Validity of a digital sepsis screening system combining the Manchester Triage System and a SIRS-based system for the detection of sepsis at triage in the emergency department

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Abstract

Background and importance

Detection of sepsis in the emergency department (ED) should be done preferably during triage of the patients. The Manchester triage system (MTS) can be used to screen for sepsis.

Objective

To investigate the accuracy and validity of the MTS for detection of sepsis during triage in the ED and a combination of the MTS with a SIRS based digital sepsis screening system.

Design

Single center retrospective study

Settings and participants

Patients presenting to an ED of a tertiary-care centre who received formal triage were included. (n=29766 patients).

Outcome measures and analysis

Calculated performance measures included sensitivity, specificity, likelihood ratios and AUC for detection of sepsis.

Main results

A total of 189 (0.7%) subjects met the Sepsis-3 criteria, with 45 cases meeting the criteria for septic shock. The MTS had a low sensitivity of 47.6% (95% CI 40.3 to 55.0) for allocating sepsis patients to the correct triage category. However, specificity was high at 99.4% (95% CI 99.3 to 99.5). Combining the MTS and the SIRS-based screening tool showed an improved sensitivity of 64.0% (95% CI 56.7 to 70.9) and a specificity of 96.8% (95% CI 96.4 to 96.8).

Introduction

Numerous studies explored how sepsis could be detected as early as possible after presentation to the emergency department to prioritise treatment of these patients using computerised decision support systems\(^1\)\(^2\).

NEWS, qSOFA, SIRS, Manchester Triage System, ATS (Australian Triage Scale), CATS (Canadian Acuity Triage Scale), and ESI (Emergency Severity Index) are among the most used scoring systems during triage, and there is a wide variation in diagnostic accuracy of these tools\(^3\)\(^{–}\)\(^{11}\).
The Manchester Triage System (MTS) is a 5-level triage system commonly used in Europe. This algorithm uses flowcharts describing the signs and symptoms of the patients, such as "general unwell being" and "abdominal pain". MTS priorities range from level 1 (emergent patients that should have immediate medical care) to level 5 (non-urgent patients that could wait a maximum of 4 hours to be seen)\(^\text{12}\).

A specific discriminator for possible sepsis was recently added to the Manchester triage system\(^\text{13}\). In the current version of the MTS, possible sepsis is defined as a patient that meets one or more qSOFA criteria.

Seymour et al. introduced the quick Sequential Organ Failure Assessment (qSOFA) score to rapidly identify patients with suspected infection at risk for sepsis outside the ICU\(^\text{14}\). It is a simple score consisting of three items: respiratory rate (RR) \(\geq 22\) breaths per minute, altered mentation (Glasgow Coma Scale [GCS] < 15), and systolic blood pressure (SBP) \(\leq 100\) mmHg. A qSOFA score \(\geq 2\) was found to be significantly predictive of increased all-cause mortality in patients outside of the ICU. Therefore, it was introduced as a score for detecting patients at risk for sepsis. However, recently, the Surviving Sepsis campaign advised against using the qSOFA as a single screening tool compared with SIRS or NEWS to identify sepsis\(^\text{15}\).

In this paper, we assess the usefulness and safety of the current version of the MTS and a combination of the MTS with a SIRS based sepsis screening tool in busy emergency departments on a real-world dataset. Additionally, we retrospectively reevaluated the MTS-assigned categories based on raw parameters collected for patients with possible sepsis.

**Methods**

**Study design**

Retrospective analysis of all adult patients (> 18 years of age) presenting to the emergency department from January 2020 to June 2021 who received a formal triage.

The ED of the Antwerp University Hospital is a level 1 trauma centre receiving about 30,000 patients annually.

Triage in the ED at our hospital is a standardised process in which triage nurses trained in using the Manchester Triage System evaluate each patient that enters the ED. Data such as vital signs are manually entered, and a SIRS based sepsis screening tool has to be filled out for every patient into the electronic health record (HER) (C2M, Cegeka Belgium).

**Sepsis screening tools used in our ED during triage**

**Manchester Triage System**
Each patient admitted to the ED is evaluated by a trained nurse using the process described by MTS to define the priority code. During the triage evaluation, the nurse chooses the appropriate MTS diagram and discriminator. The priority codes are divided into five levels of urgency: blue (non-urgent, 240 min), green (average, 120 min), yellow (urgent, 60 min), orange (very urgent, 10 min) and red (immediate, 0 min).

