Assessing the Robustness of a Machine Learning Model for Predicting Asthma Hospital Encounters during the COVID-19 Pandemic

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Rationale: Asthma imposes a significant burden on healthcare. To better allocate limited preventive care management resources and improve patient outcomes, we recently used machine learning to build the world's most accurate model to predict asthma hospital encounters (emergency department visits or inpatient stays for asthma) in the subsequent 12 months. Under pre-pandemic conditions, the model reached an area under the receiver operating characteristic curve (AUC) of >0.9. Performance of the model under COVID-19 conditions had not been previously tested.
Objective: To assess the robustness of our predictive model during the COVID-19 pandemic.
Methods: The patient cohort included all 55,435 adult asthmatic patients who visited the University of Washington Medicine facilities between 2011-2020. For each year t ($2011 \leq t \leq 2020$), the corresponding effective data were of the patients who had asthma in t, included 71 features computed on these patients' data during 2011-t, and contained these patients' outcomes in t+1 as the prediction targets. For each outcome year y ($2019 \leq y \leq 2021$), the model was trained on the 2011-(y–2) effective data and then tested on the y–1 effective data.
Results: The model yielded an AUC of 0.929, 0.892, and 0.904 for the outcome years 2019 (pre-pandemic), 2020 (peri-pandemic), and 2021 (peri-pandemic), respectively (see Table 1).
Conclusion: Our model exhibited robust performance under COVID-19 pandemic conditions, which suggests suitability for future clinical application.

Table 1. For each of the outcome years 2019, 2020, and 2021, the training and test set statistics and the model performance measures.

Outcome year	2019	2020	2021
Time period of the effective data in the training set	2011-2017	2011-2018	2011-2019
Year of the effective data in the test set	2018	2019	2020
# of data instances in the training set	63,058	76,878	89,030
# of data instances linked to poor outcomes in the training set, *n* (%)	909 (1.4)	1,056 (1.4)	1,194 (1.3)
# of data instances in the test set	13,820	12,152	9,028
# of data instances linked to poor outcomes in the test set, *n* (%)	147 (1.1)	138 (1.1)	101 (1.1)
Area under the receiver operating characteristic curve	0.929	0.892	0.904
Accuracy (%)	90.64 (12,526/13,820)	90.45 (10,992/12,152)	90.52 (8,172/9,028)
Sensitivity (%)	79.59 (117/147)	69.57 (96/138)	72.28 (73/101)
Specificity (%)	90.76 (12,409/13,673)	90.69 (10,896/12,014)	90.72 (8,099/8,927)
Positive Predictive Value (%)	8.47 (117/1,381)	7.91 (96/1,214)	8.10 (73/901)
Negative Predictive Value (%)	99.76 (12,409/12,439)	99.62 (10,896/10,938)	99.66 (8,099/8,127)

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