Validating a Machine-Learning Approach to Cancer Stage Identification Using Medicare Claims and SEER Data

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OBJECTIVE

- Administrative claims data can provide information about real-world costs, treatments, and mortality for millions of patients with cancer, but claims' diagnosis codes lack stage information, limiting research applications.
- Accurate assignment of cancer stage at diagnosis through claims would expand population research capabilities.
- This work aimed to build and validate a predictive machine-learning algorithm to assign patients' cancer stage at diagnosis using claims data.

METHODS

Patient Identification

- Patients with incident non-small cell lung cancer (NSCLC), colon cancer (CC), or rectal cancer (RC) diagnosed between 2016-2017 were identified using the SEER-Medicare data.
- In the SEER dataset, NSCLC, CC, and RC tumors diagnosed in 2016 and 2017 were identified using primary tumor codes, histology codes, and the diagnosis year listed in the registry. Patients with another tumor of a different type apparent in 2016-2017 were excluded from the analysis.
- Patients with <1 month of Medicare Parts A/B/D enrollment in 2016-2017, <12 months of A/B/D enrollment prior to the SEER diagnosis date, and cancer-related treatment within one year before index or prior cancer diagnoses were excluded. See **Table 1** for Patient Waterfall.

Data Setup and Machine Learning Model Development

- Patients' claims were flagged for evidence, frequency, and timing of cancer-related surgeries, anti-cancer therapies, microsatellite instability (MSI)/mismatch repair (MMR) testing, radiation therapies, metastatic diagnoses, hospice, and death.
- These clinical flags plus age, gender, race, frailty-related diagnoses, and nursing home residence were tested as predictors of patients' SEER-derived AJCC stage for each cancer type.
- The flagged patients were analyzed using predictive multinomial logistic regression (nnet package; Venables and Ripley 2002) with R Statistical Software (v4.1.2; R Core Team 2021).
- Patients "actual stage" was based on the derived AJCC stage associated with their primary incident tumor record in SEER.
- The model trained separately on 70% of each cancer sample and tested on 30%.

Table 1.

SEER-Medicare Patient Attrition			
Patient Criteria	**NSCLC**	**Colon**	**Rectal**
Patients in registry with tumor matching cancer type	138,444	79,530	19,160
2016 or 2017 year of first diagnosis	67,661	37,693	8,986
Meet Medicare enrollment requirements with no evidence of prior cancer treatment	24,670	13,024	2,628
SEER-derived AJCC stage available for tumor	13,494	7,145	1,424

Figure 1A.

