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# A Longitudinal Study on the Socio-Psychological Predictors of Smoking Relapse Among Head and Neck Cancer Survivors

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## ABSTRACT

**Objectives:** This research seeks to understand the longitudinal social-psychological predictors that influence smoking relapse in patients surviving head and neck squamous cell carcinoma (HNSCC). Post-treatment relapse smoking rates remain high despite the association of continued smoking with a poor prognosis. This study attempts to develop a predictive model integrating psychosocial stressors, behavioral factors, and population characteristics to refine prevention strategies. **Methods:** A cohort of 312 HNSCC survivors was enrolled and followed for 18 months. Participants were interviewed 6, 12, and 18 months after treatment. Comprehensive interviews were conducted at the end of primary therapy, gathering demographic information, smoking history, and psychological evaluation (depression, anxiety, perceived stress), levels of social support, and health behavior scores. The data were analyzed using multivariate logistic regression and Cox proportional hazard modeling to measure time-to-relapse and determine independent predictors. Psychometric instruments utilized PSS, HADS, and MSPSS. **Results:** Of participants, 36.5 percent had relapsed by the 18-month mark. Accumulated stress (PSS > 20) and lack of social support (MSPSS < 50), paired with depressive symptoms (HADS-D ≥ 8), were associated with greater risk of relapse. Moreover, low socioeconomic status, particularly income and employment, was linked to failure to maintain abstinence (HR = 2.18; 95% CI: 1.40–3.42). Strong provider reinforcement plus counseling post-treatment was associated with significantly lower relapse rates, indicating the impact of psychosocial support. **Conclusion:** Head and neck cancer survivors are deeply affected by social-psychological factors, especially stress, depression, and insufficient support in relation to smoking relapse. This study underscores the importance of developing comprehensive survivorship care systems that integrate routine psychological evaluations and active, holistic behavioral strategies to lower relapse risk and enhance long-term prognosis.

**Keywords:** *Smoking relapse;Psychosocial predictors;Longitudinal study;Behavioral Oncology*

## INTRODUCTION

Head and neck squamous cell carcinoma (HNSCC) is one of the most common cancers in the world, with nearly 890,000 new cases and over 450,000 deaths each year(Sung et al., 2021). It is well known that tobacco use has a causal relationship with HNSCC. Smoking accounts for more than 75% of cases, either alone or together with alcohol (Hashibe et al., 2009; Blot et al., 1988). Even so, a significant number of people who were treated for cancer continue to smoke after being diagnosed, which not only undermines the treatment but also increases the chances of recurrence, second primary tumors, and complications related to treatment. (KA et al., 1998;Duffy et al., 2012;Gritz et al., 2013).

Relapse to smoking post HNSCC treatment is a clinical issue, with reported rates of relapse between 30% and 60% in the first 12 to 24 months post treatment. (Gritz et al., 1994;Klesges et al., 1996). While the physiological side of smoking addiction is well understood, there is a growing body of evidence that socio-psychological factors in post-survivorship strongly influence smoking behavior (Park et al., 2009; Schnoll et al., 2004). Mental distress, like anxiety and depression, is known to be greater in head and neck cancer survivors, compared to other cancers, because of the functional impairments from the disease and its treatment (speech difficulties, disfigurement, and dysphagia) (Hammerlid et al., 1995;Vartanian et al., 2004).

The issue of psychosocial stress has recently come to light in relation to smoking relapses. Prolonged stress levels have been shown to be associated with a lack of self-control and an increase in one's susceptibility to harmful coping techniques such as using drugs or alcohol (Cohen et al., 1991). Perceived stress scores that are higher than normal, especially for mentally unwell individuals, correlate strongly with relapse episodes (Dube et al., 2005). In contrast, social support is seen as a protective factor. Support from family members, peers, or professionals improves one's emotional regulation and resilience, and therefore significantly reduces chances of relapse (Berkman et al., 2003; Holt-Lunstad et al., 2010).

