BMJ Open Quality

Implementation of early warning system in the clinical teaching unit to reduce unexpected deaths

Tara Swami,[1] Ali Shams,[1] Matthew Mittelstadt,[1] Catherine Guenther,[1] Tiffanie Tse,[1] Hifsa Noor,[1] Rabia Shahid[2]

¹University of Saskatchewan College of Medicine, Saskatoon, Saskatchewan, Canada
²Department of Medicine, University of Saskatchewan, Saskatoon, Saskatchewan, Canada

Correspondence to
Dr Rabia Shahid;
rks032@mail.usask.ca

ABSTRACT

Background Early detection of patients with clinical deterioration admitted to the hospital is critical. The early warning system (EWS) is developed to identify early clinical deterioration. Using individual patient's vital sign records, this bedside score can identify early clinical deterioration, triggering a communication algorithm between nurses and physicians, thereby facilitating early patient intervention. Although various models have been developed and implemented in emergency rooms and paediatric units, data remain sparse on the utility of the EWS in patients admitted to general internal medicine wards and the processes and challenges encountered during the implementation.

Local problem There is a lack of standardised tools to recognise early deterioration of patient condition.

Methods This was a quality improvement project piloted in the clinical teaching unit of a tertiary care hospital. Data were collected 24 weeks pre-EWS and 55 weeks post-EWS implementation. A series of Plan, Do, Study, Act cycles were conducted to identify the root cause, develop a driver diagram to understand the drivers of unexpected deaths, run a sham test trial run of the EWS, educate and obtained feedback of clinical care teams involved, assess adherence to the EWS during the pilot project (6 weeks pre-EWS and 6 weeks post-EWS implementation), evaluate outcomes by extending the duration to 24 weeks pre-EWS and 55 weeks post-EWS implementation, and retrospectively review the uptake of the EWS.

Interventions Implementation of a standardised protocol to detect deterioration in patient condition.

Results During the pre-EWS implementation phase (24 weeks), there were 4.4 events per week (1.2 septic workups, 1.9 observation unit transfers, 0.7 critical care transfers, 0.13 cardiac arrests and 0.46 per week unexpected deaths). In the post-EWS implementation phase (55 weeks), there were 4.2 events per week (1.0 septic workup, 1.9 observation unit transfers, 0.82 critical care transfers, 0.25 cardiac arrests and 0.25 unexpected deaths).

Conclusion The EWS can improve patient care; however, more engagement of stakeholders and electronic vital sign documentation may improve the uptake of the system.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Early warning system (EWS) is being used in many jurisdictions. However, there is still a lack of reports on the processes used in implementing the EWS and measuring patient-oriented outcomes.

WHAT THIS STUDY ADDS

⇒ This study discusses the implementation of EWS in the clinical teaching unit on the general internal medicine ward and discusses the process of implementation and challenges encountered.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Process of implementation and lessons learnt from this quality improvement project can be used to implement EWS.

in our hospital, and the nursing staff relied solely on their clinical judgement when to communicate with physicians. This could cause delay and gaps in the care of already very sick patients.

Available knowledge

Approximately 14%–28% of intensive care unit (ICU) transfers are unplanned.[1] Evidence supports that patients show signs of early deterioration before they become unstable.[2] The deterioration of a patient's medical status is often preceded by abnormal vital or physiological signs.[3] If these changes are detected early, unexpected deaths, serious adverse events or cardiac arrest can be prevented. Delays in ICU consultations for critically ill patients in medical wards have been associated with increased mortality.[4]

For the past two decades, the early warning system (EWS) communication tool has been employed in various medical institutions worldwide.[5][6] Using individual patient's records of vital signs, this bedside score can indicate early clinical deterioration, triggering a communication algorithm between nurses and physicians, thereby facilitating early patient intervention. The EWS was first

INTRODUCTION
Problem description

There was no standardised protocol for managing clinically deteriorating patients

introduced in 1997 in the UK and has since been implemented in multiple centres across the world.[7–10] It was initially designed to detect and respond to unrecognised deterioration and reduce inpatient mortality.[3] It significantly outperformed other early detection scores, such as the Systemic Inflammatory Response Syndrome and quick Sequential (sepsis-related) Organ Failure Assessment scores in predicting severe sepsis, septic shock, sepsis-related mortality and all-cause mortality. This suggests that the EWS may be a better prognostic tool.[11]

