Employing Explainable Artificial Intelligence (XAI) to Predict Cachexia Among Patients With Pancreatic or Oral Cavity Cancers.

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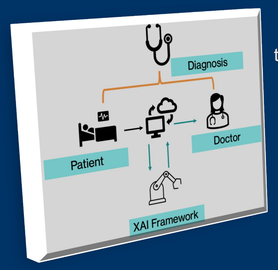
Abstract

Future clinical decision-making is expected to be influenced by machine learning (ML) and eXplainable Artificial intelligence (XAI) techniques. XAI algorithms may be of particular value in informing the best supportive cancer care(SCC). Here, using ML algorithms and XAI-based interpretation, we predicted cachexia in patients with pancreatic (PC) or oral cavity cancers (OC).

We applied predictive analytics (PA), XAI, and machine learning (ML) techniques to the National Inpatient Sample database modeling with linear and non-linear machine learning (ML) [Lasso, Ridge, and Random Forest (RF)]. Additionally, for XAI, we utilized Neural Networks (NN) and RF. The datasets were divided into training and test sets, with 70% for training and 30% for testing. We also employed XAI techniques, including permutation importance, global surrogate marker, feature interpretation, interaction, and local interpretability.

The cachexia study population consisted of 750 patients with PC and 1885 patients with OC. The feature selection methods successfully identified demographic, socioeconomic, and clinical variables. Linear models, Lasso and Ridge, showed an area under the ROC for all cohorts (>0.9 defined as excellent in training and test datasets). In contrast, tree-based models, such as RF, were less consistent, only performing excellently in the PC cohorts (AUC 0.99 train and 0.92 for test) but 0.99 in the training and 0.85 in test datasets for OC for techniques showed that those aged>70 years, Blacks, and those residing in low-income neighborhoods were associated with increased cachexia risk. Weight loss was consistently coupled with drug addiction, congestive heart failure, and chronic pulmonary disease.

We demonstrate the growing potential of PA, including XAI, in predicting cancer-related cachexia. Coupled with the mountains of data resulting from the digitalization of healthcare systems, the computational capabilities of modern servers to create ML-based care pathways pave the way for a revolution in SCC's clinical decision-making.



Utility of the AI framework

Introduction

The United States experiences a decrease in the number of deaths caused by cancer, there is a simultaneous rise in the amount of funds dedicated to supporting individuals who have survived cancer. The hospitalization expenses for patients with cachexia were 44.36% greater. Moreover, it has been observed that each additional day spent in the hospital is consistently associated with a substantial rise of $2040.59 in the total costs of hospitalization. The mortality rate for persons diagnosed with cancer cachexia within the first 12 months was determined to be 30.2% (with a 95% confidence interval of 28.4% to 32.0%), resulting in an incidence rate of 226.07 cases per 1000 patient-years.

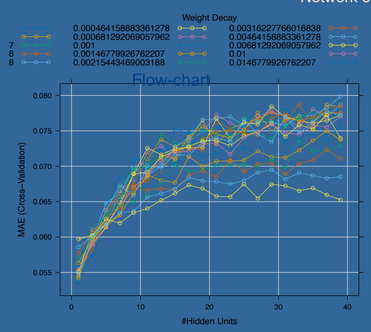
The application of prediction models in cancer survivorship is a relatively recent advancement. To comprehend the factors linked to cachexia hospitalizations and identify predictors of cachexia, we employed a combination of clinically relevant features and a machine learning approach for feature selection. Additionally, we utilized explainable artificial intelligence (XAI) to provide explanations for the predictions.

Methods

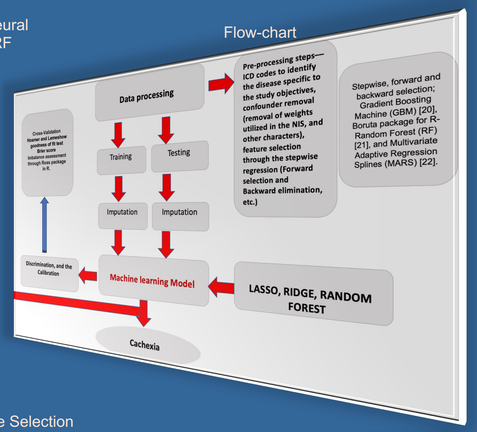
The investigation included hospitalized individuals who were experiencing cachexia. We utilized ICD-10-CM codes to identify patients with cachexia (R64) who have either a history of pancreatic cancers (Z8507), a personal history of malignant neoplasms of the tongue (Z85810), or a personal history of malignant neoplasms of other sites of the lip, oral cavity, and pharynx (Z85819). In this research, our aim was to utilize all relevant and medically significant components. The study included covariates that encompassed both patient-level and clinical-level factors, including co-morbidities.

