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CRITICAL CARE

Introduction of an electronic physiological early warning system: effects on mortality and length of stay

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Editor's key points

- Early warning scores (EWSs) are used routinely to identify critically ill patients and allow early intervention.
- This study evaluated the use of an EWS with electronically captured data and automated alerting in an acute medical unit.
- Mortality and length of stay were reduced over the study period, but this was related to reduced severity of illness.
- The use of an electronic EWS with automated alerts had little effect on mortality in acutely ill medical patients.

Background. The Worthing physiological scoring system (PSS) was first validated in 2005 as a tool to predict hospital mortality on admission and was subsequently introduced into clinical practice at Worthing Hospital, UK. Five years on, this study was conducted to determine the effects on mortality and length of stay (LOS) after the introduction of electronic alerting software using the PSS. In addition, we investigated whether the Worthing PSS predictive ability could be improved by addition of further variables.

Methods. Prospective observational study conducted in the acute medical unit, Worthing Hospital, UK. Patient physiological data on admission and discharge/transfer were collected between February and July 2010 from the electronic alerting software VitalPAC™. Patient characteristics, co-morbidity, outcomes, and biochemistry data were taken from the hospital administration and pathology systems.

Results. The observed mortality reduction from 8.3% to 5.2% over 5 yr was not statistically significant after adjustment for admission Worthing PSS score. Median LOS was reduced from 4 to 2 days, but this reflected an increase in short stay admissions. Worthing PSS was not significantly improved with the addition of biochemical variables or patient co-morbidity. A score taken before admission to a medical ward showed an improved predictive ability when compared with the initial admission score, but further analysis found no additional clinical benefit.

Conclusions. The introduction of an electronic alerting PSS did not lead to a reduction in mortality when adjusted for severity of illness defined by physiological variables. Predictive performance was not enhanced by the addition of biochemical variables and co-morbidities.

Keywords: hospital mortality; length of stay; medicine; monitoring, physiological; patient admission

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After a recommendation by the Department of Health (DoH) in 2000, the use of physiological early warning scores (EWSs) is now common practice in acute NHS hospitals in order to aid identification of patients with potential or established critical illness so that management can be instigated from appropriately skilled staff in a timely manner.[1] This recommendation led to the development of several scoring systems which prompted a systematic review, commissioned by the National Institute for Health Research Service Delivery and Organisation in 2007, to evaluate their performance.[2] This concluded that there was a lack of evidence to identify any one best EWS model. Later that year, the Royal College of Physicians recommended that the physiological assessment of all patients should be standardized across the NHS and a working group be commissioned to develop an NHS Early Warning Score (NEWS).[3]

Locally, we had developed and validated the Worthing physiological scoring system (PSS) in 2005 based on data collected in a population-based, single-centre study.[4] This predictive model was validated as a tool to predict patient hospital mortality from admission physiology and its simplicity made it ideal for a paper-based EWS. In response to the study, the Worthing PSS was introduced into clinical practice in Worthing Hospital, Worthing, UK, in 2008 with a view to conducting a post-Worthing PSS implementation observational study. The assumption was that by alerting the nursing and medical staff *early* to patients with a predicted high mortality,

early intervention would be triggered and mortality reduced in those patients where reversible pathology was present.

In 2010 Worthing Hospital implemented the electronic clinical data software system VitalPAC™ into the Acute Medical Unit (AMU) for a 6-month period. This automatically calculated the Worthing PSS and displayed an alert based on a local protocol. During this period, we conducted the post-Worthing PSS implementation study to determine whether this resulted in a reduction in mortality and LOS for patients admitted to AMU. The expectation was that this mortality prediction tool would change over time if the intervention was successful (i.e. the proportion of survivors with higher AMU admission EWS would increase over time). The discrimination achieved when the Worthing PSS was first validated in 2005 was fair with an area under the receiver operating characteristic (ROC) curve of 0.74 (95% CI 0.71–0.77).[4] We, therefore, investigated whether the prediction tool could be improved through incorporating patient co-morbidity, biochemical data or both. Finally, for patients admitted to a hospital in-patient ward from the AMU, we investigated whether the Worthing PSS score recorded at AMU discharge improved the predictive ability of the tool. Patients discharged home from AMU were excluded from this analysis.