Previous studies have examined the impact of EWS in various settings.[12–15] De Meester *et al* assessed the EWS in patients recently discharged from ICU and found a significant reduction in serious adverse events following ICU discharge.[12] Moon *et al* retrospectively examined the EWS with a critical care outreach service and found a significant decline in cardiopulmonary arrest and in-hospital mortality.[13] Conversely, Patel *et al* in a retrospective study involving trauma patients, evaluated EWS with a critical care outreach service and did not find a significant reduction in mortality.[14] A systematic review of 17 observational studies with 11 unique models that were based on vital signs and clinical evaluation suggested that EWS is useful in predicting cardiac arrest and death, but its impact on health outcomes and utilisation of resources remains unknown.[15] Although the results of studies examining the impact of the EWS on all health outcomes and resource utilisations have been mixed, widespread use of this system suggests that there are potential benefits of using EWS.[15] The National Health Services has developed a national EWS in England and considers this a key component of patient safety for better patient outcomes.[16]

Although efforts have been done to validate the model, there is still a lack of reports on the processes used in the implementation of the EWS and measurement of patient-oriented outcome.[3]

Aim
Our aim was to reduce the number of unexpected deaths and cardiac arrests by 50% in 1 year after the implementation of the EWS tool in the clinical teaching unit (CTU).

Measures
Outcome: Our outcome measure was the number of unexpected deaths (patients not receiving end-of-life care) and transfers to the critical care unit.

Process: Our process measure included the number of transfers to observation units (the highest acuity unit outside the ICU).

Balancing measure: Our balancing measure was the initiation of septic workups (blood culture, urine culture, complete blood count analysis, venous/arterial blood gas and lactate analysis, and chest radiograph).

Participants
Participants were identified through ward audits by a nursing manager and were included in the analysis if they were transferred to a higher level of care (ICU or observation unit) or had in-hospital cardiac arrest or death.

Intervention: the EWS algorithm
The CTU EWS scores range from 0 to 20 and are derived from measurements of seven physiological parameters: blood pressure, temperature, heart rate, respiratory rate, oxygen saturation, oxygen delivery and level of consciousness. A higher score is more likely to indicate clinically deteriorating patients. Each EWS score corresponds to a colour (green, yellow, orange or red), which triggers a different escalation process according to the EWS algorithm, as described above. In our unit, vital signs are entered manually by the nursing staff. Vital sign sheet was replaced by EWS scoring sheet, so the nursing staff can enter vital signs directly into the EWS scoring sheet.

METHODS
Plan, do, study, act cycle 1: root cause analysis and driver diagram
This project was implemented as a resident physician initiative after a discussion of a clinical case in quality improvement (QI) rounds. In our QI rounds, clinical cases are discussed to improve the system and patient safety. A driver diagram was initially created to understand the drivers and reduce the occurrence of unexpected deaths and cardiac arrests, which revealed a deficiency in our current system (figure 1). There was no specific protocol for managing clinically deteriorating patients, and the nursing staff relied solely on their clinical judgement to manage patients with signs of clinical instability. This highlighted the value and feasibility of implementing the EWS in the CTU. Our improvement team consisted of resident physicians, unit manager, clinical nurse coordinator and a staff physician.

Plan, do, study, act cycle 2: sham test trial run of the EWS
The EWS tool was already developed in our health region; however, it was not implemented. Our EWS system comprises two parts: (1) a clinical status score (EWS score), calculated based on systolic blood pressure, temperature, heart rate, respiratory rate, oxygen saturation, oxygen delivery and level of consciousness and (2) a standardised algorithm, based on the EWS score, the nurses followed the algorithm to escalate patient care. The escalation process is divided into four zones according to the clinical score of a patient: green (0–2), yellow (3–4), orange (5–6) and red (≥7) (online supplemental appendix 1).