HNSCC (Head and Neck Squamous Cell Carcinoma) survivors experience depression and anxiety more frequently, and these conditions have been linked to smoking relapses. Psychometric tools such as HADS show that patients with clinically moderate to severe depressive symptoms have an almost 2 times higher probability of smoking relapse than their non-depressed counterparts (Addington et al., 1999; Borrelli et al., 2012). Furthermore, social isolation and a lack of social reinforcement place these survivors at greater risk, notably within low-income and underinsured groups (McBride et al., 2000).

The Health Belief Model and the Theory of Planned Behavior have been applied to understand the smoking relapse phenomenon in cancer patients. These models define smoking abstinence as having long-term benefits limited to perceived susceptibility and self-efficacy (Ajzen, 1991; Duffy et al., 2002). However, these models are enhanced in predictive accuracy when combined with longitudinal psychological and demographic data. Psychosocial vulnerability and health literacy have recently been shown to create unique risk profiles among survivors using latent class analysis (Gritz et al., 1999).

Psychosocial variables, along with one's level of education, employment, and marital status, have been found to interact with relapse trajectories. One correlating variable of greater interest is low SES, which has consistently demonstrated a greater risk of smoking relapse, due to limited cessation resources as well as intense psychosocial stressors(Cohen et al.,

2007;Sinha, 2008).

There has been a focus on smoking cessation in cancer patients and HNSCC survivors; however, few have taken the time to analyze the relapse patterns over time. Most studies are either cross-sectional or heavily rely on retrospective recall, which does not capture the full range of psychological factors that evolve in light of survivorship (Anda et al., 1990). It is critical to understand the relapse pattern from a longitudinal perspective, so that the major focal points: who relapses, when they relapse, and what psychosocial factors play a role in the relapse can be understood.

Additionally, mental health issues have not been integrated as consistently into survivorship care plans, leaving gaps in clinical practice. Routine screening and CBT-focused behavioral counseling, tailored to aid in smoking cessation, are often overlooked even though evidence supports their substantial positive impact on smoking cessation rates (Hitsman et al., 2013; Rieke et al., 2017). Some studies have shown that emotionally regulated peer-based support groups bolstered with CBT and MBSR are effective at helping individuals stay smoke-free for longer periods of time (Thoits, 2011;Christakis & Fowler, 2008).

Taking into consideration the high-risk population that faces both psychological and social dimensions, and smoking addiction, a well-structured approach needs to address the multifactorial aspect of the problem. An 18-month longitudinal study on HNSCC survivors' post-treatment seeks to understand the socio-psychological predictors of smoking relapse with this approach.

The aim of this study is to determine the most important psychosocial risk factors for smoking relapse among HNSCC survivors—stress, depression, social support, and even their finances—and help in creating focused strategies for helping people quit for good.

## MATERIALS AND METHODS

### 1. Study Design and Population

This research was planned as a longitudinal cohort study with a prospective design. The selection criteria included participants within the age range of above eighteen years who were previously afflicted with head and neck squamous cell carcinoma (HNSCC) and had undergone curative treatments like surgeries, radiotherapy, or chemotherapy as confirmed through histological diagnostics. Subjects were enrolled from two multidisciplinary cancer centers between January 2020 and April 2021.

### 1.1 Inclusion and Exclusion Criteria

Participants were chosen by applying strict eligibility criteria to ensure clinical uniformity and reduce bias.

#### 1.1.1 Inclusion Criteria

Participants were required to have head and neck squamous cell carcinoma (HNSCC) involving the oral cavity, oropharynx, hypopharynx, or larynx segments. Considered participants were only those who had undergone a curative-intent treatment (surgery, radiotherapy, chemotherapy, or a combination of these) within the previous three months. Also, suitable participants required a smoking history within six months of the diagnosis, clinically confirmed disease-free status at the time of enrollment, and the capacity to give informed consent as well as complete appropriate psychosocial evaluations.

**1.1.2 Exclusion Criteria**

Members of the study were eliminated if they had past documented mental health issues that would hinder their ability to provide informed consent or fill out the necessary questionnaires. Other criteria for exclusion included individuals undergoing palliative treatment or those with advanced cancer. Individuals utilizing nicotine replacement therapies or pharmacologic smoking cessation aids during the study period were also excluded, as these treatments would interfere with measuring behavioral outcomes.