During the conduct of this study, Worthing Hospital merged with St Richard's Hospital to form the Western Sussex Hospitals NHS Trust. It was decided that both hospitals should adopt the NEWS. Therefore, *post hoc* analysis was performed on this study database to determine whether NEWS was an appropriate mortality prediction tool for the West Sussex population. Further *post hoc* analysis was also performed to determine whether severity of illness (as defined by the Worthing PSS) differed between weekday and weekend admissions in view of the recent much published reports showing an increased mortality for weekend emergency admissions (see Supplementary Fig. S1).[5 6]

Therefore, the aims of this study were to determine whether: (a) the Worthing PSS, calculated using VitalPAC™, resulted in a reduction in mortality and LOS; (b) mortality prediction could be improved with the addition of co-morbidity, biochemical data or both or with the Worthing PSS score recorded at AMU discharge; (c) the mortality prediction of the NEWS is comparable with that of the Worthing PSS; and (d) the severity of illness differed between weekday and weekend admissions.

Methods

This prospective observational study was conducted in the AMU of the Worthing site of the Western Sussex Hospitals Trust between 1 February 2010 and 31 July 2010, and was the continuation of work previously published.[4] The Western Sussex Hospitals Trust is an 870-bedded affiliated university hospital. The Worthing site is a 500-bedded district general hospital with 25–35 acute medical admissions every 24 h. Approval had previously been obtained from the NHS Research Ethics Committee (REC No. 05/Q1911/62), which included the post-implementation study. Processes in place for the initial work including displaying information posters explaining the research in AMU were continued throughout the study period.

Data collection

All patients admitted through the AMU had simple bedside physiological observations measured and entered into the clinical data software system VitalPAC™ by nursing staff. Data collection occurred for both weekday and weekend admissions enabling comparison. The Worthing PSS (Table 1) was automatically calculated from the physiology measurements by the VitalPAC™ software and an alert displayed.

The physiological variables recorded were:

- Systolic and diastolic blood pressure, heart rate, and oxygen saturation in air (measured with Vital Signs Monitor VS-800, Mindray Medical International Ltd or Dynascope DS-7100, Fukuda Denshi Co. Ltd)
- Whether supplemental oxygen was required
- Respiratory rate
- Temperature
- Level of consciousness (as per the AVPU score—alert, responsiveness to verbal command, pain or unresponsive)

Alerts displayed recommended intervention according to a set protocol. All therapeutic management was at the discretion of the attending doctor.

Physiological observations used to generate the Worthing PSS score on admission (Admission Worthing PSS score) and before discharge home, transfer into the hospital, or death in AMU (Final Worthing PSS score) were taken from VitalPAC™. Patient characteristic information was obtained through the hospital patient administration system (PAS) and patients were followed up to determine patient outcomes: mortality and length of stay (LOS). Patient admission biochemical data [serum creatinine, C-reactive protein (CRP) and bilirubin] were taken from the hospital pathology system. Twenty-eight co-morbidities, based on the Charlson Co-morbidity Index, were included in the analysis and were taken from the patients' coded diagnoses entered onto the PAS.

Data analysis

There were no exclusion criteria, but incomplete data sets were removed before statistical analysis. Data were entered onto an Excel© spreadsheet (Microsoft Corporation, Richmond, WA, USA) and the data were anonymized. Completeness of the data was independently verified. Anonymized data were

Table 1 Worthing PSS as published in 2007—observations measured with corresponding scores

	Score			
	0	1	2	3
Respiratory frequency	≤19	20–21	≥22	
Pulse	≤101	≥102		
Systolic blood pressure	≥100		≤99	
Temperature	≥35.3			<35.3
Oxygen saturation in air	96–100	94 to <96	92 to <94	<92
AVPU	Alert			Other