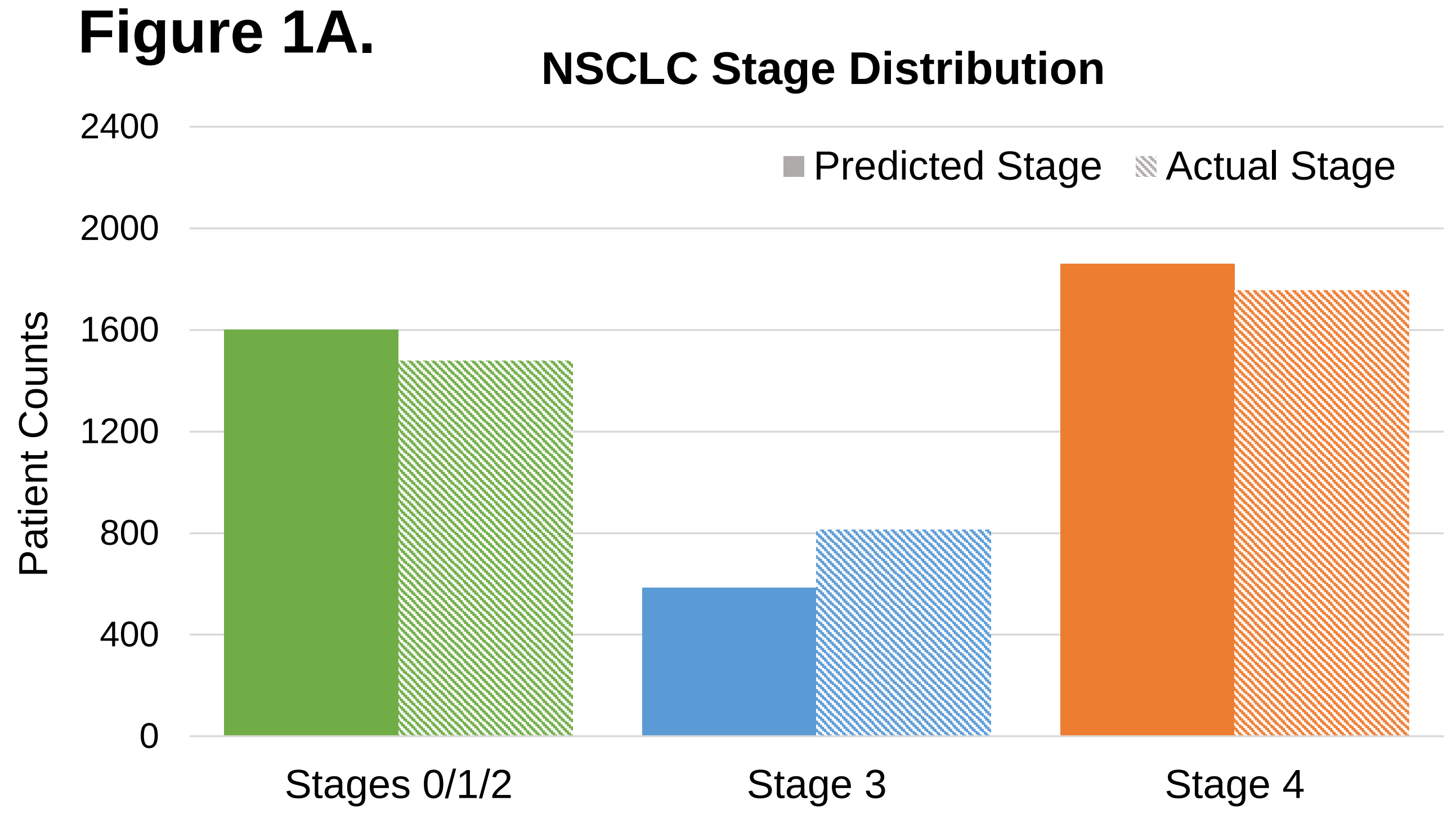


Figure 1B.