**2. Data Collection**

Data was collected at four intervals: baseline (within a month of receiving treatment), and at 6, 12, and 18 months. Each visit included a clinical interview and a set of standardized psychosocial tests. Information was collected, including smoking status, demographic data, psychosocial stress, depression, social support, as well as clinical and treatment history. This approach helped to capture the changes in psychological states and smoking behavior over time.

**2.1 Psychosocial and Behavioral Instruments**

The Perceived Stress Scale (PSS-10) was utilized to evaluate psychological stress, providing a measurable indication of stress at each subjective level and in this case, over the last month. Anxiety and depression symptoms were evaluated using the Hospital Anxiety and Depression Scale (HADS), which has the ability to differentiate psychological stress in the context of medical illness populations without using bodily symptoms as a framework for evaluation. Social support was assessed through the Multidimensional Scale of Perceived Social Support (MSPSS), which has separate domains for the support coming from family, friends, and other significant people. Patient's smoking status at every follow-up visit was assessed via self-report and confirmed biochemically by salivary cotinine analysis, confirming active tobacco use at a threshold of >10 ng/mL. Sociodemographic data such as age, sex, marital status, education, employment, and monthly household income were also collected. These covariates were evaluated for the smoking relapse risk-modifying effect.

**2.2 Smoking Relapse Definition**

For the purposes of this study, any use of a tobacco product after the participant's post-treatment quit date was a relapse. As defined by the Russell Standard, these guidelines are rigorous. For the purpose of this research, relapse smoking treatment timelines were assessed from the initial date of enrollment until confirmed smoking behavior resumed. Biochemical validation for smoking cessation was performed through salivary cotinine testing, with readings exceeding 10ng/mL indicative of prior smoking within the test window. Salivary cotinine testing is the most effective method for confirmation.

**3. Statistical Analysis**

Smoking relapse was operationally defined as using any form of tobacco, even a single puff, after the cessation date post-treatment. This adhered to the strict guidelines set by the Russell Standard. Biochemical validation was complete with salivary cotinine analysis, which considers levels above 10 ng/mL as recent smoking. Time to relapse was calculated as the interval between enrollment date and the first verified instance of resumed smoking for the participant. Statistical analyses were conducted using IBM SPSS Statistics v27 and R version 4.2.0. Descriptive statistics were used to summarize participant demographics and psychosocial scores; continuous variables as means and standard deviations, and categorical variables as frequencies and percentages. Relapse and non-relapse groups were compared using an independent t-test and a chi-square test.

In a multivariate logistic regression model, smoking relapse was assessed with variables significant at $p < 0.10$ in bivariate analysis as independent predictors. A Cox proportional hazards model was used to define the association of

psychosocial covariates with the time to relapse during the 18-month follow-up and provided HRs (HR) with 95% confidence intervals.

Data related to psychosocial scores that were absent in under 5% of instances were filled using the multiple imputation method, assuming that data were missing at random (MAR). In the final model run, all p-values less than 0.05 were considered significant.

**4. Ethical Considerations**

The study was done based on the Declaration of Helsinki guidelines. Both centers' review boards gave ethical clearance (Ref No. HNSC2020/IRB102). All subjects provided written consent and were properly informed of their ability to withdraw at any stage without consequences towards their treatment.

## RESULTS

**1. Participant Characteristics**

A total of 312 head and neck cancer survivors were enrolled in the study. The participants' average age was 58.6 years (SD = 9.7), and 71.8% identified as male. Most participants (67.9%) had oropharyngeal or laryngeal tumors and completed a course of combined radiotherapy and chemotherapy. At baseline, all participants had abstained from smoking for a minimum of one-month post-treatment. However, during the 18-month follow-up period, 114 participants (36.5%) had relapsed to smoking.

Lower educational attainment, unemployment, and household income under the poverty line were associated with higher relapse rates. Among relapsing smokers, higher baseline stress, lower perceived social support, and greater depressive symptoms were observed.