The MTS triage defines possible sepsis in patients with one or more of the qSOFA criteria: altered mental state, low blood pressure (systolic less than 100) or raised respiratory rate (rate more than or equal to 22) for which the triage nurse raised suspicion of infection. A digital sepsis alert is generated if the triage nurse chooses this category. It is important to note that vital signs data are not cross-checked with the digital Manchester Triage tool in the software system being used during this trial.

### Combination of MTS and SIRS-based screening tool

Our digital triage software system incorporated a SIRS-based sepsis screening tool using the sepsis-2 criteria. The triage nurse first determines if there is a suspicion of a new infection. Next, a digital sepsis alert fires if a new altered mental state is present. Also, if two or more selected SIRS criteria (temperature less than 36 or more than 38 degrees Celsius, heart rate more than 90 beats per minute, a respiratory rate more than 20 per minute) are entered into the software system, a digital sepsis alert is generated. Contrary to the MTS, triggers were programmed to fire the alert based on values of temperature, heart rate or respiratory rate entered in the EHR (see Fig. 1).

### Study population

All adult patients (> 18 years of age) presenting to the emergency department that received a formal triage were included (n = 29766). Patients assigned to the category “blue” were excluded from further analysis as no case of suspected or confirmed sepsis did occur in this category (no blood cultures ordered, no “possible sepsis” marked in the digital Manchester Triage system, no admittance to ICU and no case meeting sepsis criteria after admission). Also, patients that received immediate palliative care after diagnosis of possible sepsis in the ED were excluded (n = 16), leaving 28213 patients for further analysis.

### Data representation

Data was extracted as-is from the EHR. The patient’s state is represented as the earliest measurement known for each patient during their stay at the ED. This approximates the state of the patient as presented first in the ED.

### Patient chart data review

An arbitrary selection of records for in-depth review was made based on the presence of at least one or more of the following criteria: categorisation to “possible sepsis” in the MTS, NEWS score > 5, documentation of “suspicion of infection” in the triage chart, one or more qSOFA criteria, a positive SIRS-based sepsis screening, categorisation to “red” in the MTS, blood cultures taken, admission to ICU within 72 hours after admission on ED or death during hospital stay. An emergency physician (author KD)
manually reviewed these selected patient charts (n = 725) to verify the sepsis diagnosis, the triage system's correct application, and the accuracy of data input.

Of these records, two independent emergency physicians not involved in the main study reviewed 30 random cases after individual chart review by author KD to calculate inter-rater agreement, which was moderate to high (weighted kappa 0.41 and 0.86).

**Definition of sepsis**

Sepsis and septic shock were defined as per Sepsis-3 definitions: a Sequential Organ Failure Assessment (SOFA) score of ≥ 2 and suspected infection. Suspicion of infection was determined by orders for administering antibiotics or blood cultures.

**Missing data**

The total number of missing data for calculating screening scores was relatively low (975 missing SIRS criteria and 402 observations rendering the calculation of NEWS impossible (33 missing blood pressure recordings, 369 missing mental status scores). In agreement with clinical practice and prior reports, missing data for SOFA score calculation were assumed to be normal.

**Assessment of triage categorisation**

Patients with sepsis categorised as red, orange or “possible sepsis” were considered correctly triaged. Validity was assessed by the proportion of correctly triaged and undertriaged patients and the different diagnostic performance measures sensitivity, specificity, positive and negative likelihood ratio and accuracy.

The triage charts selected for manual review as described above (n = 725) were checked for correct scoring of qSOFA criteria. For example, if the respiratory rate was marked as normal, but clinical examination mentioned tachypnea or blood gases showed clear hyperventilation, this data was flagged as incorrect.

**Endpoint**

The primary endpoint was the diagnostic accuracy and validity of the MTS to identify sepsis at triage. In a subsequent analysis, we compared the performance of a combination of the MTS with a SIRS based sepsis screening tool.

**Statistical analysis**

Sample size calculation showed that given a prevalence of 0.5% of sepsis patients and a supposed sensitivity of 80% and specificity of 98% at an estimation error of 8%, a minimum sample size of 19400 was needed with a minimum number of 97 sepsis patients.

