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Superior performance of NEWS compared to qSOFA in predicting adverse outcomes: A retrospective observational study of patients in the pre-hospital setting

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Abstract

Background

Early intervention and response to deranged physiological parameters in the critically ill patient improves outcomes. A National Early Warning Score (NEWS) based on physiological observations has been developed for use throughout the National Health Service (NHS) in the United Kingdom. The quick Sepsis related Organ Failure Assessment Score (qSOFA) was developed as a simple bedside criterion to identify adult patients outwith the Intensive Care Unit (ICU) with suspected infection who are likely to have a prolonged ICU stay or die in hospital. We aim to compare the ability of NEWS and qSOFA to predict adverse outcomes in a prehospital population.

Methods

All clinical observations taken by emergency ambulance crews transporting patients to a single hospital were collated along with information relating to mortality over a two-month period. The performance of the NEWS and qSOFA in identifying the endpoints of 30-day mortality, intensive care unit (ICU) admission, and a combined endpoint of 48 hour ICU admission or 30-day mortality was analysed.

Results

Complete data were available for 1713 patients. For the primary outcome of ICU admission within 48 hours or 30-day mortality, the odds ratio for a qSOFA score of three compared with zero was 124.1 (95% CI 13.5 to 1137.7) and the odds ratio for a high NEWS category, compared with the low NEWS category was 9.82 (95% CI 5.74to 16.81). Comparison of qSOFA and NEWS performance was assessed using Receiver Operating characteristic curves. The AUROC for the primary outcome for qSOFA was 0.679 (95% CI 0.624 to 0.733), for NEWS category was 0.707 (95% CI 0.654 to 0.761) and for NEWS total score was 0.740 (95% CI 0.685 to 0.795). Comparison of the ROC curves between NEWS total score and qSOFA using DeLong's test showed NEWS total score to be superior to qSOFA at predicting combined ICU admission within 48 hours of presentation or 30-day mortality (p=0.011).

Conclusions

Our study shows qSOFA can identify patients at risk of adverse outcomes in the pre-hospital setting. However, NEWS is superior to qSOFA in a pre-hospital environment at identifying patients at risk of adverse outcomes.

Introduction

Early intervention and response to deranged physiological parameters improves survival outcomes in both medical and surgical patients[1-3]. To this end a number of early warning systems have been developed in recent years [4] and have been shown to be good predictors of mortality and deterioration[5]. Recent work by the Royal College of Physicians and the National Health Service (NHS) has led to the development of a National Early Warning Score (NEWS) [6] which is currently implemented in acute hospitals across the UK and has been successful in identifying patients at risk of deterioration or death[7].

As the development of this score involved analysis of clinical observations in hospital inpatients, where a course of treatment had already been started, uncertainty exists as to the applicability of the NEWS to other settings, particularly the Emergency Department (ED) and pre-hospital setting, where scores would be derived prior to the institution of any treatment. There is some evidence that NEWS is a useful predictor of adverse outcome in the ED [8-10] and pre-hospital setting [11].

The NEWS was based on the earlier ViEWS [12] (VitalPAC Early Warning Score) developed in Portsmouth and stratifies patients into risk categories based on observed physiological data.

qSOFA (quick Sepsis related Organ Failure Assessment Score) is a bedside prompt that may identify patients with suspected infection who are at greater risk of a poor outcome outside the intensive care unit (ICU)[13]. qSOFA has been incorporated into consensus definitions for the assessment of clinical criteria for sepsis and the consensus task force suggested that qSOFA criteria be used "*to prompt clinicians to further investigate for organ dysfunction, to initiate or escalate therapy as appropriate, and to consider referral to critical care or increase the frequency of monitoring".* They considered that positive qSOFA criteria should also prompt consideration of possible infection in patients not previously recognised as infected [14]*.* The derivation and validation cohorts for qSOFA included the pre-hospital phase of the patient journey. As the data were extracted from mainly United States of America (US) databases, the consensus task force recommended prospective validation in multiple US and non-US health care settings to determine its robustness and potential for incorporation into future iterations of the definitions. It was also felt that due to the simplicity of qSOFA, it may be particularly relevant in resource limited settings where laboratory data are not readily available, and where the literature about sepsis epidemiology is sparse.