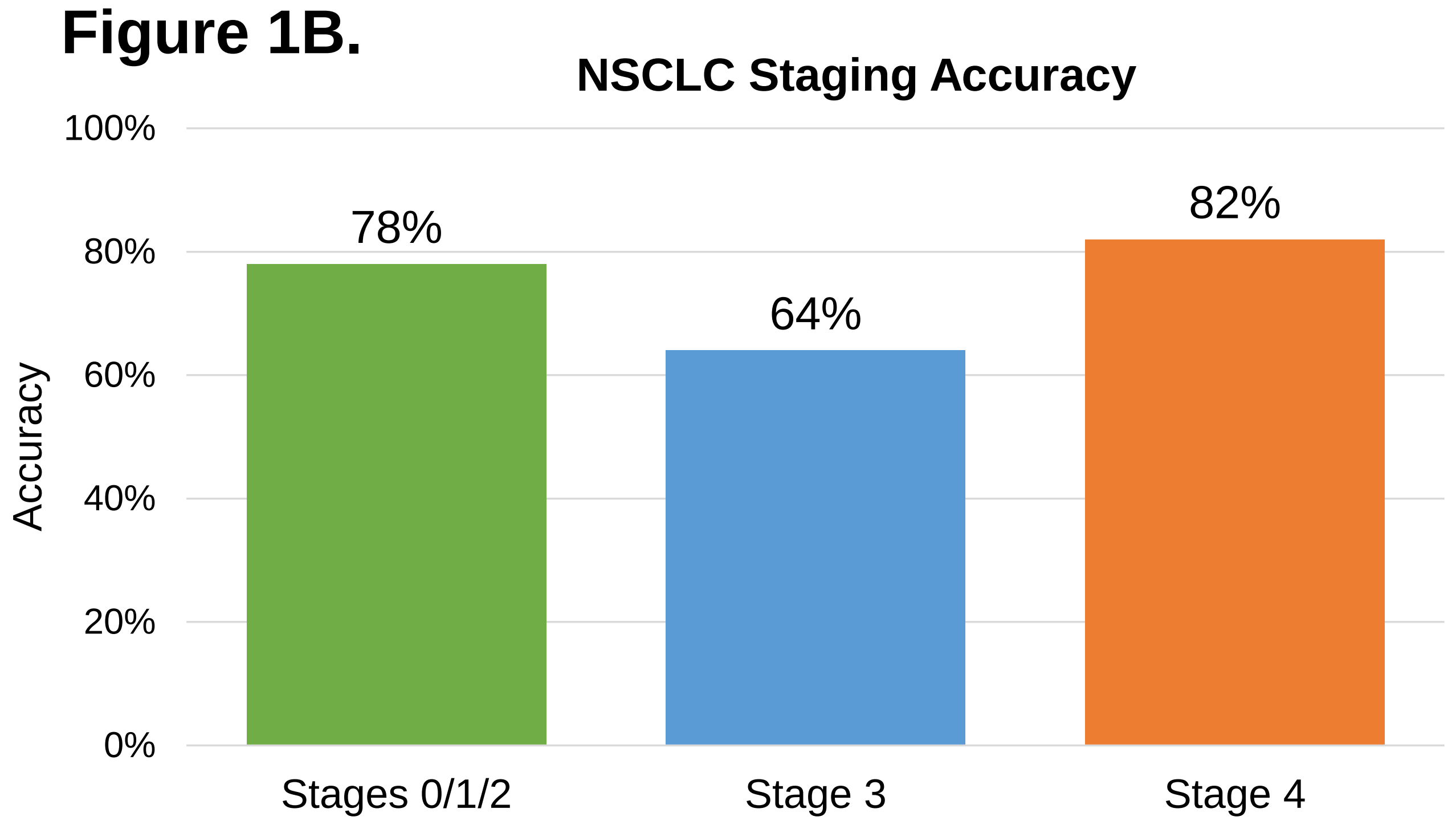


Figure 2A.