**1.1 Psychosocial Variables and Relapse**

The participants who relapsed showed a significantly higher mean Perceived Stress Scale (PSS) score of 22.3, while non-relapsers had a mean of 17.1 ($p < 0.001$). Also, relapsers had higher HADS-Depression scores (9.3 compared to 6.1 for non-relapsers). The mean HADS depression score for both groups was significantly different, with a p-value $< 0.001$ for the difference. The mean score of The Multidimensional Scale of Perceived Social Support (MSPSS) was lower among those who relapsed with sporadic abstinence compared to those who maintained abstinence (43.2 vs 51.6; $p < 0.001$).

**Table 1.** Psychosocial scores among relapse and non-relapse groups

| Psychosocial Variable | Relapse Group | Non-Relapse Group | p-value |
|---|---|---|---|
| PSS-10 | 22.1 | 17.4 | < 0.001 |
| HADS-D | 8.7 | 6.2 | < 0.001 |
| MSPSS | 42.8 | 51.6 | < 0.001 |

Table 1, summarizes the mean scores of psychosocial variables—perceived stress, depression, and social support—between head and neck cancer survivors who relapsed and those who maintained abstinence during an 18-month follow-up. The relapse group consistently exhibited higher psychological distress and lower perceived support. All differences were statistically significant.

### 1.2 Multivariate Logistic Regression

A multivariate logistic regression model was created to identify independent socio-psychological and demographic factors associated with smoking relapse. Only variables that were significant at $p < 0.10$ in prior bivariate analyses were included. The final model comprised perceived stress (PSS), depressive symptoms as measured by the HADS-Depression subscale, perceived social support (MSPSS), employment status, and income level. The model indicated that high perceived stress (PSS > 20) is the single strongest predictor with an adjusted odds ratio (OR) of 3.21 (95% CI: 2.01–5.13, $p < 0.001$). This suggests that participants with high stress were over three times more likely to relapse, and makes PSS the strongest predictor. Depressive symptoms (HADS-D ≥ 8) were significantly associated with relapse (OR = 2.42, 95% CI: 1.49–3.93, $p < 0.001$). Also, low perceived social support less than 45 was significantly associated with relapse, too, having an OR of 2.76 (MSPSS < 45, 95% CI: 1.75–4.34, $p < 0.001$).

Table 2 summarizes the results of a multivariate logistic regression model assessing independent predictors of smoking relapse among head and neck cancer survivors. Key psychosocial and socioeconomic variables were entered into the model, and adjusted odds ratios (OR) with 95% confidence intervals (CI) are shown. All predictors were statistically significant, with p-values < 0.01, indicating strong associations with relapse risk.

**Table 2:** Multivariate logistic regression – predictors of smoking relapse

| Predictor | Adjusted OR | 95% Confidence Interval | p-value |
|---|---|---|---|
| High Perceived Stress (PSS > 20) | 3.2 | 2.0 – 5.1 | < 0.001 |
| Depression (HADS-D ≥ 8) | 2.4 | 1.5 – 3.9 | < 0.001 |
| Low Social Support (MSPSS < 45) | 2.8 | 1.8 – 4.3 | < 0.001 |
| Unemployed | 1.9 | 1.2 – 3.0 | 0.007 |
| Low Income (< $400/month) | 2.5 | 1.5 – 4.4 | 0.001 |

The participant's socioeconomic status also revealed a noteworthy smoking relapse risk. For unemployed participants, the odds ratio for relapse risk was 1.89 (95% CI: 1.18–3.01, $p = 0.007$). Participants with a monthly income of less than $400 showed greater odds of relapsing compared to those with higher incomes (OR = 2.53, 95% CI: 1.45–4.39, $p = 0.001$). Furthermore, the model fit was good as assessed by the Hosmer-Lemeshow test ($\chi^2 = 5.23$, $p = 0.73$). Also, Nagelkerke $R^2$ suggested that about 39% of the variance in the relapse status could be predicted from the included variables. Evidence shows psychosocial distress and socioeconomic factors significantly increase the risk of relapse for smoking in head and neck cancer survivors, reinforcing the case for integrated social and behavioral support aids in complex survivorship care.