Baseline characteristics between different triage categories were compared using ANOVA analysis and Chi-square test where appropriate. Using a 2 × 2 contingency table, sensitivity, specificity, positive and
negative predictive values, positive and negative likelihood ratios and AUC values were calculated. Finally, the sensitivity and specificity of each model were compared using McNemar's test\(^\text{18}\).

All estimates are presented with their 95% confidence intervals, and a p-value of less than 0.05 was considered statistically significant for all analyses. MedCalc Statistical Software version 19.2.6 (MedCalc Software bv, Ostend, Belgium; https://www.medcalc.org; 2020) was used for calculations.

**Results**

A total of 189 (0.7%) subjects met the Sepsis-3 criteria, with 45 cases meeting the criteria for septic shock. See Table 1 for baseline characteristics.

![Table 1](https://via.placeholder.com/150)

**Table 1**

Baseline characteristics of the study population.

<table>
<thead>
<tr>
<th>Category</th>
<th>Green</th>
<th>Yellow</th>
<th>Orange</th>
<th>&quot;Possible sepsis&quot; category</th>
<th>Red</th>
<th>Total</th>
<th>Sign. Level difference between categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients, n</td>
<td>13250</td>
<td>11040</td>
<td>3363</td>
<td>231</td>
<td>331</td>
<td>28217</td>
<td>n/a</td>
</tr>
<tr>
<td>Mean age (range)</td>
<td>45 (30–62)</td>
<td>51 (33–67)</td>
<td>59 (41–73)</td>
<td>60,5 (49–74)</td>
<td>64 (50–75)</td>
<td>50 (33–66)</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Sepsis diagnosis, n (% of total sepsis)</td>
<td>10</td>
<td>51</td>
<td>38</td>
<td>59</td>
<td>31</td>
<td>189</td>
<td>n/a</td>
</tr>
<tr>
<td>Septic shock diagnosis, n (% of total sepsis)</td>
<td>1</td>
<td>6</td>
<td>13</td>
<td>14</td>
<td>13</td>
<td>47</td>
<td>n/a</td>
</tr>
<tr>
<td>Mean NEWS score (SD)</td>
<td>0.6 (0.9)</td>
<td>1.1 (1.3)</td>
<td>2.0 (2.3)</td>
<td>5.2 (2.8)</td>
<td>3.8 (3.9)</td>
<td>1.0 (0.0)</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>SOFA score sepsis (range)</td>
<td>5.1 (2–10)</td>
<td>4.3 (2–12)</td>
<td>6.1 (2–18)</td>
<td>5.8 (2–18)</td>
<td>9.7 (2–25)</td>
<td>6.1 (2–25)</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>ICU admission (total, n)</td>
<td>13</td>
<td>63</td>
<td>260</td>
<td>54</td>
<td>167</td>
<td>503</td>
<td>n/a</td>
</tr>
<tr>
<td>Mortality of sepsis patients, n (% per category)</td>
<td>2 (0.2)</td>
<td>5 (9.8)</td>
<td>18 (47.4)</td>
<td>21 (35.6)</td>
<td>5 (16.2)</td>
<td>51</td>
<td>n/a</td>
</tr>
<tr>
<td>Blood culture taken, n</td>
<td>578</td>
<td>1558</td>
<td>665</td>
<td>248</td>
<td>64</td>
<td>2865</td>
<td>n/a</td>
</tr>
<tr>
<td>Positive blood culture in sepsis patients, n (%)</td>
<td>8 (80)</td>
<td>32 (62.7)</td>
<td>26 (68)</td>
<td>34 (57.6)</td>
<td>19 (61.3)</td>
<td>119 (63.0)</td>
<td>n/a</td>
</tr>
</tbody>
</table>
Performance of the Manchester Triage System to detect sepsis

With the MTS to allocate sepsis patients to the specific MTS category “possible sepsis” or red category, the sensitivity was low at 47.6% (95% CI 40.3 to 55.0). However, specificity was high at 99.4% (95% CI 99.3 to 99.5). An absolute number of 99 patients with sepsis were not classified as “possible sepsis” and thus at risk for delay in treatment, given a negative likelihood ratio of 0.5 (95% CI 0.4 to 0.6). False-positive alerts were generated in 179 on a total of 269 alerts (66.5%) at a positive predictive value of 33.5% (95% CI 29.0 to 38.3).