If a patient is in the green zone, the nurses reassess and rescore the patient in 12 hours; if a patient in the yellow zone, the nurses screen for sepsis, notify the in-charge nurse, and reassess in 4 hours. If a patient' score is in the yellow zone for two consecutive assessments, the nurses verify the scores with junior resident physicians on call. If the score is in the orange zone, the nurses screen for sepsis and notify the in-charge nurse and the junior resident physician for a management plan. If the patient
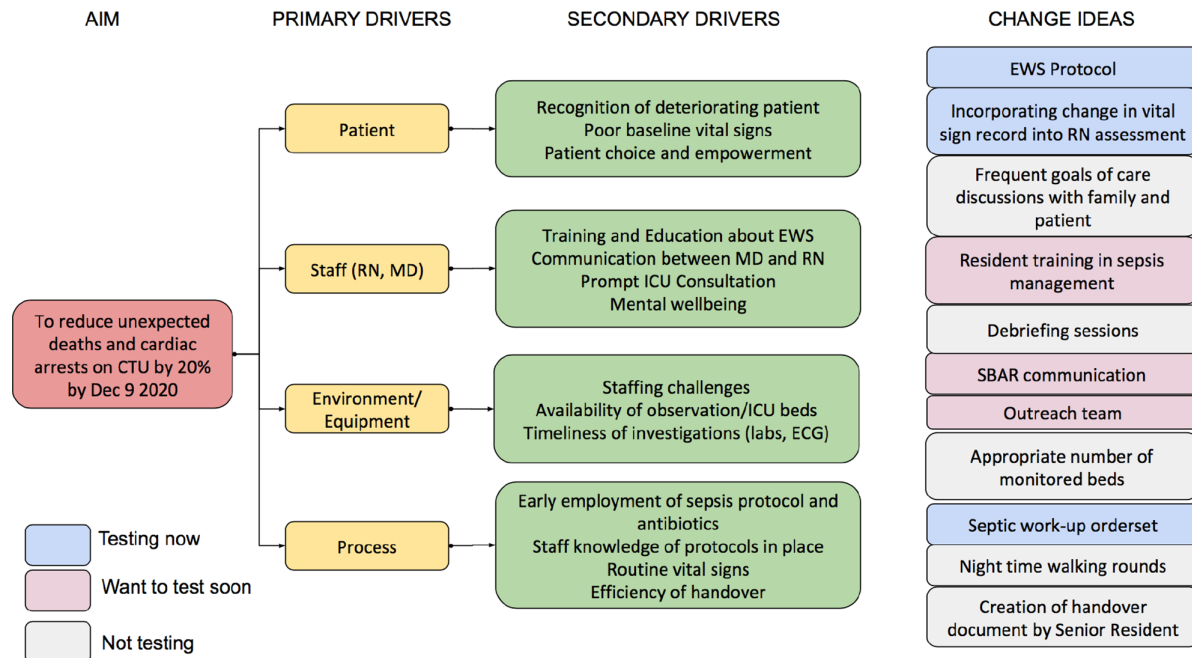
Figure 1 Driver diagram to reduce unexpected deaths.

is in the red zone, the nurses notify the senior resident physician on call for immediate assessment. The nurses used the standardised Situation-Background-Assessment-Recommendation communication sheets to communicate with the physicians.

We initially performed a sham trial of the EWS that was run for 2 weeks in the CTU by recording the number of times it was used to capture the event. We found 40 patients in the red zone, and according to the initial version of EWS protocol, the most responsible physicians (MRPs) were contacted 40 times. Our current CTU model operates such that the MRPs are not present in-house during overnight hours, and as such, there is a chance of delayed patient care in these instances. After the initial trial run and feedback from physicians and nursing staff, a change was made to inform the senior resident when the patient was in the red zone, as the senior resident remains in the hospital overnight and would facilitate more timely patient assessment. Further, the meaning of 'altered mental status' from baseline lacked clarity. Therefore, 'altered mental status' was changed to 'new onset of confusion' in the EWS scoring system.

Plan, do, study, act cycle 3: education and feedback
Education was provided to nursing staff during their education rounds. We also discussed the implementation of the EWS in various departments of medicine rounds to educate physicians working at the CTU.

Plan, do, study, act cycle 4: pilot project
The EWS intervention was launched in the CTU ward on 9 December 2019, and data were collected at 6 weeks pre-EWS and post-EWS implementation.