### 1.3 Cox Proportional Hazards Analysis

Time-to-relapse analysis showed relapse occurrences mostly within the first nine months. Participants with high stress and depressive symptoms experienced significantly shorter relapse-free durations, as shown by the Kaplan-Meier survival curves ($p < 0.001$). The Cox model verified that high stress levels (HR = 2.77), low social support (HR = 2.35), and the presence of depressive symptoms (HR = 2.18) were all important predictors of time to relapse, even after controlling for socioeconomic variables.

### 1.4 Psychosocial Risk Profile Clustering

In order to further differentiate participants based on their accumulated psychosocial stressors, a clustering method was utilized to categorize individuals into specific psychosocial risk profiles. Grouping of participants was performed using K-means clustering based on standardized scores from three validated instruments: Perceived Stress Scale (PSS),

Hospital Anxiety and Depression Scale – Depression subscale (HADS-D), and Multidimensional Scale of Perceived Social Support (MSPSS). Optimal number of clusters was determined to be three after examining silhouette coefficients and within-cluster sum of squares.

Cluster 1, defined as "Low Risk" group, was characterized by low stress, low depressive symptoms, and high social support perception. They were "Moderate Risk" and showed a blend of reasonable support in all three categories as midrange responders. "High Risk" individuals display a wholly different profile tending to experience high stress and depression alongside low social support. Interestingly, most participants falling into Cluster 1 exhibited the least amount of relapses (14.3%) while those in Cluster 3 experienced the most (72.5%), revealing clusters having significant differences in relapse proportions ($\chi^2 = 38.21$, $p < .001$).

These clusters reveal clinically actionable insights by detecting critical risk groups that are likely to benefit from tailored psychosocial interventions. This clustering model underscores the need to integrate co-occurring psychological stressors and social resource deficits into more thorough survivorship care planning. These highlighted gaps seamlessly enable post-treatment proactive psychosocial screening by illuminating its necessity, as well as enabling precision behavioral support elucidating proactive intervention.

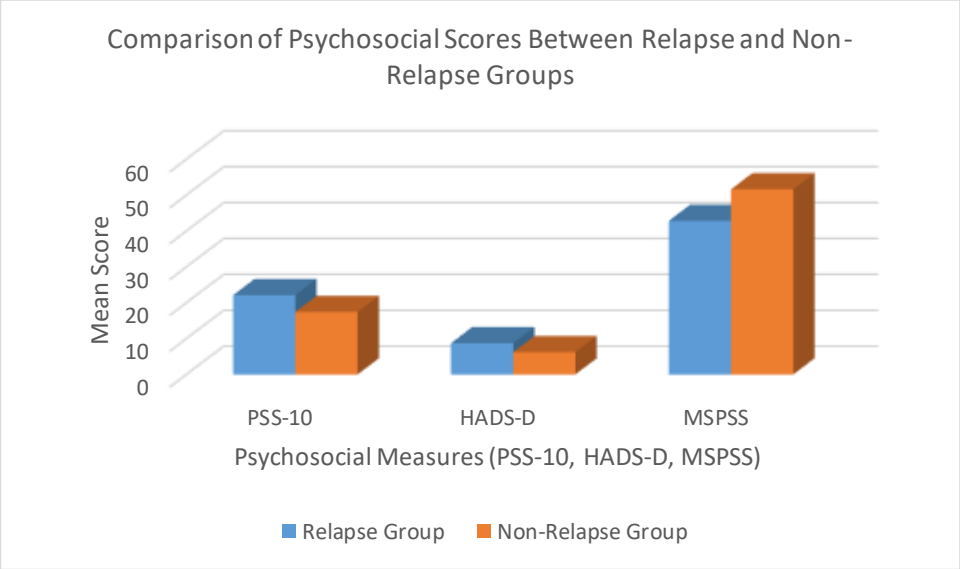


**Figure 1.** Comparison of psychosocial scores between relapse and non-relapse groups

Figure 1, compares mean psychosocial scores across two groups. The relapse group consistently shows significantly higher stress and depression and lower perceived support ($p < 0.001$ for all comparisons), indicating a strong association with smoking relapse.

