รายงานวิจัย

Research Article

การประยุกต์แบบวินิจฉัย Search Out Severity (SOS) Score ในการบ่งชี้ผู้ป่วยที่มีอาการทรุดลงในตึกผู้ป่วยสามัญ

Application of Search Out Severity (SOS) Score for Identification of Deteriorating Patients in General Wards

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บทคัดย่อ

การเกิดเหตุการณ์ไม่พึงประสงค์ในโรงพยาบาลส่วนใหญ่มักมีสัญญาณเตือน ที่เป็นการเปลี่ยนแปลงทางสรีรวิทยาและลักษณะทางคลินิกที่ทรุดลงนำมาก่อนระยะหนึ่ง ได้มีการใช้ Modified early warning score (MEWS) เป็นเครื่องมือช่วยเหลือในการค้นหาสัญญาณเตือน แม้ว่ามีหลักฐานจำกัดที่แสดงให้เห็นถึงความไว ความจำเพาะและประโยชน์ของ MEWS ก็ตาม คะแนน Search out severity (SOS) เป็นเครื่องมือที่ปรับจาก MEWS และถูกนำมาใช้ในจังหวัดพิษณุโลก ประเทศไทย การศึกษานี้มีวัตถุประสงค์เพื่อประเมินความสามารถในการทำนายของคะแนน SOS ที่ 4, 8, 12, 24 ชั่วโมงก่อนที่เหตุการณ์ไม่พึงประสงค์จะเกิดขึ้น ศึกษาแบบมีกลุ่มควบคุมซ้อนใน (nested case-control) ของผู้ป่วยผู้ใหญ่ที่มีเหตุการณ์ไม่พึงประสงค์ในหอผู้ป่วยทั่วไป และเสียชีวิตในเดือนมิถุนายนถึงเดือนกรกฎาคม พ.ศ. 2558 โดยจับคู่ 1: 2 กับผู้ป่วยกลุ่มควบคุมที่อยู่ในหอผู้ป่วยเดียวกัน วันและเวลาเดียวกัน และรอดชีวิตหลังจากที่จำหน่ายจากโรงพยาบาล ข้อมูลทั้งหมดได้จากฐานข้อมูลและการตรวจค้นเวชระเบียนย้อนหลัง การประเมินประสิทธิภาพในการจำแนกของคะแนน SOS ในแต่ละช่วงเวลา ใช้ลักษณะการวิเคราะห์ ROC ร่วมกับพื้นที่ที่สอดคล้องกันใต้เส้นโค้ง (AUC) ของคะแนน SOS ที่ 4, 8, 12, 24 ชั่วโมงก่อนเกิดเหตุการณ์ไม่พึงประสงค์และมีการวิเคราะห์ค่าความไวและความจำเพาะของคะแนน SOS ในแต่ละช่วง จากข้อมูลผู้ป่วยผู้ใหญ่ทั้งหมด 5,666 ราย คัดเลือกผู้ป่วยเสียชีวิต 41 รายให้เป็นกลุ่มตัวอย่าง และจับคู่กับผู้ป่วย 82 รายที่รอดชีวิตให้เป็นกลุ่มควบคุม พบว่า ภาวะหายใจล้มเหลวเฉียบพลัน (68.3%) เป็นเหตุการณ์ไม่พึงประสงค์ที่พบบ่อยที่สุด มีผู้ป่วยอายุรกรรมถูกคัดเข้าร่วมการศึกษามากกว่าผู้ป่วยศัลยกรรม (85.4% เทียบกับ 14.6%) คะแนน SOS ณ ที่ 4 ชั่วโมงก่อนเกิดเหตุการณ์ไม่พึงประสงค์เป็นค่าที่ดีที่สุดสำหรับทำนายเหตุการณ์ไม่พึงประสงค์ โดยมีค่าของ AUC เท่ากับ 0.972 (95% CI, 0.949-0.995) อย่างไรก็ตาม คะแนน SOS ณ ที่ 8, 12, 24 ชั่วโมงก่อนเกิดเหตุการณ์ไม่พึงประสงค์ก็ยังคงเป็นค่าที่ดีสำหรับทำนายเหตุการณ์ไม่พึงประสงค์ (AUC 0.906, 0.915, 0.860 ตามลำดับ) ค่า SOS คะแนน