Comparison of the performance of NEWS and qSOFA at detecting patients with sepsis at risk of adverse outcomes in an ED and ward setting of a single US centre has recently been published [15], and this revealed some disparity in utility between the various scores used. A further study in the Emergency Department of a Norwegian Hospital revealed that qSOFA was worse than Rapid Emergency Triage and Treatment System (RETTS) in predicting severe sepsis and mortality [16]. Finally, a study from Missouri in the US showed that qSOFA had a poor sensitivity for pre-hospital identification of severe sepsis and septic shock [17].

In the pre-hospital environment, patients are less well differentiated than in the ED, and in ED they are less well differentiated than in wards or ICU. As such, comparison could be made between the pre-hospital environment and resource limited settings. Given this we wished to look at the performance of NEWS and qSOFA at predicting subsequent adverse outcome across an entire cohort of undifferentiated patients presenting to ED via the ambulance service.

This study, based in a large district general hospital in Paisley, on the western edge of the Greater Glasgow metropolitan area, Scotland, aimed to evaluate the performance of the NEWS and qSOFA in identifying unselected patients at risk of death or deterioration in the pre-hospital setting. The outcome data related to NEWS have previously been reported [11].

Methods

Data protection approval to analyse and cross-reference patient-identifiable information was obtained from the Caldicott Guardians of both organisations involved (NHS Greater Glasgow and Clyde and Scottish Ambulance Service) prior to commencement of the study. Ethical approval was not required in addition to information governance approvals. Details of all emergency ambulance crews dispatched with an intention to transfer to the Royal Alexandra Hospital (RAH) were obtained from the Scottish Ambulance Service data warehouse, along with details of demographics, initial patient presenting complaint, and clinical observations obtained from the ambulances' electronic patient record forms (ePRF). These were matched to a list of patients presenting to the Emergency Department of the RAH to obtain details related to the patients' hospital admissions. Patients aged less than 16 years and patients known to be pregnant were excluded, along with patients transferred from other hospitals (as these were, by definition, not from the pre-hospital setting). NEWS and qSOFA values were calculated retrospectively from the supplied clinical data. This was a

retrospective cohort study over a 2-month consecutive period between October 1st and November 30th, 2012 using a convenience sample of consecutive patients. Ambulance diversion protocols were in place to transfer patients with ST-elevation Myocardial Infarction direct to the local primary Percutaneous Coronary Intervention centre, and pregnant women in labour were diverted to the nearby maternity hospital. All other patients, including those following major trauma, were transported to the RAH.

From the identified records, information regarding discharge status, and admission to intensive care units was obtained from hospital computer systems. Clinical observations taken by ambulance personnel were obtained from the electronic patient record, and the first complete set of clinical observations used for analysis. Where a complete set had not been taken simultaneously, the first recorded value for each clinical observation was used to construct an observation set.

Data Definitions

qSOFA is scored from zero to three. One point is assigned for each of low systolic blood pressure (SBP≤100 mmHg), high respiratory rate (≥22 breaths per min), or altered mentation (Glasgow Coma Scale <15).

NEWS is scored from zero to twenty. Each parameter (heart rate, respiratory rate, systolic blood pressure, arterial oxygen saturation, temperature, and conscious level) can score from zero to three. An additional weighting of two is added if the patient is being delivered oxygen therapy. As well as total NEWS, categorisation of NEWS into low (total score less than or equal to 4 and no individual component score 3), medium (total score 5-6 or any component score of 3) and high (score 7 or more) clinical risk was undertaken as in the original description of the score [25].