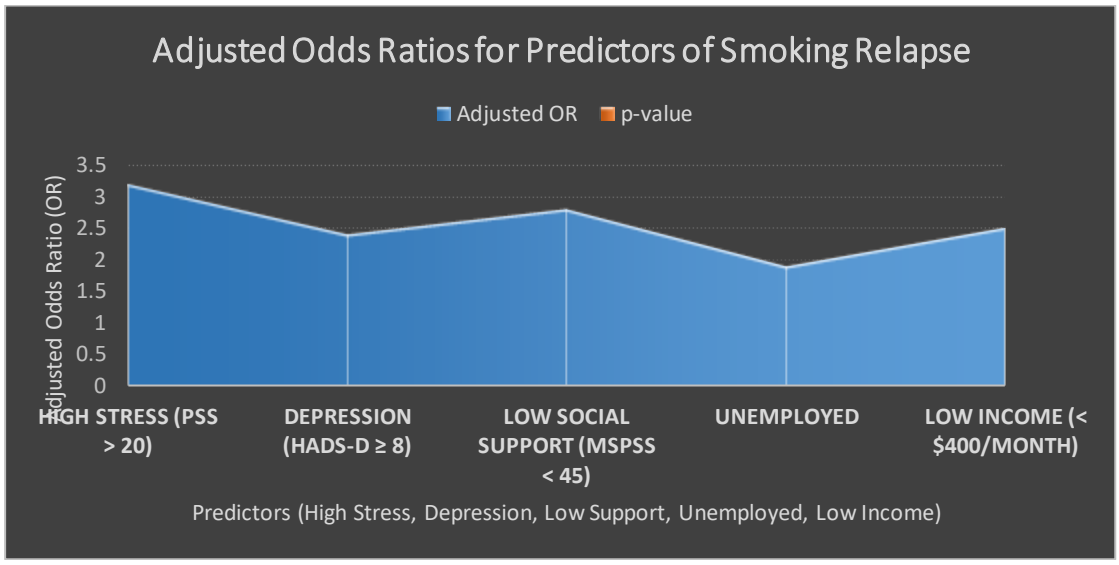


**Figure 2.** Cumulative impact of socio-psychological predictors on smoking relapse risk

Figure 2 illustrates the relative strength of various independent predictors of smoking relapse in head and neck cancer survivors. The cumulative area reflects the increasing relapse risk contributed by each factor. Psychosocial variables—particularly high stress (OR = 3.2), low support (OR = 2.8), and depression (OR = 2.4)—occupy the largest areas, indicating they exert the strongest influence on relapse likelihood. Socioeconomic variables like unemployment (OR = 1.9) and low income (OR = 2.5) also show substantial effects, underscoring the multi-factorial nature of relapse risk

## DISCUSSION

This study tracking the same subjects over time notes how stress, depression, and social support impact smoking relapse in survivors of head and neck squamous cell carcinoma (HNSCC) over time. There were a considerable number of relapses, with 36.5% of subjects relapsing within 18 months of treatment, which aligns with other studies with ranges between 30% and 60%, depending on the population and time frame considered.

In this case, high perceived stress emerged as a significant, independent predictor of relapse. Relapse stress has long been documented to damage cognitive control and cause smoking as an automatic reaction, especially for those with a nicotine dependance. The strong relationship between high stress scores and shorter relapse-free intervals suggests that the treatment of stress must be an integrated part of post-treatment support.

Also, depressive symptoms measured with HADS were significantly related to smoking relapse. Participants with HADS-D scores greater than or equal to 8 had more than 2 times the odds of relapse. These results align with the literature demonstrating that depression tends to burden cessation outcomes by demotivating the individual, heightening withdrawal sensitivity, and reducing self-efficacy. In addition, untreated depressive symptoms can foster a psychological environment that is protective and, in survivors dealing with chronic pain, functional limitations, and poor self-image owing to cancer treatment, prone to relapse.