≥ 4 ที่ 4 ชั่วโมงก่อนที่เหตุการณ์ไม่พึงประสงค์ คือ ค่าที่ดีที่สุด ที่ใช้สำหรับทำนายเหตุการณ์ไม่พึงประสงค์ โดยมีความไว 82.9%, ความจำเพาะ 95.1% และประสิทธิผลการวินิจฉัย 91.1% สำหรับ ค่า SOS คะแนน ≥ 4 ณ ที่ 8, 12, 24 ชั่วโมงก่อนเกิดเหตุการณ์ไม่พึงประสงค์ยังคงมีค่าการทำนายที่ดีสำหรับเหตุการณ์ไม่พึงประสงค์โดยมีความจำเพาะ 95.1%, 96.3%, 92.7% ตามลำดับ อย่างไรก็ตามพบว่าความไวลดลงเมื่อเวลาก่อนที่เหตุการณ์ไม่พึงประสงค์เพิ่มขึ้น ในกรณีที่ใช้คะแนน SOS ≥ 4 เพื่อเป็นค่าที่ใช้ทำนาย โดยสรุปพบว่า คะแนน SOS ณ ที่ 4, 8, 12, 24 ชั่วโมงก่อนเกิดเหตุการณ์ไม่พึงประสงค์ มีความสามารถในการคาดการณ์ที่ดีสำหรับผู้ป่วยที่มีเหตุการณ์ไม่พึงประสงค์ในหอผู้ป่วยทั่วไป SOS คะแนน ≥ 4 เป็นค่าที่เหมาะสมสำหรับในการใช้ค่านี้เป็นจุดตัดของเกณฑ์ที่จะเริ่มต้นการดำเนินการแก้ไขเหตุการณ์ไม่พึงประสงค์ SOS คะแนน ≥ 4 มีความสามารถในการคาดการณ์เหตุการณ์ไม่พึงประสงค์ที่ดี ไม่ว่าจะเป็นที่ ณ เวลาใดใน 24 ชั่วโมงก่อนเกิดเหตุการณ์ไม่พึงประสงค์

คำสำคัญ: เหตุการณ์ไม่พึงประสงค์ SOS score ค่าการทำนาย ตึกผู้ป่วยสามัญ
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Abstract

Most in-hospital adverse events do not happen without warning but are preceded by some period of physiological instability and clinical deterioration. Modified early warning score (MEWS) has been introduced despite limited high quality evidence to demonstrate their sensitivity, specificity and usefulness. Search out severity (SOS) score is a MEWS that is used in Phitsanulok, Thailand. This study assessed the predictive ability of SOS score at 4, 8, 12, 24 hours before adverse events (T_0). We conducted a nested case-control study of adult patients who had adverse events in a general ward and died during June to July 2015, matched 1:2 with control patients who stayed in the same ward, same date and time and survived after discharge. Data were obtained from administrative databases and retrospective chart review. Discrimination of the SOS score at each time was assessed within receiver characteristic (ROC) analyses for admission SOS score and SOS score at 4, 8, 12, 24 hours before adverse events and corresponding area under the curve (AUC). The sensitivities and specificities of different cut-off thresholds were investigated. 41 patients who died were selected to be the case group and 82 patients who survived were selected to be the control group. Acute respiratory failure (68.3%) was the most common adverse event. More medical patients were enrolled in study than surgical patients (85.4% and 14.6%). The SOS score at 4 hours before adverse events was the best predictor for adverse events with an AUC of 0.972 (95% CI, 0.949-0.995). However, the SOS score at 8, 12, 24 hours before adverse events were still good predictors for adverse events (AUC 0.906, 0.915, 0.860 respectively). The SOS score $\geq$ 4 at 4 hours before adverse events was the best cut-off value for adverse events with a sensitivity 82.9%, a specificity 95.1% and a diagnostic effectiveness 91.1%. The SOS score $\geq$ 4 at 8, 12, 24 hours before adverse events were still good cut-off values for adverse events with a specificity 95.1%, 96.3%, 92.7%, respectively. However, sensitivity fell when the time before adverse events was increased if the SOS score $\geq$ 4 to be the cut-off value was used.In conclusion,the SOS score at 4, 8, 12, 24 hours before adverse events is a good predictive ability for patients who had adverse events in a general ward. The SOS score $\geq$ 4 is reasonable for using this value to be cut-off point of trigger threshold to initiate action for worsening adverse events. The SOS score $\geq$ 4 has a good predictive ability regardless of the time intervals leading up to 24 hours before adverse events.

