Predicting Hospital Admission at Triage in an Emergency Department
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Predicting hospital admission for Emergency Department (ED) patients at the time of triage may improve ED throughput. To predict admission status we created and validated a Bayesian Network (BN) from 48 variables available at triage from 47,993 patient visits (training set: n=23,996, validation set: n=9,599, and independent test set: n=14,398). The area under the receiver operator characteristic curve was 0.833 (95% CI: 0.826 – 0.840) for the expert-built BN and 0.790 (95% CI: 0.781 – 0.799) for the control variable (acuity only). Predicting hospital admission status early during an encounter may help anticipate ED workload and potential overcrowding.

INTRODUCTION
Emergency Department (ED) overcrowding is a national problem that can impact patient outcomes. When a patient has extended boarding times in the ED, ED throughput decreases as treatment beds are blocked for additional patients. Early identification of patients who will be admitted to the ED could help manage workflow through requesting hospital beds earlier during the visit. Previous works predicting ED admission have applied both rule-based methods and machine learning techniques. The goal of our study was to evaluate the performance of a Bayesian Network (BN) to predict hospital admission limited to operational and patient data available at triage.

METHODS
The Vanderbilt Medical Center adult ED is a level 1 trauma center with >50,000 patient visits annually. We retrospectively obtained data from the ED patient tracking board and the computerized triage application. The study was approved by the institution’s IRB. All patients presenting to the adult ED during 2006 were eligible for inclusion. We excluded patients if they did not have electronic triage, were transferred out of the ED, were deceased on arrival, or left without seeing the physician. Data from 48 variables were divided into three sets, a 50% training set (n=23,996), a 20% validation set (n=9,599), and a 30% independent test set (n=14,398). The primary outcome variable was the prediction of the patient’s admission to the hospital. Predicting admission using acuity (Emergency Severity Index) alone acted as a control. BN performance was evaluated using the area under the receiver operator characteristic curves (AUC).

RESULTS
From 54,669 eligible patients, 6,676 (12.2%) patients were excluded. The hospital admission rate was 26.8%. Various expert-built networks ranged from 4 to 30 prediction nodes. The AUC range was 0.794 to 0.833. The figure shows the best network created which had an AUC of 0.833 (95% CI: 0.826 – 0.840) and the control network which had an AUC of 0.790 (95% CI: 0.781 – 0.799).

The table shows the expert BN’s test characteristics at fixed 90% and 95% sensitivity.

Table: Operating characteristics.

<table>
<thead>
<tr>
<th>SEN (%) (fixed)</th>
<th>SPEC (%)</th>
<th>PPV (%)</th>
<th>NPV (%)</th>
<th>PLR</th>
<th>NLR</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>53.9</td>
<td>41.9</td>
<td>93.6</td>
<td>1.95</td>
<td>0.19</td>
</tr>
<tr>
<td>95</td>
<td>41.1</td>
<td>37.3</td>
<td>95.7</td>
<td>1.61</td>
<td>0.12</td>
</tr>
</tbody>
</table>


DISCUSSION
AUCs for expert-built BNs did not vary substantially and had small performance improvements over the control. This may indicate an inherent limitation of the data set and difficulties in hospital admission prediction in general with data from triage alone.

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