Pre-EWS implementation: Fifteen patients experienced an outcome with 28 events, compared with 24 patients,

corresponding to 41 events post-EWS implementation. The following events were observed: a decreased number of unexpected deaths 6 weeks post-EWS implementation (6 pre-EWS implementation and 2 post-EWS implementation), an increased number of code blues called (1 pre-EWS implementation and 4 post-EWS implementation), an increased number of transfers to critical care (2 pre-EWS implementation and 8 post-EWS implementation), and more septic workups ordered (5 pre-EWS implementation and 10 post-EWS implementation), while there was no change in the number of transfers to the observation unit (15 pre-EWS implementation and 15 post-EWS implementation). The notable increase in septic workups performed following the intervention could indicate the effect of the EWS in early detection of clinical deterioration.

Plan, do, study, act cycle 5: adherence of the EWS during the pilot project
Adherence to the EWS was also assessed during the pilot project. Six weeks post-EWS implementation, the EWS was adhered to at the rate of 41.4%. For patients with high EWS scores, compliance increased to 60.0%, whereas compliance was 46.2% for patients with low scores. The odds of a patient having a high score and nurses complying with the EWS algorithm were 1.75 (95% CI 0.08 to 3.42).

Plan, do, study, act cycle 6: 24 weeks pre-EWS implementation and 55 weeks post-EWS implementation
To understand the true effect of the EWS, we extended the project to evaluate the baseline status at 24 weeks pre-EWS implementation and 55 weeks post-EWS implementation. Results from this phase are discussed in the results section below.

Plan, do, study, act cycle 7: retrospective review of the uptake of the EWS

A retrospective chart review was conducted between February and June 2020 to examine the uptake of the EWS after the pilot project. Convenience sampling was performed by including patients admitted in the first week of each month. The following questions were used: (1) were all vitals correctly assigned in the patient's chart?; (2) were any vitals missing from the patient's EWS score assessment?; (3) were all EWS scores calculated on the EWS chart? and (4) were there any errors in the final calculated EWS scores in the EWS chart?

In total, 172 patients were included in this review. Of the 172 patients, only 26 (15.11%) had all the vital signs assigned correctly on the score sheet, 139 (86%) patients had missing vital signs and 33 (14%) had complete vital signs, and of those who had their EWS scores calculated, only 38 (32%) had calculated correctly scores.

RESULTS

The QI macro for Excel 2017 was used to create charts. Baseline data were collected in real time for 6 weeks before the implementation of EWS for the pilot project (as mentioned in plan, do, study, act (PDSA) cycle 4); subsequently, additional 18 weeks of data were collected retrospectively to cover baseline data for the total of 24 weeks. During the pre-EWS implementation phase (24 weeks), 42 patients experienced the desired outcome. There were 106 events (29 septic workups, 46 transfers to observation units, 17 transfers to critical care units, 3 cardiac arrests and 11 unexpected deaths). There were 4.4 events per week (1.2 septic workups, 1.9 observation unit transfers, 0.7 critical care transfers, 0.13 cardiac arrests and 0.46 unexpected deaths).

In the post-EWS implementation phase (55 weeks), there were 233 events (56 septic workups, 104 transfers to observation units, 45 transfers to critical care units, 14 cardiac arrests and 14 unexpected deaths) (figure 2). Overall, there were 4.2 events per week (1.0 septic workup, 1.9 observation unit transfers, 0.82 critical care transfers, 0.25 cardiac arrests and 0.25 unexpected deaths).

DISCUSSION

Our EWS was designed with the intent to reduce unexpected deaths and cardiac arrests 1 year after its integration into the CTU. Although we did not achieve our aim, we observed an absolute reduction in the number of unexpected deaths. Nevertheless, our current QI assessment did not reveal meaningful reductions in code blue calls or unexpected deaths post-EWS implementation. Our study is limited by the small number of events and the effect of the COVID-19 pandemic. The number of septic workups was our balancing measure, as there was a concern that by implementing the EWS, the number of septic workups might increase. Although we did see an increase in septic workups in our pilot phase, we did not observe this after 1 year.

We consider that the implementation of the EWS before the COVID-19 pandemic might have affected its uptake, which may have resulted in suboptimal adherence.