Keywords: adverse event, SOS score, prognostic, general ward

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Introduction

Failure to identify changes in deteriorating patients and act upon them can result in an increased severity of illness and then worsening morbidity and mortality. Critical physiological changes have been described in 51–86% of patients who suffered a subsequent cardiopulmonary arrest in the general wards, often several hours before the arrest. The previous data suggests that most in-hospital cardiopulmonary arrests do not happen without warning. Most are preceded by some period of physiological instability and clinical deterioration, which are either not recognized or inadequately treated.[1-4]

The early warning score (EWS) was developed as a track and trigger tool for the prompt identification of seriously ill patients. The scoring system was developed because not all unwell patients can be monitored in intensive care or high dependency units. It allows deteriorating patients to be identified, before physiological deterioration has become too profound.[5-10] Early warning scores are sometimes also referred to as Patient at Risk scores (PARS) or Modified Early Warning Scores (MEWS). The Modified Early Warning Score (MEWS) has been widely adopted throughout the world.In July 2007, the National Institute for Clinical Excellence (NICE) definitive guidance on “Acutely ill patients in hospital” recommended as a priority that physiological track and trigger systems should be used to monitor all patients in acute hospital settings.[11] In July 2012, The Royal College of Physicians in the UK launched National Early Warning Score (NEWS) for standardizing the assessment of acute illness severity in the NHS.[12] In Thailand, a modified early warning scoring system was developed from a number of sources, including a previously validated scoring system and other local examples.[13,14] Values of each parameter (assigns from zero to three points) was modified to reflect our patients’ higher acuity and to avoid excessive false-positive triggers. The final scoring system was modified and launched with new nomenclature, “SOS (search out severity) score” [15] Changing the nomenclature of EWS was anticipated to facilitate the recognition of physiological deterioration.

Predictive abilities of MEWS for worse outcomes and adverse events vary between different studies,and little is known regarding common practices concerning the measurement of vital signs on nursing wards.[16-22] The place, the time of the sampling point for physiological variables to calculate the score and the predictive value of EWS scores for patient outcomes are the important factors that make predictive abilities vary between different studies.[23] This study investigated the predictive abilities of SOS score before the adverse events to identify hospitalized patients at risk and focus on predictive abilities of SOS score for adverse events of patients in general hospital wards. This study had focus on the most in-hospital adverse events that did not happen without warning, but were preceded by some period of physiological instability and clinical deterioration. The more challenging questions in this study were “what is the proper cut-off value” and “what is the best time to use SOS score for the patients in general hospital wards, before adverse events occur?”

Material and Methods

A retrospective study by reviewed medical chart was used for this study. Patients admitted in general ward during June-July 2015 were enrolled. We excluded all patients who had one of the following criteria (1) patients who had a length of stay in general ward less than 48 hours (2) patients with incomplete epidemiological or discharge data

