Machine Learning Models in Prediction of Head and Neck Squamous Cell Carcinoma Survivability

Rohatgi O[1], Agrawal N[1], Goswami S, [1] Vivek V[1], Chaudhuri M[1], Aparasu RR[2]

[1]Complete HEOR Solutions (CHEORS), PA, 18914, USA;
[2]University of Houston College of Pharmacy, Houston, TX

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KEY POINTS

Machine learning models were found to have improved efficiency over the logistic regression model, in prediction of Head and Neck Squamous Cell Carcinoma Survivability

BACKGROUND

- Head and neck squamous cell carcinoma (HNSCC) is the sixth most commonly malignancy develop in oral cavity, pharynx, and larynx[1]
- Predicting the survival of a patient is one of the most challenging tasks for a physician
- Machine Learning (ML) is a subfield of artificial intelligence, that learns and discovers complex data patterns.
- Decision trees (DT), Random Forest (RF), and Support vector machines (SVM) are commonly used ML algorithms.
- Although ML algorithms are often used in healthcare, there is limited competitive data to model the survivability among patients with HNSCC.

The 5-year overall survival rate of patients with HNSCC is 40–50%[2]

OBJECTIVE

To evaluate the performance of common ML models in predicting the 5-year overall survival of patients with HNSCC

METHOD

Data Source:
Surveillance, Epidemiology, and End Results (SEER) 17 registries database

Study Population:
Patients of age ≥20 years with HNSCC in Larynx, Nasopharynx, Oral Cavity, Oropharyngeal, and Sinonasal Cavity (identified using ICD-O3 and histology type codes) were selected from SEER database during 2008-19

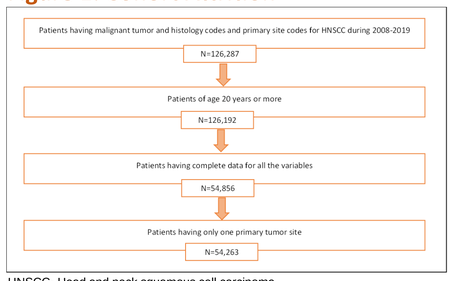
Outcome:
5-year overall survivability among patients with HNSCC

Statistical Analysis:
- Logistic regression (LR), DT, RF, and SVM models were developed
- Dataset was split into training and validation set in 70%-30% ratio. The models were validated on the hold out sample.
- Accuracy, AUROC curve, and F1 score were used to evaluate the model performance

RESULTS

- The study included 54,263 patients with HNSCC. Most of the selected patients were White (84.3%), male (74.0%), and of age ≥65 years (44.9%) (Table 1)

Figure 1: Cohort Attrition



HNSCC- Head and neck squamous cell carcinoma

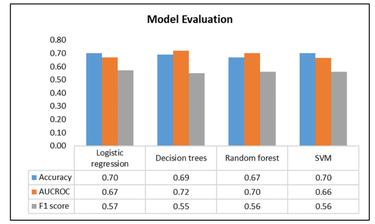
- For majority of selected patients, primary site of tumor was oropharyngeal (39.4%), followed by oral cavity (33.1%), larynx (17.6%), sinonasal cavity (7.7%), and nasopharynx (2.2%) (Table 1)
- Based on AU-ROC score, DT (0.72) showcased the best distinguishing capability, followed by RF (0.70), LR (0.67), and SVM (0.66) models (Figure 3)
- However, LR (0.70) and SVM (0.70) had higher accuracy followed by DT (0.69) and RF (0.67) models (Figure 2)
- The Average F1 score was 0.57 and was similar for all the models (Figure 2)

Table 1: Patient Characteristics

Demographic Characteristics (N=54,263)	
Age groups N (%)	
20-44 years	2,364 (4.4)
45-54 years	9,550 (17.6)
55-64 years	17,958 (33.1)
65+ years	24,391 (44.9)
Sex N (%)	
Female	14,090 (26.0)
Male	40,173 (74.0)
Year of diagnosis N (%)	
2008-11	18,061 (33.3%)
2012-15	20,821 (38.4%)
2016-19	15,381 (28.3%)
Race N (%)	
Black	4,924 (9.1)
White	45,748 (84.3)
Other	3,591 (6.6)
Marital status N (%)	
Married/ domestic partner	30,442 (56.1)
Unmarried	23,821 (43.9)
Income N (%)	
<$55,000	15,063 (27.8)
$55,000-$75,000	23,867 (44.0)
$75,000+	15,333 (28.3)
Urbanicity N (%)	
Metro	46,207 (85.2)
Non-metro	8,056 (14.8)