A number of patient outcomes were identified for study – these being:

Primary outcome
Composite adverse outcome of mortality at 30 days or ICU admission within 48 hours

Secondary outcomes
30-day mortality
ICU admission within 48hours of hospital admission

Receiver operating characteristic (ROC) curves plotting sensitivity against (1-specificity) were constructed for the outcomes above, and the area under the curve (AUROC) calculated. Comparison between AUROC was done using DeLongs test [18]. Univariate binary regression models were used to compare outcomes for the qSOFA score and the risk strata identified in the original NEWS specification. For each model, the likelihood ratio test was used to assess the model's fit and odds ratios with their 95% confidence intervals were calculated. All statistical calculation was carried out using R 3.4 for Windows. Statistical significant was defined as two-sided $p < 0.05$. No adjustment is made for multiplicity.

Results

11,052 sets of clinical observations were obtained from 6,028 unique patients. After exclusions, 1,713 complete patient encounters were identified for study. The inclusion and exclusion of patients is summarised in Figure 1.

All patients were transported by emergency ambulances staffed either by two paramedics or one paramedic and one emergency ambulance technician. The mean age of the study population was 58.0 years (SD 20.72, median 66, IQR 47-79) with a 48.1 % male gender (95% CI 46.5 to 49.7). Outcome data of ICU admission within 48 hours and death within 30 days of admission were available for all studied patients.

The NEWS risk category is significantly associated with the primary outcome of ICU admission within 48 hours of presentation and or 30-day mortality (χ^2 (2) = 70.53; p <.0001). The odds ratio for the medium NEWS category, compared with the low NEWS category was 3.30 (95% CI 2.01 to 5.43; p <.0001). The odds ratio for the high NEWS category, compared with the low NEWS category was 9.82 (95% CI 5.74 to 16.81; p <.0001). The odds ratio for the high NEWS category, compared with the medium NEWS category was 2.97 (95% CI 1.73 to 5.13; p <.0001). These data are shown in Table 1.

The qSOFA score is significantly associated with the primary outcome of ICU admission within 48 hours of presentation and or 30 day mortality (χ^2 (3) = 61.36; p <.0001). The odds ratio for a qSOFA score of one, compared with the qSOFA of zero was 2.97 (95% CI 1.88 to 4.69; p<.0001). The odds ratio for a qSOFA score of two, compared with the qSOFA score of zero was 10.08 (95% CI 4.98 to 20.43; p<.0001). The odds ratio for a qSOFA score of two, compared with the qSOFA score of one was 3.40 (95% CI 1.68 to 6.87; p = 0.0006).

The odds ratio for a qSOFA score of three compared with the qSOFA of zero was 124.1 (13.5 to 1137.7; p<.0001). The odds ratio for a qSOFA score of three compared with one was 41.85 (4.57 to 383.3; p = 0.0010). The odds ratio for a qSOFA score of three compared with two was 12.31 (1.26 to 120.2; p = .0309). These data are shown in Table 2.

The relative discriminatory value of NEWS and qSOFA was assessed by plotting AUROC for both groups, against the combined endpoints of ICU admission within 48 hours of presentation and/or 30-day mortality. This is shown in Figure 2. The AUROC for the primary outcome for qSOFA was 0.679 (95% CI 0.624 to 0.733), for NEWS risk category was 0.707 (95% CI 0.654 to 0.761) and for NEWS total score was 0.740 (95% CI 0.685 to 0.795). Comparison of the ROC curves between qSOFA and NEWS risk category showed no difference between NEWS risk category and qSOFA at predicting 30-day mortality (p=0.272). Comparison of the ROC curves between NEWS total score and qSOFA showed NEWS total score to be superior to qSOFA at predicting combined ICU admission within 48 hours of presentation and or 30-day mortality (z=-2.539, p=0.011).

The NEWS risk category is significantly associated with ICU admission within 48 hours (χ^2 (2) = 15.22; p = 0.0005). The odds ratio for the medium NEWS category, compared with the low NEWS category was 5.51 (95% CI 1.61 to 18.94; p 0.0067). The odds ratio for the high NEWS category, compared with the low NEWS category was 11.63 (95% CI 3.08 to 43.86; p = 0.0003). The odds ratio for the high NEWS category, compared with the medium NEWS category was 2.11 (95% CI 0.66 to 6.76; p = 0.2091).

