A Simple Predictive Score for Pre-Admission Identification of Risk of 30-day Hospital Readmission or Death in Heart Failure

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Background

Readmissions after heart failure (HF) are the focus of pay-for-performance initiatives. Most risk calculations for HF patients incorporate inpatient data. Early and accurate identification of patients at risk for readmissions may improve quality and reduce cost of care.

Methods

The OM1 data platform links together structured and unstructured clinical, administrative and other data from a large number of sources at the individual level to construct patient journeys, measure health outcomes and benchmark care. Prescriptive analytics resulting from machine and deep learning are used to identify actions that clinicians can take to avoid adverse events or to improve outcomes as part of learning health systems. OM1 Linked Data contains linked claims and EMR data from tens of million US patients. Of ~200,000 patients with HF, 24,615 met study criteria of at least 1 HF-related hospital admission and at least 6 months data preceding that admission. Logistic regression, random forests, classification and regression trees were used to identify pre-admission predictors of 30-day readmission or death. Models were built in training set with 67% randomly selected patients and validated in the remaining 33% patients. We computed the simple risk score by adding the assigned weights to each predictor based on the parameter estimates from the logistic regression. The risk score ranged from 1 to 10, with 10 indicating the highest risk. In the weighted analysis, the weights were the number of patients within the same risk score stratum.

Table 1. Patient Characteristics at the Time of Index Admission

| | | 30-Day Readmission | | |
|--|------------|------------------------|----------------------------|-------------------|
| Pre-Admission Characteristics | | Readmission N=3,474 | No Readmission N=21,141 | Total N=24,615 |
| Gender n (%) | Female | 1,702 (49%) | 10,224 (48%) | 11,926 (48%) |
| | Male | 1,737 (50%) | 10,463 (49%) | 12,200 (50%) |
| Age (years) at index hospitalization | Mean (SD) | 70 (13) | 71 (13) | 71 (13) |
| Hospitalizations within 12 months prior to index hospitalization | 0 | 1,601 (46%) | 13,024 (62%) | 14,625 (59%) |
| | 1-3 | 1,586 (46%) | 7,553 (36%) | 9,139 (37%) |
| | 4-7 | 245 (7%) | 531 (3%) | 776 (3%) |
| | ≥8 | 42 (1%) | 33 (0%) | 75 (0%) |
| Interval between most recent prior | 1-2 months | 1,438 (41%) | 5,769 (27%) | 7,207 (29%) |
| hospitalization and index hospitalization | 3-4 months | 670 (19%) | 4,335 (21%) | 5,005 (20%) |
| | 5-6 months | 572 (16%) | 4,282 (20%) | 4,854 (20%) |
| | >6 months | 794 (23%) | 6,755 (32%) | 7,549 (31%) |
| Chronic Obstructive Pulmonary Disease | | 1,737 (50%) | 8,383 (40%) | 10,120 (41%) |
| Chronic renal failure | | 1,714 (49%) | 8,337 (39%) | 10,051 (41%) |
| Charlson comorbidity index at index admission | O-1 | 512 (15%) | 5,007 (24%) | 5,519 (22%) |
| | 2-4 | 1,369 (39%) | 9,052 (43%) | 10,421 (42%) |
| | 5-9 | 1,450 (42%) | 6,609 (31%) | 8,059 (33%) |
| | ≥10 | 143 (4%) | 473 (2%) | 616 (3%) |
| Low diastolic blood pressure (mmHg) | <80 | 2,849 (82%) | 17,456 (83%) | 20,305 (83%) |
| within 12 months prior to the index | 80-89 | 463 (13%) | 2,838 (13%) | 3,301 (13%) |
| admission | 90-99 | 122 (4%) | 673 (3%) | 795 (3%) |
| | ≥100 | 38 (1%) | 170 (1%) | 208 (1%) |
| Healthcare utilization within 12 months | <10 | 370 (11%) | 4,090 (19%) | 4,460 (18%) |
| before index admission* | 10-19 | 474 (14%) | 3,686 (17%) | 4,160 (17%) |
| | ≥20 | 2,630 (76%) | 13,365 (63%) | 15,995 (65%) |