(3) patients who had one of the following adverse events (cardiopulmonary arrest, acute respiratory failure, shock) before admission or in the first 24 hours after admission (4) patient who had sudden deterioration (from seconds to minutes) before adverse events (5) patient who had been documented as a palliative care patient and (6) patient who had adverse events outside general ward (adverse events occurred in ICU, OR, CCU and other special units). Group of patients that had adverse events (case) were all admitted patients who died (status post discharge was summarized as dead) and endured one of the following adverse events (cardiopulmonary arrest, acute respiratory failure, shock) in general ward. Group of patients that didn't have adverse events (control) were all admitted patients who survived after discharge (status post discharge was summarized as improved or transferred) and matched with each case that had adverse events by matching criteria. The first priority of the matching criteria, in selecting control patients for each case is the patient was using the same ward, the same date and the same time of each case patient's adverse events. After that, 2 control patients of each case patient's adverse events were selected, and matched further by using the nearest age of each case patient (case-control ratio was one to two). Sample size determination for diagnostic accuracy studies involving bi-normal receiver operating characteristic (ROC) curve indices was used for calculating sample size.[24, 25] The sample size estimation was based on area under the ROC curves (AUC) of at least 0.8. We estimated predictive ability of SOS score by AUC at least 0.8 from the previous study.[10] We used Power (1- Beta) = 0.9 and Alpha (significant level) = 0.05. Our study matched 1:2, case:control subjects. After being calculated, the sample size in the case group should be 20 cases, and 40 controls. Baseline characteristics of cases were reported as means with standard deviations, or medians and interquartile ranges (if the assumption of normal distribution was violated) for continuous variables. Categorical variables were reported as numbers and percentages. Baseline data of case and control patients was shown to compare as means with standard deviations or medians and interquartile ranges (if the assumption of normal distribution was violated) for continuous variables. Discrimination of the SOS score at each time was assessed within receiver characteristic (ROC) analyses for admission SOS score and SOS score at 24 hours, 12 hours, 8 hours, 4 hours before adverse events (T_0) and corresponding area under the curve (AUC). The sensitivities and specificities of different cutoff thresholds were investigated for predictors with an AUC of at least 0.6. CIs for the AUC, sensitivity, and specificity of SOS score were calculated using bootstrapping, a nonparametric method that involved taking 1,000 samples of the data with replacement to obtain an empirical sampling distribution. Statistical analyses were completed using SPSS version 15. This study used the STARD checklist for reporting on diagnostic accuracy. This research protocol submitted for approval by the Ethics Committee of Buddhachinaraj Phitsanulok Hospital.

Results

All 5,666 adult patients were admitted in general wards in June-July 2015. After excluding 2,461 patients who had a length of stay less than 2 days, and 77 patients whose status post discharge was summarized to be other than dead, improved and transferred, all 213 patients who died were assigned to be selected for cases that had adverse events and all 2,915 patients who survived were assigned to be selected for match control with each case that had adverse events. Among all

patients who died, 172 were excluded by exclusion criteria, and then 41 patients were selected to be in the case group. Of all 2,915 patients who survived, 82 were selected to be the control group by using matching criteria (figure 1). General characteristics of the cases and controls were shown in table 1. Acute respiratory failure (68.3%) was the most common adverse events in the case group. Seventy eight percent of cases died from septic shock. Both groups of patients have low SOS scores at admission, because this study had already excluded patients who had adverse events before admission or in the 24 hours after admission. Gender of controls did not match exactly with cases because the neurosurgical ward in our hospital did not use separate ward for males and females (table 2). Figure 2 shows box plots that compared SOS score at 4, 8, 12, 24 hours before adverse events of the case and control group.