Performance of a digital sepsis alert combining MTS and SIRS based sepsis screening

Combining the MTS and the SIRS-based screening tool showed an improved sensitivity of 64.0% (95% CI 56.7 to 70.9) and a specificity of 96.8% (95% CI 96.6 to 97.0). See Table 2 for details.

An absolute number of 68 patients with sepsis did not give an alert in our digital patient overview with a negative likelihood ratio of 0.37 (95% CI 0.31 to 0.45)

This tool's false-positive alerts were 895 on a total of 1016 alerts (88.1%), given a PPV of 11.9% (95% CI 10.7 to 13.3). See Table 3 for contingency tables with absolute values.
Table 2
Performance measures of MTS and combined screening system

<table>
<thead>
<tr>
<th>Test Characteristic</th>
<th>MTS category possible sepsis</th>
<th>95% CI</th>
<th>MTS plus SIRS-based system</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>47.6%</td>
<td>40.3–55.0%</td>
<td>64.0%</td>
<td>56.7–70.9%</td>
</tr>
<tr>
<td>Specificity</td>
<td>99.4%</td>
<td>99.3–99.5%</td>
<td>96.8%</td>
<td>96.6–97.0%</td>
</tr>
<tr>
<td>AUC</td>
<td>0.74</td>
<td>0.73 to 0.74</td>
<td>0.80</td>
<td>0.80 to 0.81</td>
</tr>
<tr>
<td>Positive Likelihood Ratio</td>
<td>74.6</td>
<td>60.5 to 92.0</td>
<td>20.1</td>
<td>17.7 to 22.7</td>
</tr>
<tr>
<td>Negative Likelihood Ratio</td>
<td>0.5</td>
<td>0.4 to 0.6</td>
<td>0.37</td>
<td>0.31 to 0.45</td>
</tr>
<tr>
<td>Positive Predictive Value</td>
<td>33.5%</td>
<td>29.0–38.3%</td>
<td>11.9%</td>
<td>10.7–13.3%</td>
</tr>
<tr>
<td>Negative Predictive Value</td>
<td>99.7%</td>
<td>99.6–99.7%</td>
<td>99.8%</td>
<td>99.7–99.8%</td>
</tr>
<tr>
<td>Accuracy</td>
<td>99.0%</td>
<td>99.0–99.1%</td>
<td>96.6%</td>
<td>96.4–96.8%</td>
</tr>
</tbody>
</table>

Table 3
Absolute numbers of triage categorization

<table>
<thead>
<tr>
<th>MTS category &quot;possible sepsis&quot;</th>
<th>Sepsis</th>
<th>No sepsis</th>
<th>Total, n</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTS possible sepsis</td>
<td>90</td>
<td>179</td>
<td>269</td>
</tr>
<tr>
<td>MTS no possible sepsis</td>
<td>99</td>
<td>27845</td>
<td>27944</td>
</tr>
<tr>
<td>Total, n</td>
<td>189</td>
<td>28024</td>
<td>28213</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MTS plus SIRS based system</th>
<th>Sepsis</th>
<th>No sepsis</th>
<th>Total, n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital Sepsis Alert</td>
<td>121</td>
<td>895</td>
<td>1016</td>
</tr>
<tr>
<td>No Digital Sepsis Alert</td>
<td>68</td>
<td>27129</td>
<td>27197</td>
</tr>
<tr>
<td>Total, n</td>
<td>189</td>
<td>28024</td>
<td>28213</td>
</tr>
</tbody>
</table>

Comparison of test performance measures
The sensitivity of the combination of the screening tools was significantly higher than the MTS screening system alone. However, specificity was statistically slightly lower (McNemar’s test for sensitivity and specificity \( p < 0.0001 \)).

**Audit of triage categorisation to MTS category "possible sepsis"**

All cases marked with an incorrect categorisation due to incorrect qSOFA scoring (n = 193) were excluded for a subanalysis of performance measures (see Table 4).