Future PDSA cycles will be aimed at re-educating the nursing staff and expanding our patient selection to include other CTUs.
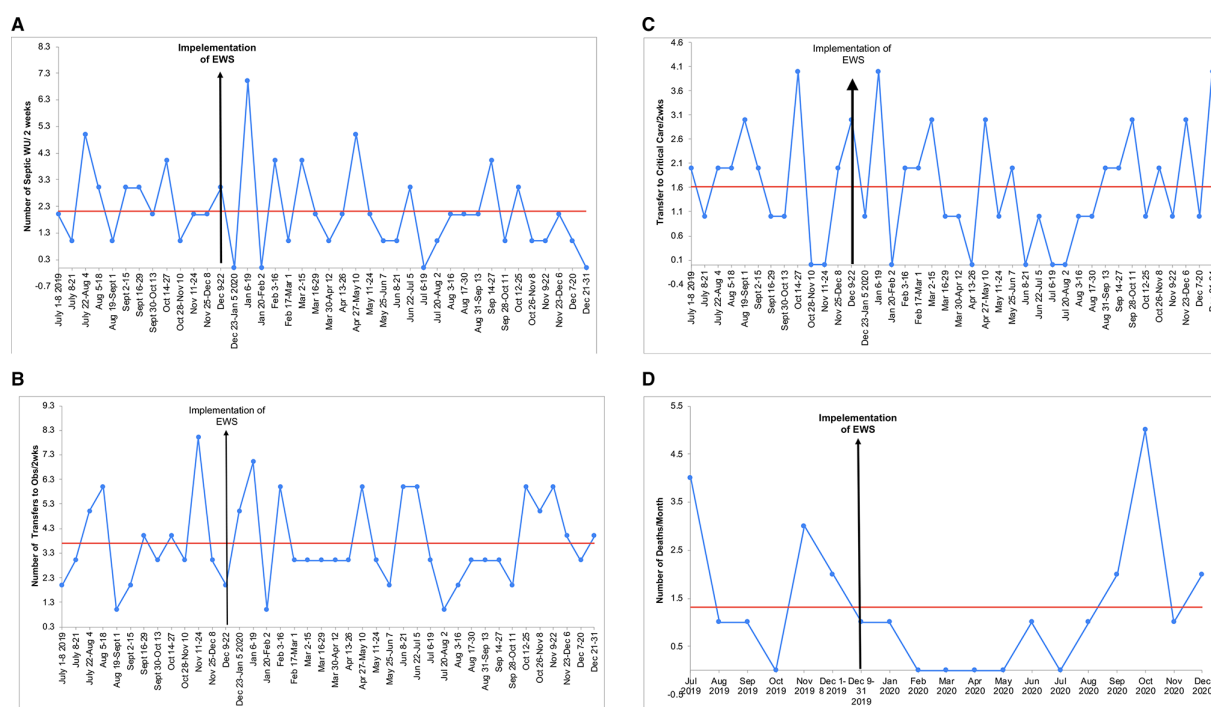
Figure 2 Control charts before and after implementation of early warning system. (A) Number of septic workup. (B) Number of transfers to observation unit. (C) Number of critical care transfers. (D) Number of deaths.

The educational outcomes of the PDSA cycle were not assessed but would have been useful.

Another limitation might be that the calculation of EWS was performed manually; therefore, heavy workload and change in protocols during COVID-19 might have impacted the implementation. It was not scope of this project to see if this version of EWS accurately detects patient's early deterioration, however, would be important to evaluate in the future. Lastly, we did not record the total number of admissions to the unit during the implementation phase of the project to calculate the proportion of the events. However, our unit has a fixed number of beds, and there was no change in the number of beds in the unit before and after the implementation of EWS. Furthermore, beds are always occupied in the CTU. Hence, we anticipate that there was no major difference in the number of patients before and after implementation.

Accurate assessment and documentation of vital signs are keys for the effective use of the EWS; perhaps, electronic vital signs charting and automatic calculation could overcome this barrier in the future.