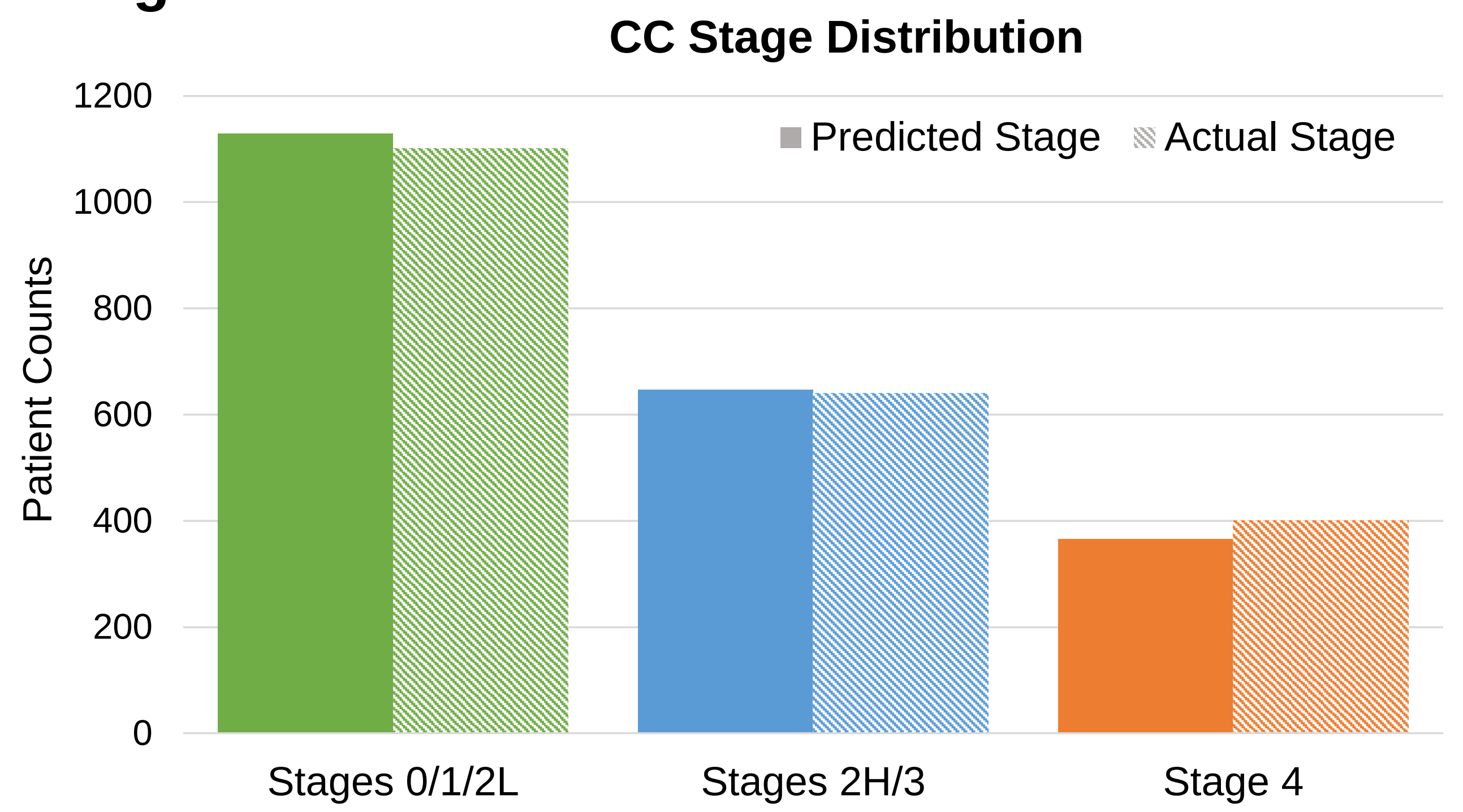


Figure 2B.