<table>
<thead>
<tr>
<th>MTS category</th>
<th>Incorrect respir. Rate scoring</th>
<th>Incorrect mental state scoring</th>
<th>Incorrect blood pressure scoring</th>
<th>Total number incorrect qSOFA scoring</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sepsis diagnosis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Possible sepsis&quot;</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other than &quot;possible sepsis&quot;</td>
<td>24</td>
<td>28</td>
<td>13</td>
<td>58</td>
</tr>
<tr>
<td><strong>No sepsis diagnosis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Possible sepsis&quot;</td>
<td>22</td>
<td>2</td>
<td>10</td>
<td>32</td>
</tr>
<tr>
<td>Other than &quot;possible sepsis&quot;</td>
<td>53</td>
<td>11</td>
<td>46</td>
<td>103</td>
</tr>
</tbody>
</table>

We recalculated scores after excluding cases with poor application of the MTS (see Table 5). Overall, we see improved results for detecting sepsis with the combined screening system, with increased sensitivity of 92.4% (95% CI 86.4–96.3%). Furthermore, only 10 out of 131 (7.6%) patients with sepsis did not give an alert in this recalculated data set. On the other hand, the absolute number of false-positive alerts in this subset was 863 on a total of 984 alerts (87.7%), given a low positive predictive value of 12.3% (95% CI 11.4–13.2%) next to a positive likelihood ratio of 29.8 (95% CI 27.5 to 32.4). See Table 6 for contingency tables with absolute values.
### Table 5
Test characteristics with exclusion of cases with incorrect application of MTS

<table>
<thead>
<tr>
<th>Test characteristic</th>
<th>MTS category possible sepsis</th>
<th>95% CI</th>
<th>MTS plus SIRS-based system</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>68.7%</td>
<td>60.0–76.6%</td>
<td>92.4%</td>
<td>86.4–96.3%</td>
</tr>
<tr>
<td>Specificity</td>
<td>99.5%</td>
<td>99.4–99.6%</td>
<td>96.9%</td>
<td>96.7–97.1%</td>
</tr>
<tr>
<td>AUC</td>
<td>0.84</td>
<td>0.84 to 0.85</td>
<td>0.95</td>
<td>0.94 to 0.95</td>
</tr>
<tr>
<td>Positive Likelihood Ratio</td>
<td>130.3</td>
<td>106.9 to 158.9</td>
<td>29.8</td>
<td>27.5 to 32.4</td>
</tr>
<tr>
<td>Negative Likelihood Ratio</td>
<td>0.3</td>
<td>0.2 to 0.4</td>
<td>0.1</td>
<td>0.0 to 0.1</td>
</tr>
<tr>
<td>Positive Predictive Value</td>
<td>38.0%</td>
<td>33.4–42.8%</td>
<td>12.3%</td>
<td>11.4–13.2%</td>
</tr>
<tr>
<td>Negative Predictive Value</td>
<td>99.9%</td>
<td>99.8–99.9%</td>
<td>100.0%</td>
<td>99.9–100.0%</td>
</tr>
<tr>
<td>Accuracy</td>
<td>99.3%</td>
<td>99.2–99.4%</td>
<td>96.9%</td>
<td>96.7–97.1%</td>
</tr>
</tbody>
</table>

### Table 6
Absolute numbers of triage categorization with exclusion of cases with incorrect application of MTS

<table>
<thead>
<tr>
<th>MTS category &quot;possible sepsis&quot;</th>
<th>Sepsis</th>
<th>No sepsis</th>
<th>Total, n</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTS possible sepsis</td>
<td>90</td>
<td>147</td>
<td>237</td>
</tr>
<tr>
<td>MTS no possible sepsis</td>
<td>41</td>
<td>27742</td>
<td>27783</td>
</tr>
<tr>
<td>Total, n</td>
<td>131</td>
<td>27889</td>
<td>28020</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MTS plus SIRS based system</th>
<th>Sepsis</th>
<th>No sepsis</th>
<th>Total, n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital Sepsis Alert</td>
<td>121</td>
<td>863</td>
<td>984</td>
</tr>
<tr>
<td>No Digital Sepsis Alert</td>
<td>10</td>
<td>27026</td>
<td>27036</td>
</tr>
<tr>
<td>Total, n</td>
<td>131</td>
<td>27889</td>
<td>28020</td>
</tr>
</tbody>
</table>

Characteristics of missed diagnosis of sepsis by Manchester triage.
Although our study was not designed nor powered to analyse the outcome of missed cases of sepsis by our screening tool, we explored the individual health records of these patients.

More than half of missed cases of patients with sepsis that died during hospital stay (n = 51) suffered an incorrect application of the Manchester triage tool due to incorrect scoring of qSOFA criteria. Of the missed cases of sepsis, not a single patient did not receive antibiotics in the ED. However, no valid data on the exact timing of administration of antibiotics was available.