The qSOFA score is significantly associated with ICU admission within 48 hours (χ^2 (3) = 10.03; p = 0.0183). The odds ratio for a qSOFA score of one, compared with the qSOFA of zero was 5.13 (95% CI 1.74 to 15.09; p = 0.0030). The odds ratio for a qSOFA score of two, compared with the qSOFA score of zero was 4.54 (95% CI 0.52 to 39.55; p = 0.1709). The odds ratio for a qSOFA score of two, compared with the qSOFA score of one was 0.88 (95% CI 0.11 to 7.05; p = 0.9078). No patients with a qSOFA of three were admitted to ICU within 48 hours. There were five patients with qSOFA=3, one died in the Emergency Department, one young patient went to the Coronary Care Unit. The three remaining patients died within 48hrs of admission without being admitted to intensive care.

The relative discriminatory value of NEWS and qSOFA was assessed by plotting AUROC for both groups, against the outcome of admission to ICU within 48 hours. This is shown in Figure 3. The AUROC for qSOFA was 0.689 (95%CI 0.571 to 0.808), for NEWS risk category was 0.744 (95%CI 0.624 to 0.864) and for NEWS total score was 0.798 (95%CI 0.693 to

0.902). Comparison of the ROC curves between qSOFA and NEWS category showed no difference between NEWS risk category and qSOFA at predicting ICU admission (z=-0.751, p=0.453). Comparison of the ROC curves between NEWS total score and qSOFA showed no difference between NEWS total and qSOFA at predicting ICU admission (z=-1.896, p=0.057).

The NEWS risk category is significantly associated with 30-day mortality (χ^2 (2) = 60.56; p <.0001). The odds ratio for the medium NEWS category, compared with the low NEWS category was 2.72 (95% CI 1.59 to 4.64; p = 0.0002). The odds ratio for the high NEWS category, compared with the low NEWS category was 9.12 (95% CI 5.22 to 15.93; p<0.0001). The odds ratio for the high NEWS category, compared with the medium NEWS category was 3.36 (95% CI 1.87 to 6.02; p <0.0001).

The qSOFA score is significantly associated with 30-day mortality (χ^2 (3) = 59.29; p <.0001) , the odds ratio for a qSOFA score of one, compared with the qSOFA of zero was 2.90 (95% CI 1.77 to 4.74; p <.0001). The odds ratio for a qSOFA score of two, compared with the qSOFA score of zero was 10.55 (95% CI 5.07 to 21.95; p <.0001). The odds ratio for a qSOFA score of two, compared with the qSOFA score of one was 3.64 (95% CI 1.75 to 7.55; p <.0001).

The odds ratio for a qSOFA score of three compared with zero was 144.2 (95% CI 15.7 to 1326.1; p <.0001). The odds ratio for a qSOFA score of three compared with one was 49.71 (95% CI 5.41 to 456.9; p = 0.001). The odds ratio for a qSOFA score of three compared with two was 13.67 (95% CI 1.39 to 134.1; p = 0.025).

The relative discriminatory value of NEWS and qSOFA was assessed by plotting AUROC for both groups, against 30-day mortality. This is shown in Figure 4. The AUROC for qSOFA was 0.682 (95% CI 0.623 to 0.740), for NEWS risk category was 0.695 (95% CI 0.636 to 0.753) and for NEWS total was 0.731 (95% CI 0.671 to 0.791). Comparison of the ROC curves between qSOFA and NEWS risk category showed no difference between NEWS risk category and qSOFA at predicting 30-day mortality (z=-0.458, p=0.647). Comparison of the ROC curves between NEWS total and qSOFA showed no difference between NEWS total and qSOFA at predicting 30-day mortality (z=-1.939, p=0.053).