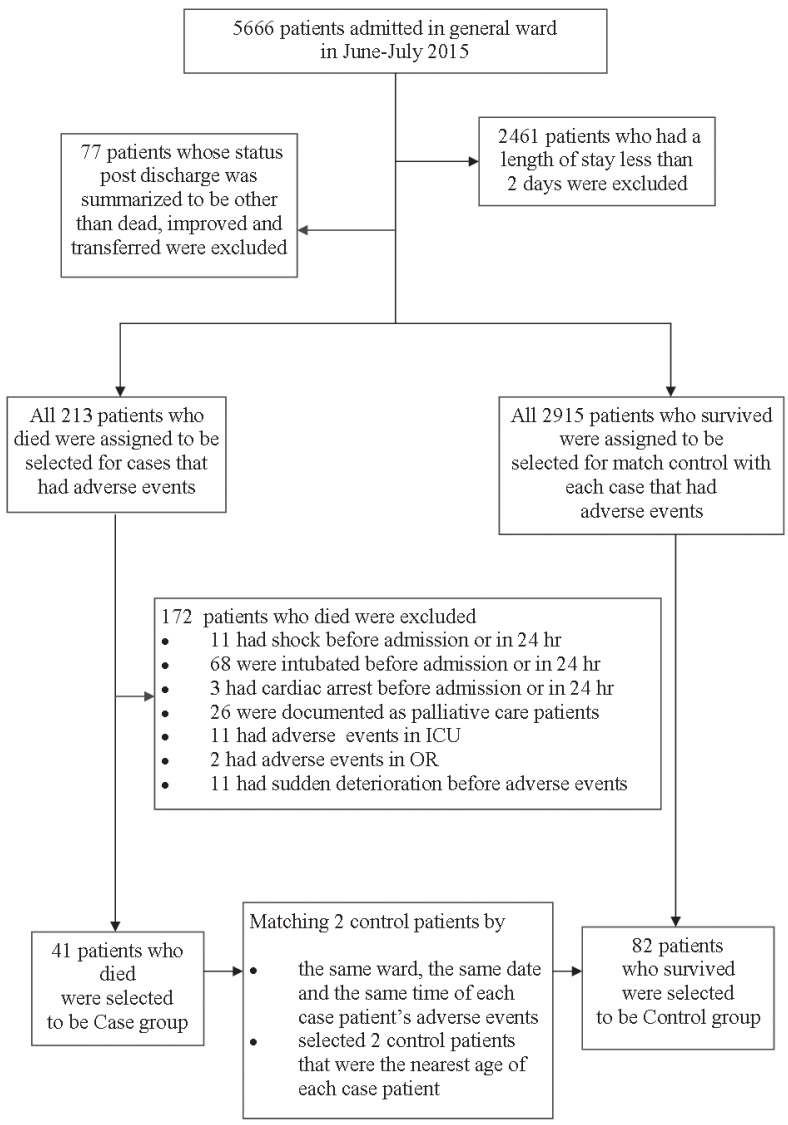

Figure 1 Diagram to report flow of participants through the study

Table 1 General characteristics of the patients who had adverse events (case group)

Characteristic	Value (n =41)
Type of adverse events-no.(%)	
Acute respiratory failure	28 (68.3%)
Cardiac arrest	5 (12.2%)
Septic shock	5 (12.2%)
Other shock	3 (7.3%)
SOS score value, median (IQR)	
4 hours before adverse events	6 (4-7)
8 hours before adverse events	5 (4-6.5)
12 hours before adverse events	5 (3-6.5)
24 hours before adverse events	5 (3-6)
Shift time of adverse event-no.(%)	
Morning (8.30-16.30)	15 (36.6%)
Evening (16.30-0.30)	13 (31.7%)
Night (0.30-8.30)	13 (31.7%)
Died from septic shock-no.(%)	32 (78%)
Length of stay, median (IQR)	7 (3-19)