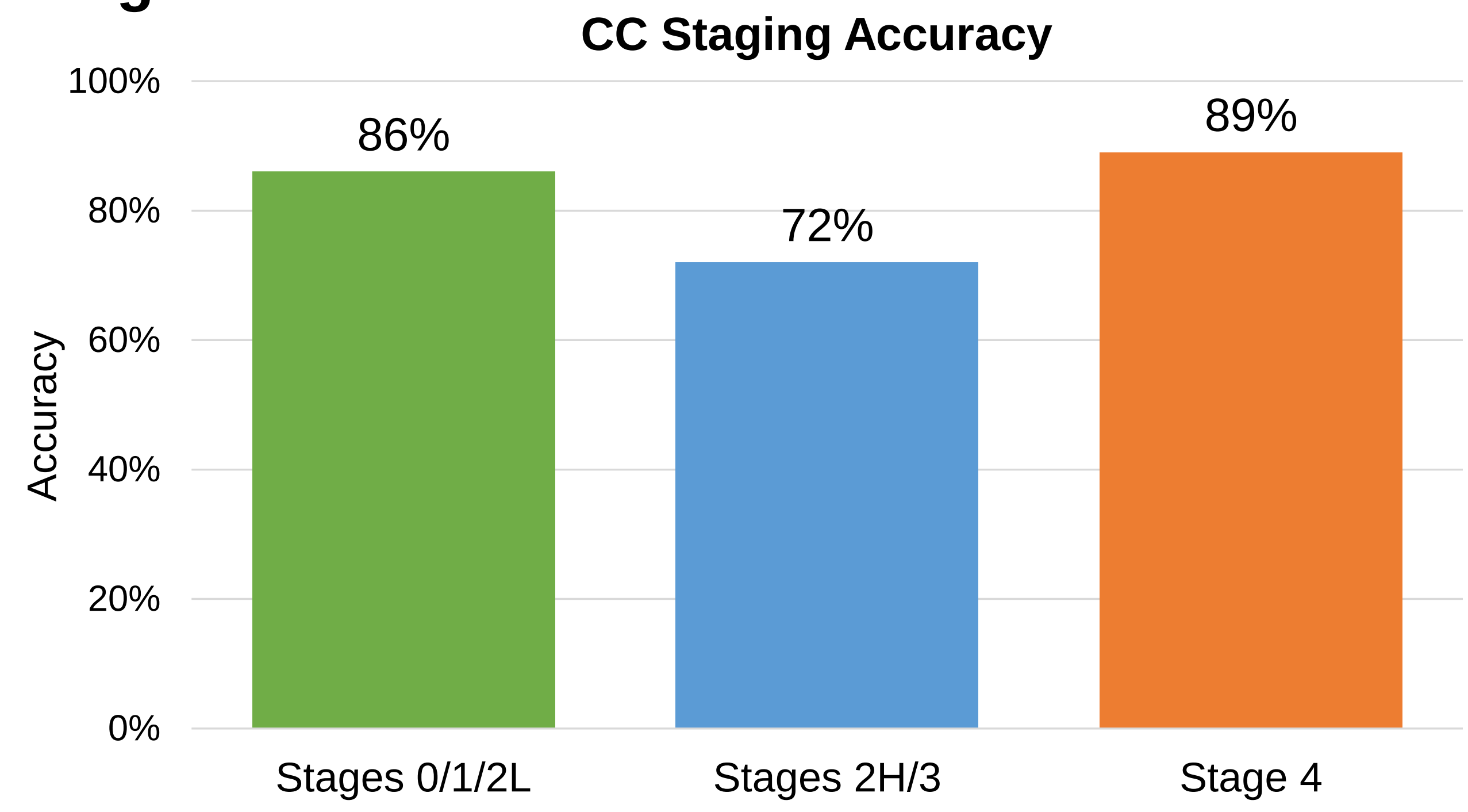


Figure 3A.