We utilized predictive analytics (PA), explainable artificial intelligence (XAI), and machine learning (ML) methodologies to analyze the National Inpatient Sample database. We employed both linear and non-linear ML techniques, including Lasso, Ridge, and Random Forest (RF) models. In addition, we employed Neural Networks (NN) and Random Forest (RF) for XAI. The datasets were partitioned into training and test sets, allocating 70% of the data for training and 30% for testing. In addition, we utilized XAI methodologies such as permutation importance, global surrogate marker, feature interpretation, interactivity, and local interpretability.

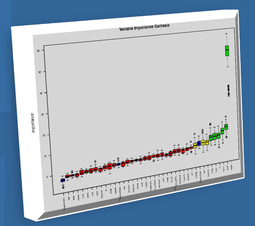
Explain with Neural Network or RF

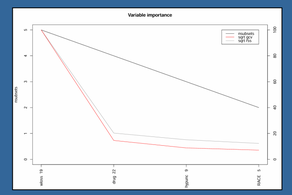


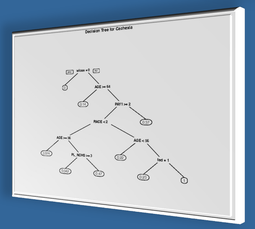
Flow-chart

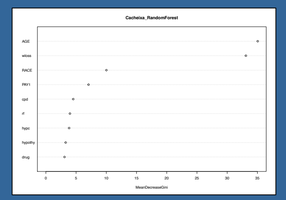


Variable Selection

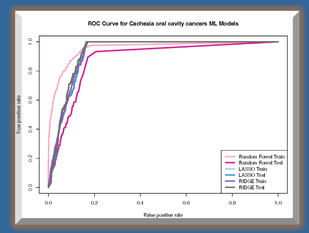


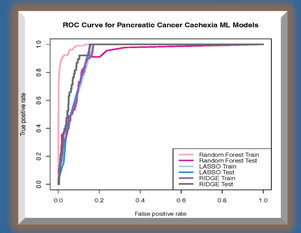




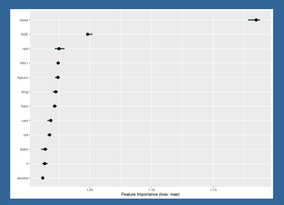


Random Forest

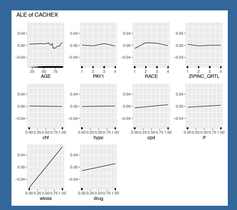




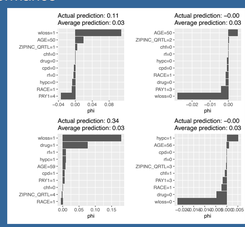
Discriminating Performance



XAI-Neural network-based Tree



Accumulated Local Effect plot



NN based Explainable plot

Results

The study population for cachexia included 750 patients diagnosed with pancreatic cancer (PC) and 1885 individuals diagnosed with oral cancer (OC). The feature selection approaches effectively detected demographic, socioeconomic, and clinical characteristics. The linear models, Lasso and Ridge, demonstrated an area under the ROC curve greater than 0.9, which is considered excellent, in both the training and test datasets for all cohorts. Tree-based models, like RF, showed less consistency compared to other models. They performed exceptionally well in the PC cohorts (AUC 0.99 train and 0.92 test), but in the OC cohorts, the performance was 0.99 in training and 0.85 in testing datasets. The analysis revealed that individuals aged>70 years, Blacks, and those living in low-income neighborhoods had a higher risk of cachexia. Weight loss was consistently associated with drug addiction, congestive heart failure, and chronic pulmonary illness. In addition, the neural network and random forest algorithms provided further understanding of the underlying variables contributing to machine learning algorithms' interpretability. The XAI analysis indicated that several factors, such as weight loss, drug addiction, age, race (specifically Blacks pancreatic cancer), living in low-income neighborhoods (pancreatic cancer), renal failure, and chronic pulmonary disease, were found to be significant variables in predicting cachexia.

Conclusions

We showcase the increasing promise of predictive analytics with XAI, for the prediction of cachexia associated with cancer. A paradigm shift in clinical decision-making at supportive care is possible thanks to the computational power of contemporary servers, the deluge of data produced by healthcare IT digitization, and the development of ML-based care pathways.

References

1. Satheesh Kumar Poolakkad Sankaran et al., Employing machine learning (ML) and explainable artificial intelligence (XAI) to predict and explain suicidal ideation among patients with prostate cancer.. JCO 42, e23086-e23086(2024). DOI:10.1200/JCO.2024.42.16_suppl.e23086