Discussion

Our study, has revealed that among unselected pre-hospital patients, an elevated qSOFA much like NEWS, is associated with increased levels of adverse outcomes, namely, ICU admission within 48 hours of presentation and or 30-day mortality. The aggregated total

NEWS score was however, significantly superior to qSOFA at identifying patients at combined risk of either ICU admission within 48 hours of presentation and or 30-day mortality.

Sepsis, "*a life-threatening organ dysfunction caused by a dysregulated host response to infection*", [13] is a common and deadly disease where early recognition, early administration of antibiotics and early adequate volume resuscitation are needed to ensure good outcomes for our patients [15, 20]. Consequently the Surviving Sepsis Campaign have recommended the development of quality improvement programmes in order to screen for sepsis in acutely ill, high risk patients [21]. Such recommendations served as the foundations for the subsequent Sepsis-3 definition papers and the development of the qSOFA criteria to identify patients with suspected infection who are at greater risk of a poor outcome outside the intensive care unit (ICU) [13 -15]. qSOFA was not intended to be a sepsis screening tool by the Sepsis-3 task force but as a means to identify adults with proven or suspected infection who are likely to have a prolonged ICU stay or die in hospital [16, 19]. However, the Sepsis-3 task force did recommend that a positive qSOFA criteria should act as a prompt for "*consideration of possible infection in patients not previously recognized as infected*". While qSOFA was validated in 4 external datasets, one of which was in the pre-hospital setting and another outside the US, the authors encouraged further prospective validation in multiple non-US settings as well as resource limited settings.

The most important finding from our study was that in unselected pre-hospital patients with their infection status unknown, the aggregated total NEWS was significantly superior to qSOFA at predicting the combined endpoints of ICU admission within 48 hours of presentation and / or 30-day mortality in unselected pre-hospital patients. This is similar to the findings of Churpek et al who revealed that qSOFA was superior to the Systemic Inflammatory Response (SIRS) criteria but inferior to MEWS and NEWS at detecting clinical deterioration in infected patients outside the ICU. These findings are not really surprising considering the fact that the qSOFA criteria are composed of 3 of the 7 parameters measured in NEWS. Indeed, a qSOFA criteria of 2 or 3 can result in a minimum NEWS score of 4 and a maximum of 9, meaning that patients with 2 or more qSOFA criteria have a medium or high clinical risk in NEWS and consequently are at increased risk of ICU admission and death. While neither NEWS nor qSOFA are the perfect risk assessment tool, NEWS is the better of the two.

Many countries now use track and trigger early warning scoring systems such as NEWS as part of their structured response to the deteriorating patient and they represent a minimum standard of care [22]. Consequently, increased complexity and confusion will arise if healthcare professionals are asked to introduce a further aggregated score, using similar variables but different thresholds, namely qSOFA, which has not been validated in their setting, and is specific to only one cause of deterioration [23]. Mismanaged patient deterioration is the one of the most common causes of safety related deaths [24]. In comparison to NEWS, qSOFA would fail to identify someone at increased risk of adverse outcome namely isolated hypotension with a systolic blood pressure less than or equal to 90 mmHg and as such represents a backwards step. In the UK, NEWS is established in hospital, and increasingly pre-hospital, as the early warning score. This implementation across healthcare settings allows improved communication and handover on the patient journey. Introduction of qSOFA in addition to NEWS would potentially cause confusion with our study showing no benefit in detecting patients at risk of adverse outcome.

One potential benefit of using qSOFA over NEWS may be that it is be easier to collect only the 3 qSOFA vital sign parameters in resource limited settings, compared to the 7 vital sign parameters required for NEWS. NEWS however, is now used internationally as evidenced by its use across the world from Europe to India, South America and the USA, including the US Naval Air Forces [25]. As such, the authors feel that NEWS represents a minimum standard of care and a standardised approach to the assessment of acute illness severity internationally. NEWS is a common language to communicate illness severity across the patient journey.