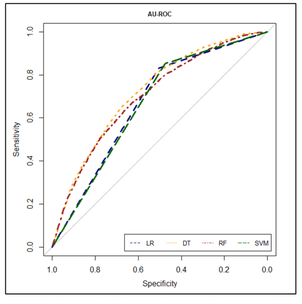
Clinical Characteristics (N=54,263)	
Stage N (%)	
Distant	10,545 (19.4)
Localized	15,752 (29.0)
Regional	27,703 (51.1)
Unknown/unstaged/In situ	263 (0.5)
Radiation N (%)	
Yes	36,958 (68.1)
None/unknown/refused	17,305 (31.9)
Chemotherapy N (%)	
Yes	24,639 (45.4)
No/Unknown	29,624 (54.6)
Grade N (%)	
Moderately differentiated	27,076 (49.9)
Well differentiated	7,314 (13.5)
Poorly differentiated/ Undifferentiated	19,873 (36.6)
Surgery at primary site N (%)	
Yes	32,882 (60.6)
No	21,381 (39.4)
Primary tumor site N (%)	
Larynx	9,525 (17.6)
Nasopharynx	1,168 (2.2)
Oral Cavity	17,981 (33.1)
Oropharyngeal	21,401 (39.4)
Sinonasal Cavity	4,188 (7.7)
Tumor size (in cm) N (%)	
<1	5,064 (9.3)
1-1.9	10,874 (20.0)
2-3.9	23,970 (44.2)
>4	14,355 (26.5)
5-year survival N (%)	
1 (Alive)	32,717 (60.3)
0 (death)	21,546 (39.7)

Figure 2: Model Evaluation Metrics



AUROC- Area under the receiver operating curve; SVM- Support Vector Machine

Figure 3: AUROC Score



AUROC- Area under the receiver operating curve; SVM- Support Vector Machine; LR- Logistic Regression; DT- Decision Trees; RF- Random Forest

CONCLUSIONS

- The study found all ML models were in the acceptable range with DT exhibiting best performance based on the AUROC score.
- This study provides a step forward to utilize ML-based methods to predict patients' chances of survival and can provide decision aid for cancer management
- However, these methods need to be validated externally to develop reliable and generalizable ML models.

LIMITATIONS

- Cases with multiple primary sites can impact survivability and were not considered in this analysis which might influence the model performance
- The SEER database has inherent limitations as it does not report environmental and behavioral risk factors.
- SEER database also lacks human papillomavirus (HPV) status-related information which can impact HNSCC survivability and affect the model performance

For any questions please email: swarnali.goswami@cheors.com

Contact us:

CONFLICT OF INTEREST

• No funding was received from any external organization
• The authors report no other conflicts of interest in this work

References

1. Johnson DE, Burtness B, Leemans CR, Lui VW, Bauman JE, Grandis JR. , "Head and neck squamous cell carcinoma.," Nature reviews Disease primers, vol. 6, no. 1, pp. 1-22, 2020.
2. Lu, L., Wu, Y., Feng, M., Xue, X., Fan, "A novel seven miRNA prognostic model to predict overall survival in head and neck squamous cell carcinoma patients," Molecular Medicine Reports, vol. 20, no. 5, pp. 4340-48, 2019.
3. Du E, Mazul AL, Farquhar D, Brennan P, Anantharaman D, Abedi-Ardekani B, Weissler MC, Hayes DN, Olshan AF, Zevallos JP., "Long-term survival in head and neck cancer: impact of site, stage, smoking, and human papillomavirus status.," The Laryngoscope, vol. 129, no. 11, pp. 2506-13, 2019.
4. Surveillance, Epidemiology, and End Results (SEER) Program (www.seer.cancer.gov) SEER*Stat Database: Incidence - SEER Research Data, 17 Registries, Nov 2021 Sub (1975-2019) - Linked To County Attributes - Time Dependent (1990-2019) Income/Rurality, 1969-2020 Counties, National Cancer Institute, DCCPS, Surveillance Research Program, released April 2022, based on the November 2021 submission.