a relationship between MEWS score and in-hospital death.[14]

Our study differs from the above studies in a number of respects. First, the scores for the SEWS cohort were recorded immediately on admission for all patients. Second, in contrast to MEWS, SEWS incorporates oxygen saturation, recently revalidated as an important independent predictor of mortality.[15] Third, the SEWS score demanding medical review was a point lower than in MEWS. Last, whereas the MEWS escalation policy called for medical assessment within 60 minutes, the SEWS limit was set at no longer than 30 minutes, thus encouraging more rapid intervention.

An unexpected finding was the favourable trend in overall mortality accompanying the implementation of the SEWS chart. The explanation for this is unclear, but, as described in relation to critical care outreach,[16] the intensive staff education programme may have been an important contributory factor. Less likely is altered case mix, as the sampling time periods were virtually contiguous.

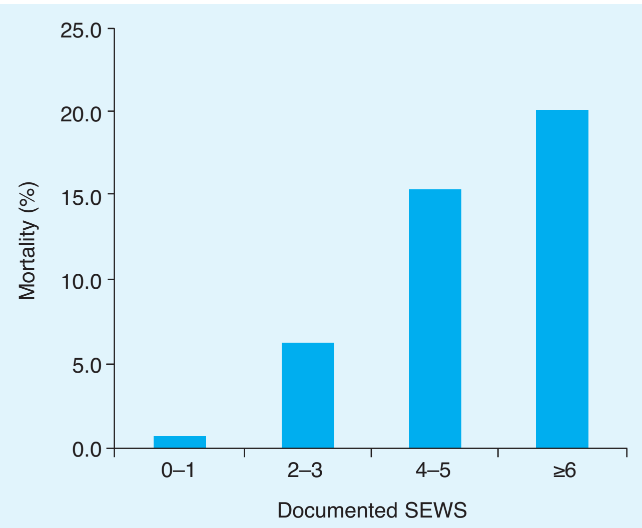

Fig 1. SEWS score and in-hospital mortality. SEWS = standardised early warning scoring system.

Table 4. SEWS score and LOS in days.*

Score	Median LOS (interquartile range)
0–1	2.0 (1.0–5.0)
2–3	2.0 (1.0–4.0)
4–5	5.0 (2.0–15.2)
≥6	7.0 (3.0–13.0)

*Significantly correlated (P=0.001, Kruskal-Wallis).
LOS = length of stay; SEWS = standardised early warning scoring system.

The admission SEWS score also correlated with length of stay, which more than doubled to five days and above for scores of ≥4. Conversely, a score of 0–3 predicted a 48-hour length of stay, and therefore should facilitate safe and effective advanced discharge planning from the time of admission.

Supported by the opinion of those responding to our survey, we propose that systems such as SEWS should be standard practice in the acute setting, representing a simple but effective means of alerting less experienced staff to illness severity and potential mortality. Further, we believe that the implementation of validated scoring systems aimed at the recognition of higher risk patients at point of entry to care may resolve some of the issues raised in the NCEPOD report.[5]

Key Points

Early warning scoring systems are valuable tools in assessing illness severity and prompting clinical decision making

Introduction of a standardised early warning scoring system improved the documentation of key physiological parameters

Incorporation of oxygen saturation improves the power of early warning scoring systems

A standardised early warning score recorded immediately on admission predicts in-hospital mortality and length of stay

Acknowledgements

The Illness Severity Scoring Subgroup (Emergency Medical Admissions Scoping Group: NHS Quality Improvement Scotland) comprises A Bramley, C Howie, M Jones, S Lam, D MacLeod, M Pollock, and D Thetford.

RP, DT, SL, and DB designed the study. RP and SL ran the introductory education sessions for the scoring system. RP, DT, and AB collected the data. CG was responsible for statistical analyses. RP, DCM, and DB wrote the manuscript, for which DB is the guarantor.

References

1 Buist MD, Burton PR, Bernard SA, Waxman BP, Anderson J. Recognising clinical instability in-hospital patients before cardiac arrest or unplanned admission to intensive care. *Med J Aust* 1999;171:22–5.
2 Goldhill DR, White SA, Sumner A. Physiological values and procedures in the 24 hours before ICU admission from the ward. *Anaesthesia* 1999;54:529–34.
3 Cooper N. Patient at risk! *Clin Med* 2001;1:309–11.
4 Hillman KM. Recognising and preventing serious in hospital events. *Med J Aust* 1999;171:8–9.
5 Cullinane M, Findlay G, Hargraves C, Lucas S. *An acute problem?* London: National Confidential Enquiry into Patient Outcome and Death, 2005. www.ncepod.org.uk/2005report
6 Royal College of Physicians. *The interface between acute general medicine and critical care.* Report of a working party. London: RCP, 2002.
7 Department of Health. *Comprehensive critical care – A review of adult critical care services.* London: DH, 2000.
8 Bowton DL, Scuderi PE, Haponik EF. The incidence and effect on outcome of hypoxemia in hospitalized medical patients. *Am J Med* 1994;97:38–46.
9 Subbe CP, Kruger M, Rutherford P, Gemmel L. Validation of a modified Early Warning Score in medical admissions. *QJM* 2001;94:521–6.
10 SEWS Chart. www.nhslothian.scot.nhs.uk/health_promotion/sewskey.pdf
11 Goldhill DR, McNarry AF. Physiological abnormalities in early warning scores are related to mortality in adult inpatients. *Br J Anaesth* 2004;92:882–4.
12 Kelly CA, Upex A, Bateman DN. Comparison of conscious level assessment in the poisoned patient using the alert/verbal/painful/unresponsive scale and the Glasgow Coma Scale. *Ann Emerg Med* 2004;44:108–13.
13 Resuscitation Council (UK). *Advanced life support manual*, 4th edn. London: Resuscitation Council (UK), 2004.
14 Subbe CP, Davies RG, Williams E, Rutherford P, Gemmell L. Effect of introducing the modified early warning score on clinical outcomes, cardiopulmonary arrests and intensive care utilisation in acute medical admissions. *Anaesthesia* 2003;58:775-803.
15 Buist M, Bernard S, Nguyen TV, Moore G, Anderson J. Association between clinically abnormal observations and in-hospital mortality: a prospective study. *Resuscitation* 2004;62:137–41.
16 Priestley G, Watson W, Rashidian A *et al.* Introducing critical care outreach: a ward-randomised control trial of phased introduction in a general hospital. *Intensive Care Med* 2004;30:1398–404.