CONCLUSION

Implementing a protocol is more complex than developing a protocol. Having evidence and designing a tool do not mean that it can be used in clinical practice effectively. Furthermore, even if it is used, it does not mean that it is being used accurately. Hence, continuous PDSA cycles are important for evaluating whether the tool in place is used and is used correctly and consistently. We learnt some very important lessons through our PDSA cycles. First, this QI effort was limited by the COVID-19 pandemic a few weeks after the implementation. We initially had the engagement of stakeholders, but during the pandemic, shifts in the roles of staff from one area to another effected our implementation. It is very well possible that the number and acuity of the patients were different in the pre-EWS and post-EWS implementation phase, as we observed that the number of patients was less, early in the pandemic. In our next steps to roll the system to other units, we would need not only the continuous engagement of stakeholders and education, but also some assessment of education.

The EWS protocol provides an objective and simple screening method for clinically deteriorating patients. The EWS may detect deterioration earlier and reduce the number of unexpected deaths. Future directions should also elucidate whether a change in the EWS score can predict poor clinical outcomes. More resources to implement electronic vital sign charting and automatic calculation of the EWS score might improve the uptake of the EWS.

REFERENCES

1. Bapoje SR, Gaudiani JL, Narayanan V, *et al*. Unplanned transfers to a medical intensive care unit: causes and relationship to preventable errors in care. *J Hosp Med* 2011;6:68–72.
2. Hillman KM, Bristow PJ, Chey T, *et al*. Duration of life-threatening antecedents prior to intensive care admission intensive care MED. *Intensive Care Med* 2002;28:1629–34.
3. Gerry S, Birks J, Bonnici T, *et al*. Early warning scores for detecting deterioration in adult hospital patients: a systematic review protocol. *BMJ Open* 2017;7:e019268.
4. Blotsky A, Mardini L, Jayaraman D. Impact of a local low-cost ward-based response system in a Canadian tertiary care hospital. *Crit Care Res Pract* 2016;2016:1518760.
5. Morgan RJM, Williams F, Wright M. An early warning scoring system for detecting developing critical illness. *Clin Intensive Care* 1997;8:100.
6. McGaughey J, O'Halloran P, Porter S, *et al*. Early warning systems and rapid response to the deteriorating patient in hospital: a systematic realist review. *J Adv Nurs* 2017;73:2877–91.
7. Prince Charles Hospital. *Modified Early Warning Score (MEWS), Escalation and ISBAR, The Prince Charles Hospital Procedure TPCHS10085*.
8. Deteriorating patient programme and national early warning system (NEWS) [HSE.ie]. n.d. Available: https://www.hse.ie/eng/about/who/cspd/ncps/acute-medicine/national-early-warning-score/
9. Churpek MM, Yuen TC, Park SY, *et al*. Derivation of a cardiac arrest prediction model using ward vital signs*. *Crit Care Med* 2012;40:2102–8.
10. Douw G, Huisman-de Waal G, van Zanten ARH, *et al*. Nurses 'worry' as Predictor of deteriorating surgical ward patients: a prospective cohort study of the Dutch-early-nurse-worry-indicator-score. *Int J Nurs Stud* 2016;59:134–40.
11. Usman OA, Usman AA, Ward MA. Comparison of SIRS, qSOFA, and NEWS for the early identification of sepsis in the emergency department. *Am J Emerg Med* 2019;37:1490–7.
12. De Meester K, Das T, Hellemans K, *et al*. Impact of a standardized nurse observation protocol including MEWS after intensive care unit discharge. *Resuscitation* 2013;84:184–8.

13 Moon A, Cosgrove JF, Lea D, *et al*. An eight year audit before and after the introduction of modified early warning score (MEWS) charts, of patients admitted to a tertiary referral intensive care unit after CPR. *Resuscitation* 2011;82:150–4.

14 Patel MS, Jones MA, Jiggins M, *et al*. Does the use of a track and trigger warning system reduce mortality in trauma patients *Injury* 2011;42:1455–9.

15 Smith MEB, Chiovaro JC, O'Neil M, *et al*. Early warning system scores: a systematic review. Washington (DC) Department of Veterans Affairs (US); 2014.

16 National Health Service (NHS). National early warning score (NEWS). Available: https://www.england.nhs.uk/ourwork/clinical-policy/sepsis/nationalearlywarningscore/ [Accessed 10 Mar 2023].