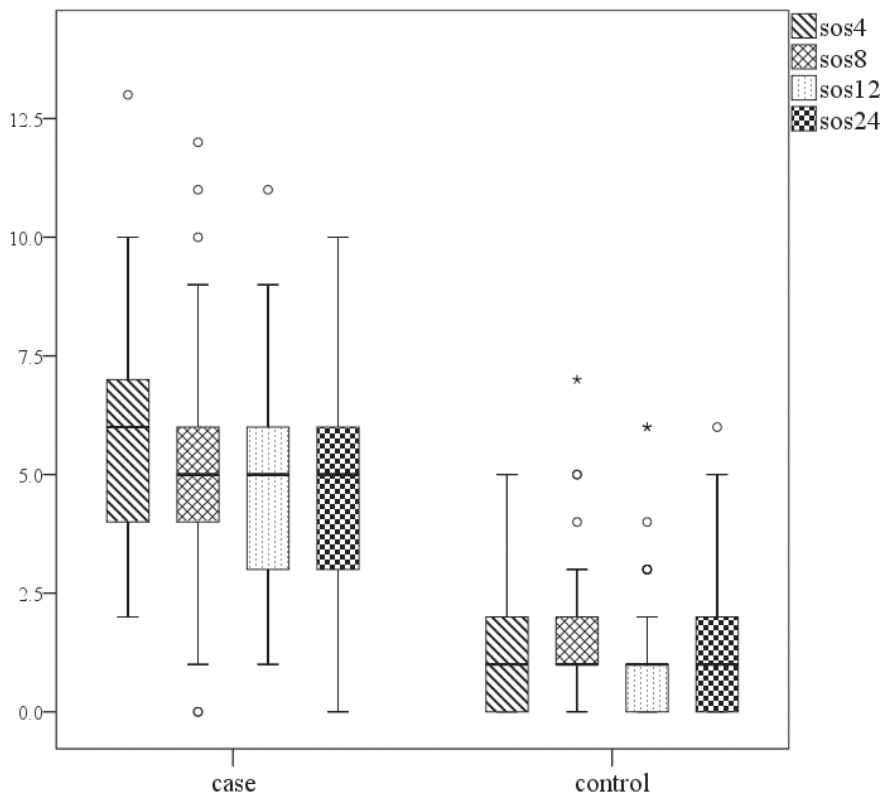

Figure 2 Box plots of SOS score at 4, 8, 12, 24 hours before adverse events of cases and controls

Table 2 Baseline characteristics of 2 groups of patients (cases and controls)

Characteristic	Cases (n = 41)	Controls (n = 82)
Age-yr (mean ± SD)	65 ± 16.9	58 ± 15.8
Male sex-no.(%)	19 (46.3%)	37 (45.1%)
Type of patient		
Medical condition-no.(%)	35 (85.4%)	70 (85.4%)
Surgical condition-no.(%)	6 (14.6%)	12 (14.6%)
SOS score admission, median (IQR)	2 (1-3)	1 (0-2)

Comparison of SOS score discrimination at different time

Area under the curve (AUC) was used to evaluate discriminatory power for time interval before adverse events. An SOS score at 4 hours before adverse events was the best predictor for adverse events with an AUC of 0.972 (95% CI, 0.949-0.995). However, SOS scores at 8, 12, 24 hours before adverse events were still good predictor for adverse events (AUC 0.906, 0.915, 0.860 respectively) as shown in figure 3.

Comparison of SOS score discrimination at different points (value)

Sensitivity, specificity and diagnostic effectiveness were used to evaluate discriminatory power for the value of SOS scores before adverse events. An SOS score ≥ 4 at 4 hours before adverse events was the best cut-off value for adverse events with a sensitivity of 82.9%, a specificity of 95.1% and a diagnostic effectiveness of 91.1%. An SOS score ≥ 4 at 8, 12, 24 hours before adverse events were still good cut-off values for adverse events with a specificity of 95.1%, 96.3%, 92.7%, respectively. However, sensitivity fell when the time before adverse events was increased, if a SOS score ≥ 4 was used to be the cut-off value, as shown in table 3.

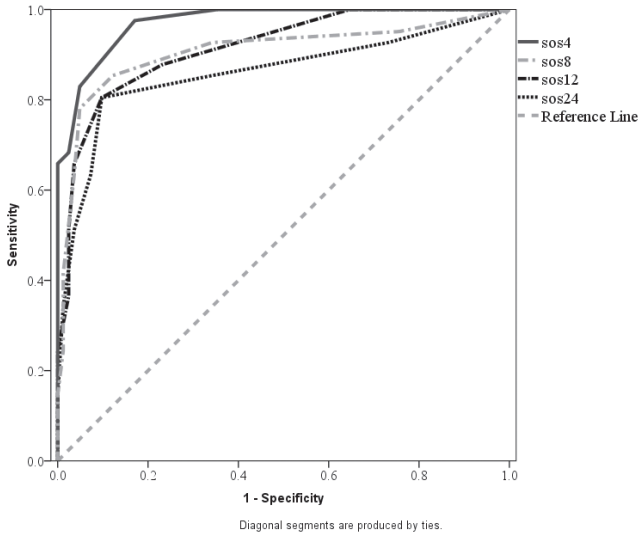

Figure 3 Receiver Operating Characteristics (ROC) curves of SOS score at 4, 8, 12, 24 hours before adverse events for discriminating case and control group

Table 3 Comparison discrimination ability at each cut-off of SOS score at 4, 8, 12,24 hours before adverse events (AEs) SOS score Sensitivity, % (95% CI) Specificity, % (95% CI) Accuracy, % Area under ROC curve (95% CI)

