Introduction

Purpose and Motivation
- Centers for Medicare and Medicaid Services (CMS) reduced Medicare payments for hospitals with excess readmissions (within 30 days of discharge) for following health conditions:
  - Heart Attack, Heart Failure, Pneumonia, Hip/Knee Replacement, Chronic Obstructive Pulmonary Disease.
- Readmissions can lead to longer stays, and put patients at additional risk of hospital-acquired infections and complications.

Development of LACE
- Currently the LACE index is a widely used readmission model in the United States, due to its simplicity and moderate predictive power.
- LACE scores every patient on the risk of readmission upon discharge based on the following parameters:
  - Length of stay
  - Acuity of admission
  - Comorbidity
  - Emergency department visits in the previous 6 months.
- LACE scores range from 0-19
  - Low Risk 0-4
  - Moderate Risk 5-9
  - High Risk 10-19

Data Summary
- Data acquired from single hospital consisting of 76,538 patients in five years

Methodology

Logistic Regression
- A regression model where the data set has a binary response or a multinomial response and several predictors.
- We are interested in predicting the probability a patient is readmitted to the hospitals within 30 days after discharge based on characteristics such as:
  - age, gender, length of stay during admission, diagnoses, admission from emergency department, number of emergency visits, etc...
- Logistic regression links the binary outcomes of readmission status with a combination of the linear predictors.
- Let \( p \) = probability the patient is readmitted within 30 days after discharge
- Let \( b_0 \) = intercept
- Let \( b_1, b_2, \ldots, b_p \) = coefficients of variable
- Let \( X_1, X_2, \ldots, X_p \) = variable

\[
p = \frac{\exp(b_0 + b_1 X_1 + b_2 X_2 + \ldots + b_p X_p)}{1 + \exp(b_0 + b_1 X_1 + b_2 X_2 + \ldots + b_p X_p)}
\]

Validation
- Logistic regression is built on 80% of the data set. The remaining 20% of the data set is used for internal validation.
- A confusion matrix was examined to compare the sensitivity (true positive rate), specificity (false negative rate), positive predicted value, and \( c \)-statistic.
- A new cutoff value was created to compromise the tradeoff between the true positive rate and false negative rate.

Models
- Three models were created:
  - LACE model
  - General Model
  - Age 65+ model with CMS penalty conditions

<table>
<thead>
<tr>
<th>Criteria</th>
<th>LACE</th>
<th>General Model</th>
<th>Age 65+ and Penalty Condition Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>45</td>
<td>7</td>
<td>26</td>
</tr>
<tr>
<td>Specificity</td>
<td>88</td>
<td>7</td>
<td>86</td>
</tr>
<tr>
<td>PPV</td>
<td>17</td>
<td>15</td>
<td>21</td>
</tr>
<tr>
<td>AUC</td>
<td>N/A</td>
<td>78</td>
<td>71</td>
</tr>
</tbody>
</table>

Table to compare predicted and actual readmissions using the age 65+ model:

<table>
<thead>
<tr>
<th>Decile</th>
<th>Number in decile</th>
<th>Mean Prediction within Quintile</th>
<th>Actual Readmissions</th>
<th>Predicted Readmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>666</td>
<td>0.0902</td>
<td>6.1</td>
<td>6.1</td>
</tr>
<tr>
<td>10-20</td>
<td>666</td>
<td>0.0114</td>
<td>4.0</td>
<td>7.6</td>
</tr>
<tr>
<td>20-30</td>
<td>666</td>
<td>0.0165</td>
<td>15.0</td>
<td>12.3</td>
</tr>
<tr>
<td>30-40</td>
<td>666</td>
<td>0.0252</td>
<td>15.0</td>
<td>17.0</td>
</tr>
<tr>
<td>40-50</td>
<td>666</td>
<td>0.0364</td>
<td>22.0</td>
<td>24.2</td>
</tr>
<tr>
<td>50-60</td>
<td>666</td>
<td>0.0568</td>
<td>48.0</td>
<td>37.8</td>
</tr>
<tr>
<td>60-70</td>
<td>666</td>
<td>0.0821</td>
<td>60.0</td>
<td>54.7</td>
</tr>
<tr>
<td>70-80</td>
<td>666</td>
<td>0.1052</td>
<td>81.0</td>
<td>68.7</td>
</tr>
<tr>
<td>80-90</td>
<td>666</td>
<td>0.1366</td>
<td>98.0</td>
<td>91.0</td>
</tr>
<tr>
<td>90-100</td>
<td>666</td>
<td>0.2319</td>
<td>157.0</td>
<td>154.4</td>
</tr>
</tbody>
</table>

| Stat | 6,460 | 486.1 | 473.9 |

Conclusions
- Sensitivity values in logistic regression models are higher than the value in the LACE model.
- Specificity is higher in LACE, however the slightly lower specificity values in the regression models are worth the compensation to gain sensitivity.
- This indicates an improvement in predictive power of regression models compared to the LACE model.
- When comparing both regression models, the general model is preferred because of its higher sensitivity, specificity, and AUC values compared to the age and penalty specific model.

References
1. Van Walraven C, Dhalla IA, Bell C, et al. Derivation and Validation of an Index to Predict Early Death or Unplanned Readmission After Discharge From Hospital to the Community. CMAJ 2010; 182: 551-557.