**Discussion**

By combining the MTS with a SIRS based sepsis screening tool, a method already suggested in previous research\(^{19}\), our digital sepsis alert showed an overall good performance.

The number of false-positive alerts with our digital sepsis alert (895 false positive alerts on a total of 1016 alerts) seems acceptable in practical terms. However, harm from false-positive alerts may include missing alternative diagnoses due to early anchoring on sepsis and the subsequent effects of early, aggressive fluid intervention\(^{20}\). More research is needed to confirm these assumptions.

We were surprised by the high rate of poor application of the triage system in our data set.

Human error leads to over-and underestimating scores of clinical prediction tools, which makes the validation of these triage systems difficult. One study investigated the effect of redesigning an electronic triage interface to make data entry less effortful\(^{21}\). Documentation of correct respiratory rate more than doubled following the interface change in this study. Importantly, we recommend that measures be taken to monitor the correct application of this triage tool and to adapt the user interface of the digital screening tools to minimise human error. In our case, the input of vital sign data during triage (for instance, oxygen saturation and blood pressure) should trigger the Manchester categorisation.

Interestingly, much research is being done in the field of machine learning to develop algorithms that could be used in clinical practice in the future\(^{22,23}\). A recent systematic review showed that on retrospective data, individual machine learning models could accurately predict sepsis onset ahead of time\(^{24}\).

Although the literature shows promising results, clinical implementation studies are needed to bring these concepts to the bedside. In addition, we believe that future studies should use machine learning methods to develop generalisable tools beyond the diagnostic challenge of sepsis, such as diagnosis of pulmonary embolism, prediction of deterioration of respiratory diseases and prediction of major cardiac adverse events.

One of the strengths of this study includes the rigorous iteration to screen our dataset for a definitive diagnosis of sepsis to avoid selection bias. For example, if we had only reviewed patients based on suspicion of infection in the ED as described by Seymour et al\(^{14}\), patients who were undertriaged and
patients without a sepsis workup in the ED been admitted to ICU within 48 hours because of sepsis, would not have been included.

**Limitations**

Limitations of this study include the retrospective design of the study. In addition, our dataset suffered from missing data with a possible significant influence on the results found. However, we took maximum effort to verify important data points on an individual patient level, so we believe our results can be extrapolated to clinical practice.

NEWS is currently used in our centre as a standard early warning system, and this system is internationally widespread, so it would be interesting to include this system in a comparative analysis.

No definite conclusions can be made regarding the clinical implications of the performance of these sepsis screening tools. Therefore, future research should include prospective clinical outcome variables in validation studies of screening tools in the emergency department.

The COVID-19 pandemic started during the collection of our data, and our study was not designed to analyse the impact of this disease on the performance of our triage tool. However, a preliminary analysis showed that many COVID-19 patients triaged as having possible sepsis ended up with a diagnosis of COVID-19 pneumonia without sepsis.

**Conclusion**

The use of a combination of the recently updated version of the Manchester Triage System with a specific discriminator for possible sepsis and a SIRS based screening tool appears to have an overall acceptable performance in the early detection of sepsis.

Incorrect application of triage scales appears to be highly prevalent, so more effort should be made to audit triage performance in the emergency department. In addition, software development should aim to render interfaces user-friendly to avoid wrong application of the triage scales.

Future research should facilitate the implementation of machine learning techniques to detect sepsis and other life-threatening pathology and investigate clinical implications and the outcome of screening systems in the emergency department.

**Abbreviations**

ED: Emergency Department

SIRS: Systemic inflammatory Response Syndrome

(q)SOFA: (quick) sequential organ failure assessment
Declarations

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Authors' contributions

KD conceived the study, designed the protocol, analysed the data and drafted the manuscript. ES collected and analysed the data. ER and ES supervised the data analyses. ES, SVI, HJ, KD and ER contributed substantially to its revision. KD takes responsibility for the paper as a whole. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

DECLARATIONS

Ethical approval

The study has been approved by the local ethics committee at Antwerp University Hospital, Wilrijk, Belgium. We certify that the study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Informed consent was waived after review by the local ethics committee of Antwerp University Hospital due to the retrospective nature of the study.

Consent for publication

Not applicable

Competing interests

The authors report no potential conflicts of interest.
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References


**Figures**

**Figure 1**

Process of sepsis screening during triage