SOS score	Sensitivity, % (95% CI)	Specificity, % (95% CI)	Accuracy, %	Area under ROC curve (95% CI)
4 hr before AEs				0.972 (0.949-0.995)
SOS ≥ 2	100 (91.4-100)	64.6 (53.3-74.9)	76.4	
SOS ≥ 3	97.6 (87.1-99.9)	82.9 (73.0-90.3)	87.8	
SOS ≥ 4	82.9 (67.9-92.8)	95.1 (87.9-98.7)	91.1	
SOS ≥ 5	68.3 (51.9-81.9)	97.6 (91.5-99.7)	87.8	
SOS ≥ 6	65.9 (49.4-79.9)	100 (95.6-100)	88.6	
8 hr before AEs				0.906 (0.839-0.974)
SOS ≥ 2	92.7 (80.1-98.5)	65.9 (54.5-75.9)	74.8	
SOS ≥ 3	85.4 (70.8-94.4)	87.8 (78.7-93.9)	86.9	
SOS ≥ 4	78.0 (62.4-89.4)	95.1 (87.9-98.7)	89.4	
SOS ≥ 5	63.4 (46.9-77.8)	96.3 (89.7-99.2)	85.4	
SOS ≥ 6	41.5 (26.3-57.9)	98.8 (93.4-99.9)	79.7	
12 hr before AEs				0.915 (0.862-0.968)
SOS ≥ 2	87.8 (73.8-95.9)	76.8 (66.2-85.4)	80.5	
SOS ≥ 3	80.5 (65.1-91.2)	90.2 (81.7-95.7)	86.9	
SOS ≥ 4	65.9 (49.4-79.9)	96.3 (89.7-99.2)	86.2	
SOS ≥ 5	51.2 (35.1-67.1)	97.6 (91.5-99.7)	82.1	
SOS ≥ 6	36.6 (22.1-53.1)	97.6 (91.5-99.7)	77.2	
24 hr before AEs				0.860 (0.779-0.942)
SOS ≥ 2	85.4 (70.8-94.4)	65.9 (54.5-75.9)	72.3	
SOS ≥ 3	80.5 (65.1-91.2)	90.2 (81.7-95.7)	86.9	
SOS ≥ 4	63.4 (46.9-77.9)	92.7 (84.7-97.3)	86.2	
SOS ≥ 5	51.2 (35.1-67.1)	96.3 (89.7-99.2)	81.3	
SOS ≥ 6	34.1 (20.1-50.6)	98.8 (93.4-99.9)	77.2	

Discussion

This study emphasized the advantages of using SOS score for the early detection of deteriorating patients in general wards. Results from this study indicated that SOS score (which is one type of MEWS used in Thailand) have a good predictive ability for adverse events in patients that were admitted in general wards. From data of the recent systematic reviews, there is no study reported on the predictive ability of MEWS for acute respiratory failure.[23] This is the first study that reported on the predictive ability of SOS score for adverse events in general wards that included acute respiratory failure or shock. Our study confirmed that SOS score can be used for early detection in other adverse events, because cardiac arrest is a profound event that is too late for early intervention. We reported SOS score at 24, 12, 8, 4 hours before adverse to identify patients with more needs for immediate resuscitations and managements, so that early intervention could be done before adverse events occurred. Therefore, all patients in general hospital ward should be monitored by SOS score in order to early detect and resuscitate deteriorating patients. However,

education and training should be provided to ensure staff have the competencies in monitoring, measurement, interpretation and response to the SOS score.[11]

Moseson and colleagues reported multiple scoring systems that have been developed in Intensive Care Unit (ICU), had superior performances in predicting mortality in hospital.[26] “What is the best scoring system?” Sometimes, it was not about the development of a completely novel tool, but simple and effective tools already in place, which all nurses can monitor and detect these sub-acute adverse events as part of routine practice, because sub-acute adverse events occur frequently, and can happen in every patient with unspecific diseases.[17,18]Routine measurement of the SOS score can be done easily in general wards. The time taken to calculate SOS score is less than 30 seconds after routine measurements of vital signs.