Defined as number of service codes in claims

Figure 2. Correlation between Risk Score and Readmission Rate

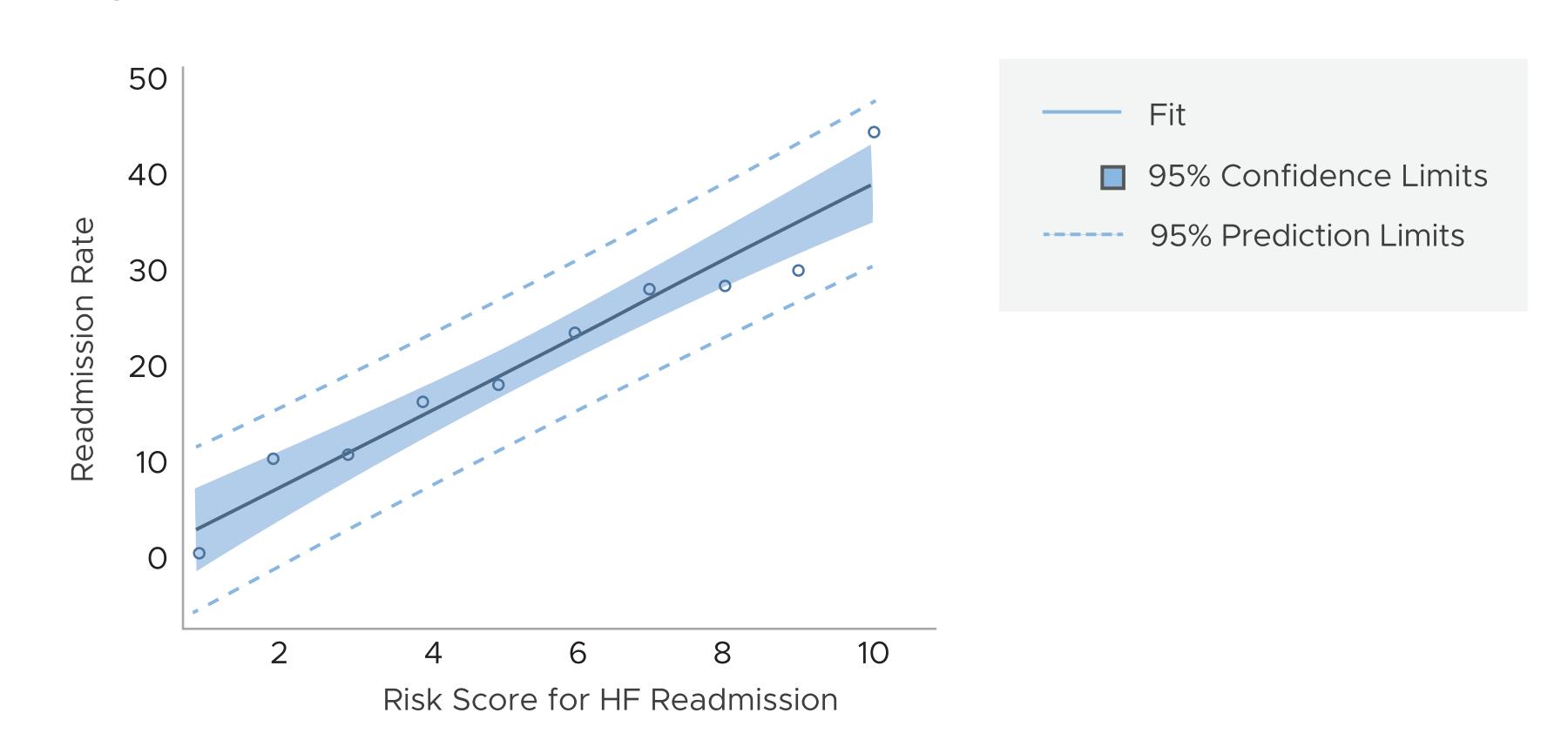


Figure 1. Odds Ratios for Predictors of HF Readmission

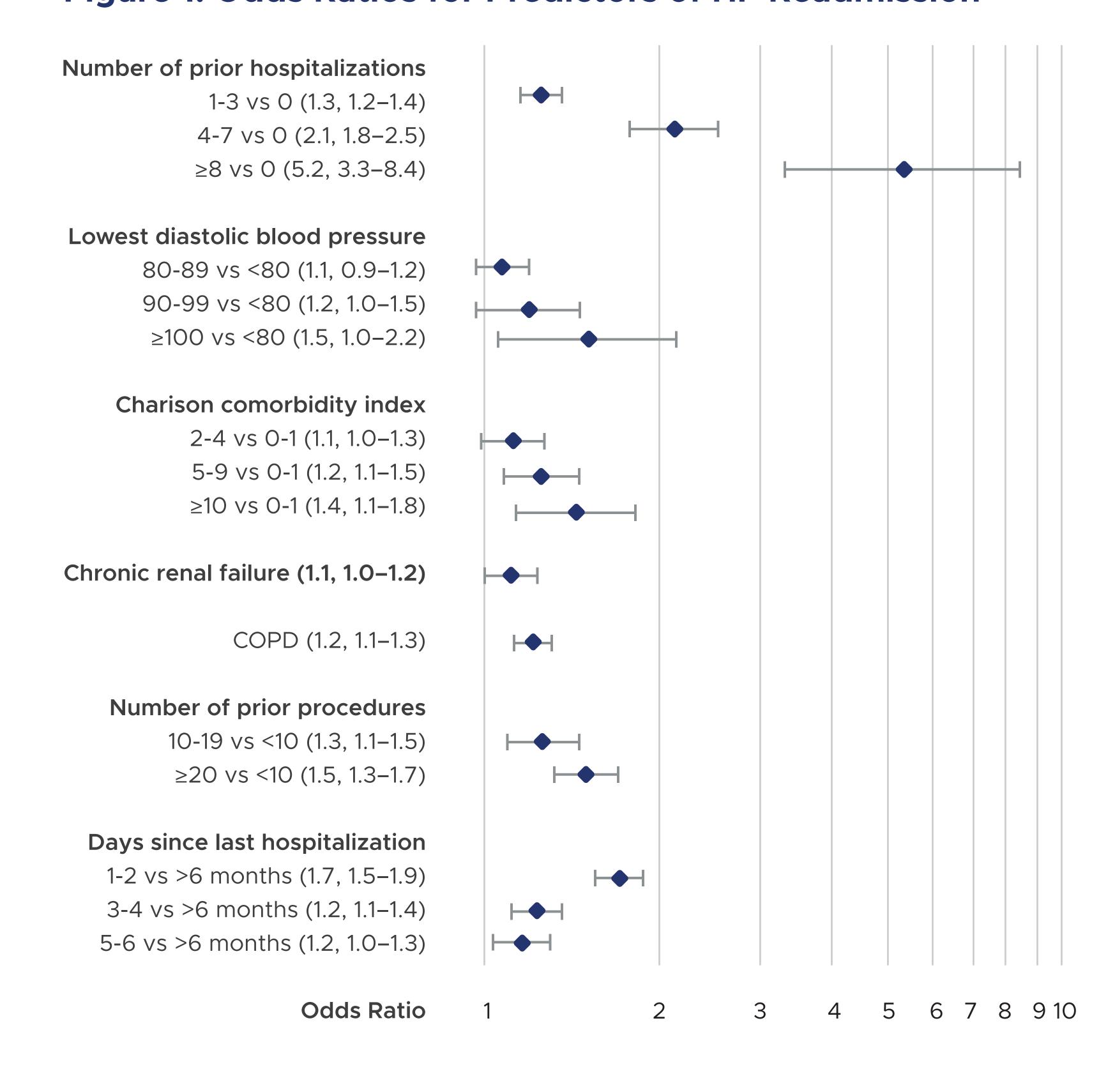
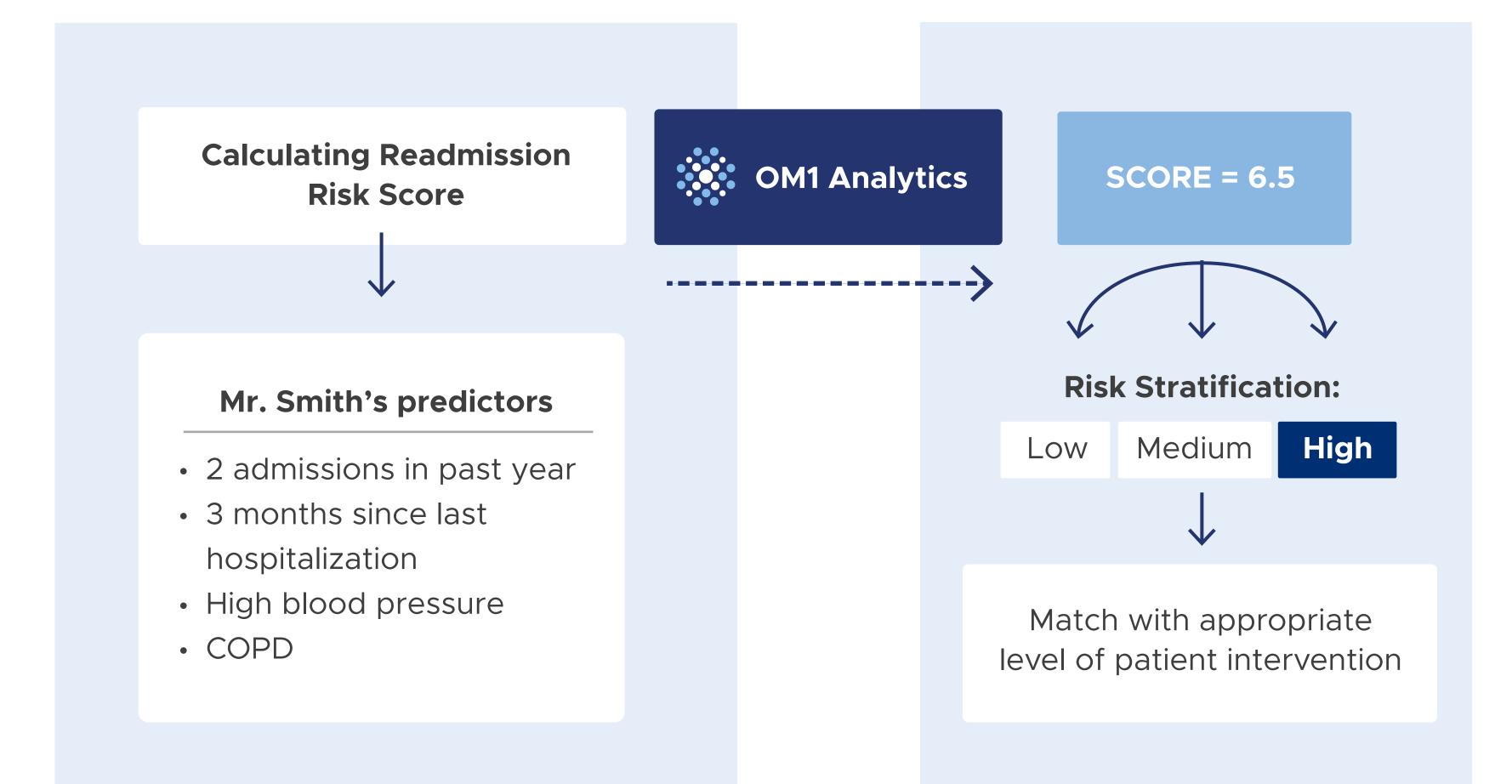


Figure 3. Application of Risk Score



Results (continued)

Of the 24,615 patients with index HF hospitalization, 3,109 (13%) were readmitted within 30 days and 365 (1.5%) died. Number of hospitalizations in the previous year, healthcare utilization in the previous year, Charlson comorbidity index, and months since last hospitalization were the strongest predictors. The risk score was highly correlated with the readmission rate (R2=0.94). Patients with a risk score of 5 or higher were considered at high risk for HF readmission. In the validation set, 1,855 (22.6%) patients were at high risk, with an average readmission rate of 22.5%. This compared to 6,351 (77.4%) patients at medium or low risk, with an average readmission rate of 11.6%. The overall mis-classification rate in the validation set was 26.5%.

Conclusions

We developed a simple score using data elements routinely collected in an outpatient setting to identify HF patients at risk for readmissions. Our model correctly predicted 30-day readmission or death prior to index HF admission, in at least 7 out of 10 randomly selected patients.

References

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