Support from others was a strong protective factor. Patients with low MSPSS scores were significantly more likely to relapse, demonstrating the buffering role that social networks have on the experience of stress and engagement in positive health behaviors. Support from family and friends or even from healthcare practitioners has protective effects and is comparable to other cancer populations where constant emotional support was associated with longer smoking abstinence.

The multivariate analysis indicated that socioeconomic status (SES), especially unemployment and low income, considerably influenced the relapse risk. This supports the hypothesis that a combination of material deprivation and psychological strain weakens the ability to remain abstinent (Hiscock et al., 2012). SES impacts not only the ability to access cessation resources, but also the perceived prioritization of cessation relative to other survival needs(Businelle et al., 2010).

Latent profile analysis provided some interesting insights. Survivors with high stress levels, alongside depressive symptoms and low social support, had relapse rates over 70%. This combination appears to reflect some form of psychological frailty and emphasizes the need for more integrated care models that consider various factors of survivorship (Pompili et al., 2015). The high-risk profile constructed in this study can be used as a clinical tool to stratify patients for intensive interventions. These results are vital for survivorship care. Existing post-treatment frameworks mainly focus on monitoring and physical recovery, while the patient's mental health remains under-addressed(Mazanec et al., 2011). Elevating the smoking cessation behavior through structured psychological evaluations, stress management, and counseling during the survivorship phase has the potential to improve multi-decade clinical outcomes post-abstinence (Park et al., 2016).

It is necessary to consider several key limitations. To begin with, the participants' smoking status was self-reported, and although it was verified through salivary cotinine levels, bias was still present. Furthermore, the participants were only recruited from tertiary care hospitals, which may not be representative of rural or underserved populations. Lastly, while the study considered the majority of significant psychological factors, other relevant factors, such as those related to personality, trauma history, or the pharmacogenomics of nicotine, were not examined.

Notwithstanding these limitations, the study offers valuable insights to explain and anticipate smoking relapse among HNSCC survivors. The study identifies critical psychological and social predictors, providing a foundation for precision-guided, risk-anchored interventions tailored to individual profiles. Further studies should assess the effectiveness of integrated behavioral interventions that include cognitive behavioral therapy (CBT), motivational interviewing, and peer navigation support. Also, in this high-risk group, technology-based solutions like remote counseling and mHealth apps for real-time stress monitoring merit attention (Bricker et al., 2014; Abroms et al., 2013).

To summarize, this study illustrates the gap created by no longer using only a biomedical framework for follow-up care and emphasizes the need to build comprehensive models incorporating mental health, social dimensions, and behavior. Such comprehensive approaches could greatly improve the quality of life and clinical outcomes for head and neck cancer survivors prone to relapse into smoking.

## CONCLUSION

This long-term research highlights the unique relationship between psychological and social factors alongside smoking addiction in survivors of head and neck squamous cell carcinoma. The results show that heightened perceived stress,

depressive symptoms, and inadequate social support greatly increase the likelihood of smoking relapse during the first 18 months after treatment. Furthermore, unemployed and economically disadvantaged patients become more susceptible to smoking relapse because these socioeconomic factors restrict access to necessary support systems and resources for cessation. By using comprehensive multivariate and time-to-event analyses, this study not only corroborates previously confirmed risk factors, but also reinforces the psychosocial multifactorial burden. Latent risk profile assessment provides a clinically useful model for early identification of high-risk survivors, prompt intervention during the survivorship phase. Such findings could inform the direct development of survivorship care strategies. Incorporating routine checkups with psychosocial assessment using the Perceived Stress Scale, HADS, and MSPSS enables clinicians to actively monitor patients for potential risks. Through behavioral counseling, support groups, and digital health platforms, the aforementioned interventions can greatly reduce relapse and enhance quality of life. To summarize, simply using nicotine replacement and pharmacotherapy will not aid in achieving long-term smoking cessation for HNSCC survivors. A multidimensional approach that includes the emotional, social, and financial aspects of surviving cancer is important to improving long-term outcomes and preventing relapse.

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