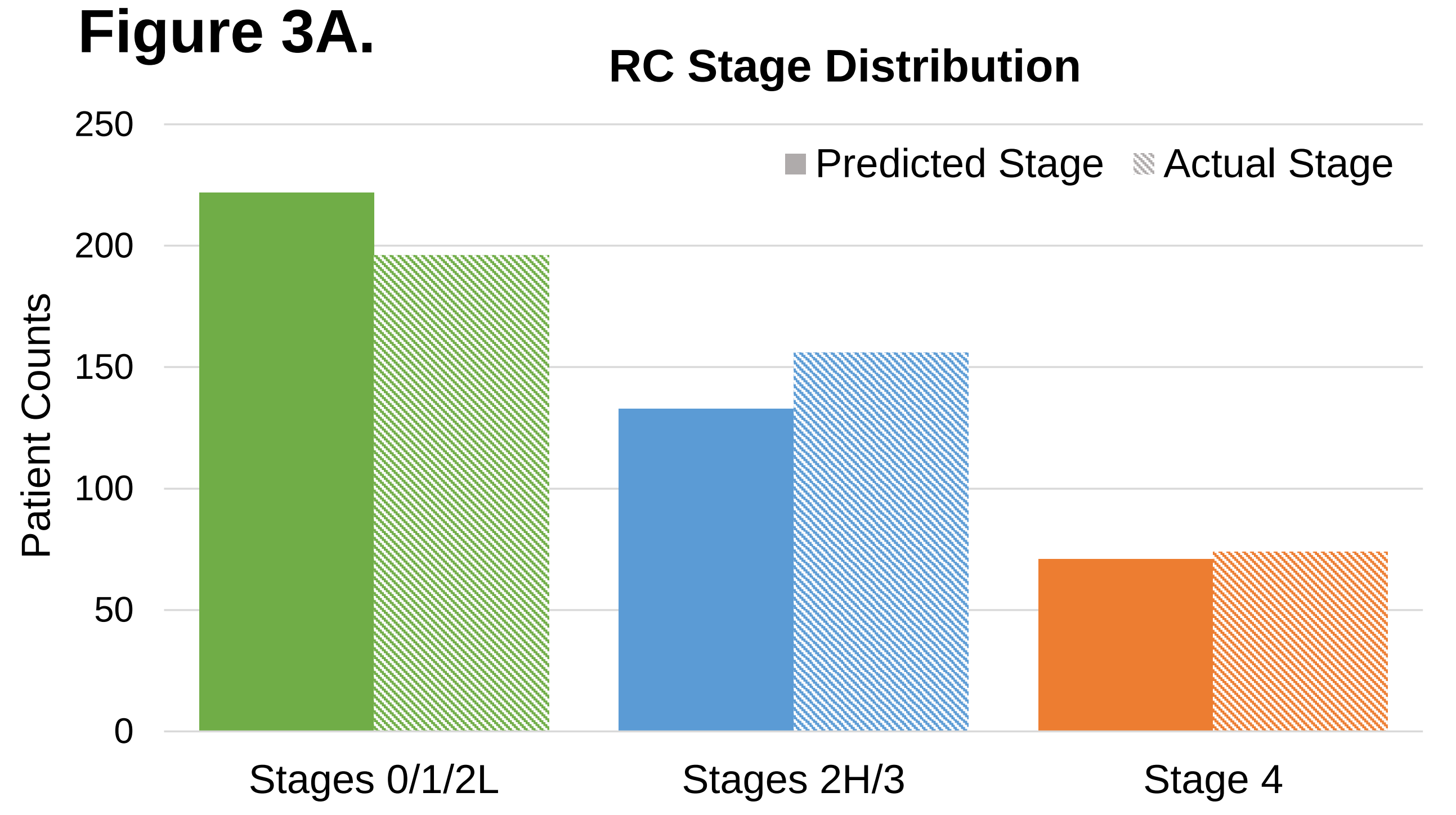
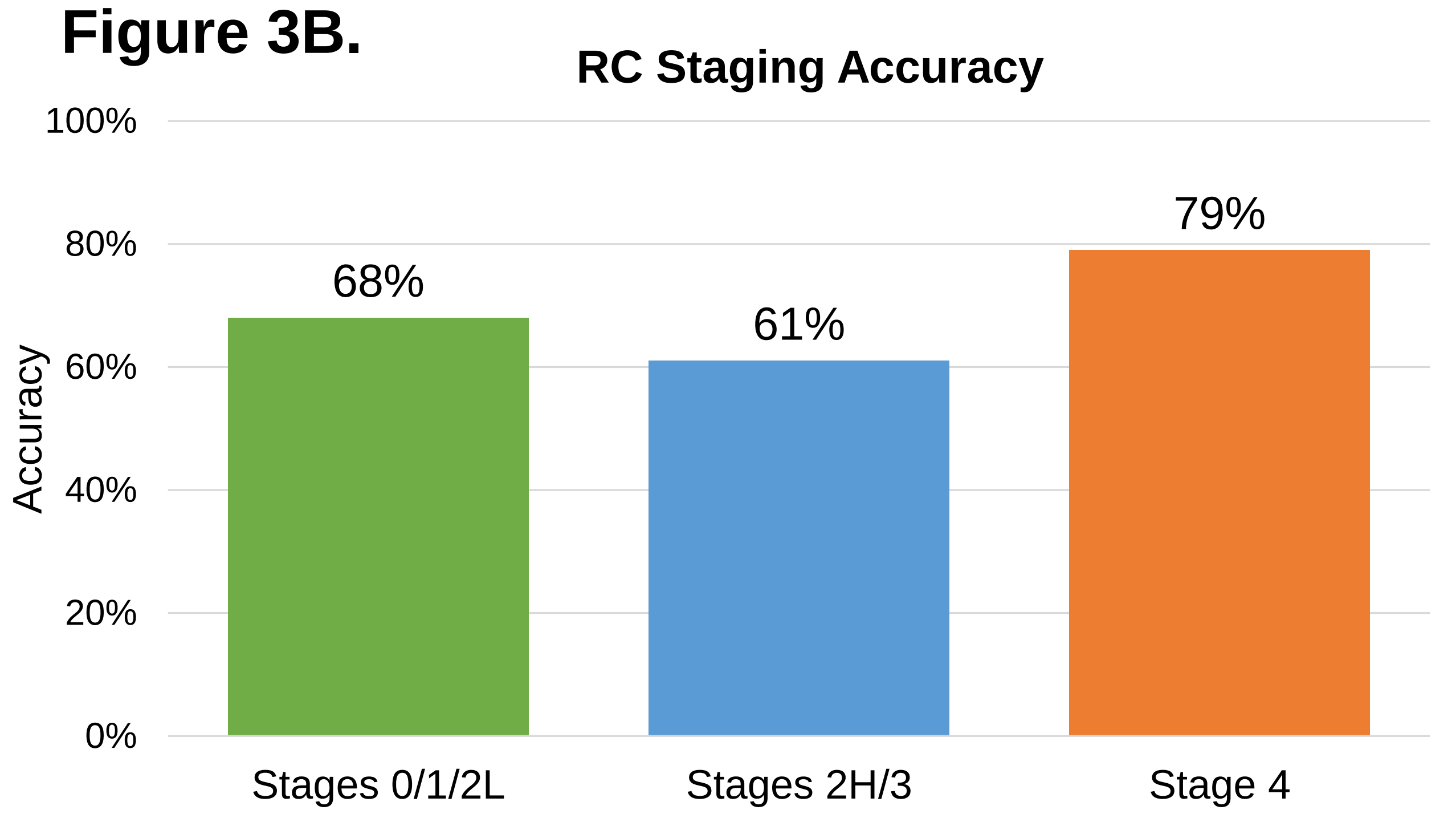