From the results of AUC, sensitivity, specificity and diagnostic effectiveness (accuracy) in this study, the SOS score should be one of the tools for early detection of adverse events in general wards. The SOS score ≥ 4 is a reasonable value to use to be the cut-off point of trigger threshold to initiate action for worsening adverse events. This study showed that the SOS score ≥ 4 had a good predictive ability regardless of the time intervals leading up to 24 hours before the adverse events. The SOS score is the most optimum score that allow monitoring clinical progress in general hospital ward, at least in Thailand context.

Urine output is another physiological parameter that added in the SOS score. Urine output is one of the three windows for tissue perfusion monitoring and important in many clinical settings[27]. Urine output is not routinely recorded for every patient in general wards. Our SOS protocol will add the urine output parameter to the SOS calculation in the cases that have an SOS score ≥ 2. Smith and Oakey found that urine output is the most inconsistently recorded data.[28] However, Hammond and coworkers found that urine output monitoring can improve after MEWS implementation.[29] Our study prove that urine output monitoring can be recorded routinely when the patients have an SOS score ≥ 2 after SOS score implementation. There are no studies that prove adding urine output in the MEWS calculation will increase discriminative power of MEWS. However, we found that the SOS score had a higher predictive ability when compared with past studies that used MEWS which didn’t add urine the output to calculation.[12] Further study should evaluate the value of adding the urine output in the MEWS calculation.

In Thailand, the SOS score is well-known for the early detection of septic patients, but with no clear cut-off value for early aggressive intervention. Adverse events in this study included septic shock (12.2%) and 78% of patients who had adverse events died from septic shock. MEWS was used in the early detection septic patients,[30,31] but there is no strong evidence to clarify MEWS to be a sepsis screening tool. Our study might increase indirect evidence for using MEWS as a screening tool for sepsis. While this study confirmed that SOS scores have the predictive ability to identify patients at risk of clinical deterioration, there is limited high-level data on the impact of their implementation on patient outcomes.[23,32] Further study to test the impact of intervention under the SOS score protocol should be done.

The limitation of our study is design of methodology. Although RCTs are considered the strongest form of evidence, the complexity of introducing a MEWS system, with an accompanying educational program and audit, might suggest

that a single RCT of a MEWS might be almost impossible. It would be impracticable to randomize individual patients on the same ward to receive different levels of monitoring.[33,34] This study should be done in cohort design, but in view of ethical considerations, we cannot perform this study in a cohort manner because, if we suspected someone will deteriorate, we should do something to prevent it, and then adverse events will not occur. This is the main problem and is why this study had to be done in a retrospective nested case-control design.[35]

We excluded patients who were already worse before admission, or who had worsened in the 24 hours after admission for separate good patients in the first 48 hours after admission. The baseline SOS score at the time of admission of case and control in this study help to confirm the good status of patients before admission. We excluded patients who were admitted into, or who had adverse events in settings other than the general medicine or surgical wards such as ICU, and did not include acute sudden adverse events, because these were outside of our proposed scope. Thus, this study showed the real predictive ability of the SOS score, when it was used on the right patient (patients who had sub-acute adverse events), in the right place (in general wards) and at the right time (4-24 hours before adverse events). However, it will be at risk for "over-fitting" data to the population under study. Our study may exaggerate the predictive ability of models and, furthermore, may not be broadly applicable to all populations. Another thing that should be reminded in our study is that positive and negative predictive values are largely dependent on disease prevalence in the examined population. Therefore, if we used the SOS score in the real world practice, positive and negative predictive values from our study will be changed when used the SOS score in other setting with a different prevalence of the disease in the population. Despite good discriminative ability, this study also found clinically important trade-offs in sensitivity and specificity of the SOS score when using specific scores as a cut-off value. A range of sensitivities and specificities depending on the cut-off value used. However, in this study showed that SOS score ≥4 had a high sensitivity and specificity (sensitivity of 82.9%, specificity of 95.1%) at 4 hours before adverse events.

In conclusion, the SOS score at 4, 8, 12, 24 hours before adverse events has a good predictive ability for patients who had adverse events in general wards. The SOS score ≥ 4 is a reasonable value to be the cut-off point of trigger threshold and to initiate action for worsening adverse events. SOS score ≥ 4 had a good predictive ability regardless of the time intervals leading up to 24 hours before adverse events.

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