Predicting Hospital Admissions and Emergency Department Visits in Patients Receiving Immune Checkpoint Inhibitors

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Background: Since the approval of Ipilimumab in 2011 use of immune checkpoint inhibitors (ICIs) has become a mainstay of cancer therapy with the potential to dramatically improve outcomes for even patients with advanced disease[1]. Despite the dramatic potential for these innovative therapies, ICIs come with side effects which can be extensive. Immune related adverse events (irAEs) have been reported in as many as 12-79% of patients taking ICIs and contribute to increased healthcare utilization by cancer patients[2, 3]. Analysis of irAEs is further complicated by a lack of unified nomenclature or diagnostic codes to categorize these events. Our team created a novel machine learning model to identify patients at risk of irAEs and target them for intervention in the outpatient setting before they require admission or emergency care.

Methods: Our model's training cohort consisted of all adult patients who received CTLA4 inhibitors and/or PD-1/PD-L1 inhibitors at Duke University Hospitals between October 2015-July 2021. We predict the risk of any ED visit or hospital admission within the next two weeks from time of prediction for the first 6 months a patient receives an ICI or until death or ICI cessation. Our score updates weekly to incorporate data from any new visits across the health system. Inputs for the model consisted of over 150 features including lab values, vitals, medication information, and encounter level data. We assessed the quality of our raw data for conformance, completeness, and plausibility. The model was trained using a light gradient boosted machine with an 80/20 train/test split, a learning rate of 0.2, and maximum tree number of 200 with 30% of our data sampled by each tree. Our model will be implemented in Duke's outpatient GU and thoracic oncology clinics. Clinicians will receive automated alerts when their patient is newly high risk, gather additional information as needed, and intervene if indicated by providing education about symptoms, when to visit the emergency room, or by scheduling the patient in our same day acute care clinic.

Results: Retrospective analysis comports with previously published studies. In our data, 33.5% of our 3962 unique patients had a hospital admission or ED visit in the first 6 months after ICI initiation with a median time of 6 weeks from time of ICI initiation. Outcomes were similar across medication type (36.7, 35.3, and 36.1% respectively). Consistent with the known difficulty capturing irAEs, only 14.4% of our outcomes (5.0% of the total cohort) could be clearly attributable to irAEs as measured by clinician identified ICD-10 codes. Model performance yielded an AUC of 0.76. The 5 most important factors to model prediction were length of time on immunotherapy, current albumin level, current white blood cell count, pulse, and thyroid stimulating hormone at time of ICI initiation.

Conclusion: Our model is designed to generate a risk score which easily encapsulates the likelihood of an ED visit or hospital admission in the next 2 weeks for patients on ICIs. Allowing providers to proactively intervene on patients at high risk of an adverse event will increase the utility and minimize risk of this important and rapidly growing field of cancer therapy.

References:

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