Figure 3B.



RESULTS

- The NSCLC (n = 13,494) overall staging accuracy was 77.5% [CI 76.2%-78.8%] (**Figures 1A & 1B**).
- The Colon Cancer (n = 7,145) overall staging accuracy was 82.3% [CI 80.6%-83.9%] (**Figures 2A & 2B**).
- The Rectal Cancer (n = 1,424) overall staging accuracy was 67.4% [CI 62.7%-71.8%] (**Figures 3A & 3B**).
- All models most accurately identified patients with stage 4 disease.
- Among all cancer types analyzed, metastatic diagnoses and surgery occurred sooner after diagnosis for stage 4 cohorts, but chemotherapy was received later after diagnosis when compared to stage 0/1/2 cohorts. Stereotactic ablative radiotherapy (SABR) was more common for stage 0/1/2 cohorts. Table 2 shows key stage predictors for each cancer.

Table 2.

Key Predictors of Cancer Stage		
NSCLC	**Colon**	**Rectal**
Metastatic Diagnoses		
SABR (radiotherapy)	Frailty	Days to 1st Surgery
Cisplatin/ Carboplatin Regimen	Days to 1st Chemo Treatment	Days to 1st MSI/MMR Testing
Evidence of Hospice Care	Evidence of Chemotherapy	Evidence of Hospice Care

CONCLUSION

- Multinomial logistic regression using claims data accurately predicts stage at diagnosis for patients with NSCLC, CC, and RC. We were able to identify several significant predictors from claims data that can distinguish stage within each cancer type.
- These findings suggest machine-learning algorithms may be a viable approach for assigning patients' cancer stages at diagnosis when analyzing administrative claims data.
- This work could facilitate widespread analyses of cancer costs by stage and the impacts of early detection and treatment.
- Future validation on more recent data could be useful for incorporating new or emerging treatment advancements into the model.

Limitations

- Practice patterns change over time as new treatments emerge. This model will need to be retrained on future data and retested to evaluate accuracy.
- There is likely a ceiling on the accuracy of machine learning models due to variation in practice patterns, individual patient care, and other characteristics that cannot be accounted for by such models.
- The inclusion of mortality in this model could limit its applications. For example, studies of survival by stage may be less reliable if survival status were used to predict stage.

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