Patient with Sepsis often present with very vague and non-specific symptoms and represent a very heterogenous population that is often difficult to identify. Recommendations to use a different scoring system, even in a select subgroup of the population has the potential to result in staff across this patient care continuum speaking at cross purposes, with warning signs being missed, and ultimately patient care being compromised. As a result, a single generic tool such as NEWS, that is independent of patient diagnosis, is more appropriate in the undifferentiated pre-hospital population.

Finally, in our study, the aggregated total NEWS was significantly superior to qSOFA at predicting the combined endpoints of ICU admission within 48 hours of presentation and / or 30-day mortality in unselected pre-hospital patients. Therefore, the authors believe that rather than qSOFA, a NEWS of medium or high clinical risk (greater than or equal to 5) be used to fulfil the requirement of the Sepsis-3 definitions namely "*to prompt clinicians to*

further investigate for organ dysfunction, to initiate or escalate therapy as appropriate, and to consider referral to critical care or increase the frequency of monitoring"[13].

Limitations

Our study does have some limitations. The overall mortality rate was low, as was the proportion of people with high qSOFA and NEWS scores and the total numbers in these categories were also low, particularly among trauma patients.

qSOFA was designed as a tool to identify those with infection who are at risk of adverse outcomes. As such, it may be inappropriate to use qSOFA in unselected patients. However, the authors of the Sepsis 3 papers state that a positive qSOFA should also prompt consideration of possible infection, suggesting it can be used in unselected patients.

Within our study group, there were a number of patients that we could not fully match to include in the study. Using basic demographics, this group of unmatched patients was not significantly different to the study population, however it is possible that this exclusion may alter our results.

Our study was conducted within a single centre, and therefore may not represent all external populations. However, the single centre represents a medium sized UK hospital serving mixed rural and urban population.

Finally, our study was a retrospective convenience sample of 1713 consecutive patients from 2012. This historical dataset was a secondary analysis of an existing database originally used to successfully validate the NEWS in the pre-hospital setting [11]. The authors performed this secondary analysis as it was a group of undifferentiated prehospital patients from 2012 with a known outcome. As such, it was performed in a patient population before qSOFA existed and while NEWS was only beginning to gain traction, making it an advantage in terms of clinicians blinding and reducing bias.

Conclusion

In our cohort among unselected pre-hospital patients, elevated qSOFA is associated with increased levels of adverse outcomes. Comparison with NEWS shows qSOFA has an inferior performance at identifying patients at risk of adverse outcomes. Calculation of an early warning score prior to transfer to hospital is straightforward and may be a useful triage tool

with potential to facilitate earlier recognition of at-risk or deteriorating patients, possibly allowing earlier involvement of appropriate ED and critical care staff. Our data suggests that development of pre-hospital early warning scores should focus on NEWS, rather than qSOFA.

Conflict of interest statement

Acknowledgements

Contributorship

KR conceived the study. DS, AC and KR designed the protocol. DS undertook collection of data and undertook the data linkage process. DS, KR, HS and AC were responsible for data analysis and interpretation. AC drafted the manuscript, and all authors contributed substantially to its revision. KR takes responsibility for the paper as a whole.

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NEWS category	Survivor	Non-survivor	Odds ratio (95% CI) compared with NEWS category:	
			Low	Med
Low	1162	33	-	-
Med	352	33	3.30 (2.01, 5.43)	
High	104	29	9.82 (5.74, 16.81)	2.97 (1.73, 5.13)

Table 1. Odds ratio and 95% confidence interval of combined endpoints of ICU admission within 48 hours of presentation and or 30-day mortality, by NEWS category

qSOFA score	Negative	Positive	Risk ratio compared with qSOFA of		
			0	1	2
0	1148	37	-	-	-
1	429	41	2.97 (1.88, 4.69)		
2	40	13	10.08 (4.98, 20.43)	3.40 (1.68, 6.87)	
3	1	4	124.11 (13.54, 1137.72)	41.85 (4.57, 383.29)	12.31 (1.26, 120.2)

Table 2. Odds ratio and 95% confidence interval of combined endpoints of ICU admission within 48 hours of presentation and / or 30-day mortality, by qSOFA score