Introduction

The use of tobacco products in their various forms has resulted in multiple health complications such as chronic obstructive pulmonary disease, cancer, cardiovascular diseases, and many more cases (1). Tobacco has been proposed as a major risk factor for periodontal diseases, oral mucosal lesions, and dental caries (2); however, the contradictory effects of tobacco have been observed on the teeth. A researcher showed that increased tobacco smoking led to a reduction in dental caries, believing the potential inhibitory effects of thiocyanate in the saliva of smokers to be responsible for this reduction (3). On the other hand, the possible lower pH of smokers’ saliva, along with its reduced buffering effect and the increased number of oral bacteria have been demonstrated to make teeth susceptible to caries (3, 4). Nevertheless, although these contradictions have been reported with regard to the association between tobacco and dental caries in smokers, the same may not necessarily be true for smokeless tobacco (ST) users. ST is referred to tobacco products typically dipped, chewed, sucked, or simply put on the gingiva (5). It has been suggested that tobacco can...
contribute to tooth decay by suppressing the immune system’s response to oral infections (2). In addition, the wide range of additives and sweeteners used for the preparation of different tobacco products, as well as the abrasive constituents of ST can increase the risk of dental caries (6).

The current study aimed to determine the frequency of posterior teeth decay due to ST use while investigating the potential predisposing factors.

Materials and Methods
Participants
Individuals with consistent ST use, including nas and tanbak for more than 2 years were evaluated in this cross-sectional study. Participants were recruited from Bandar Abbas, Hormozgan, Iran from March 21, 2018, to March 20, 2019, through multi-stage cluster sampling. Individuals with less than 2 years of ST use were excluded from the study.

Study Design
The general characteristics of the participants were recorded, including age, gender, education, occupation, income, residence, the number of family members, and smoking status in addition to the duration of ST use, the use of mouth wash, and the frequency of using dental floss and toothbrush. All patients underwent complete oral examination by an expert dentist using a mouth mirror, a tongue depressor, and a sterile gauze in the dental health care center. Posterior teeth decay, defined as the loss of enamel or dentin, or the destruction of roots visible by the naked eye, was noted based on the evaluation. Therefore, interproximal decay, caries not visible by the naked eye, and arrested enamel decay were not taken into account. The surface of teeth with decay (lingual, buccal, mesial, distal, and occlusal) was recorded as well.

Data Analysis
The Statistical Package for the Social Sciences (SPSS) software (version 25.0, Armonk, NY: IBM Corp.) was used for data analysis. The mean, standard deviation, frequency, and percentages were applied to describe the results. Based on the results of the Kolmogorov-Smirnov normality test, the Mann-Whitney test was used to compare quantitative variables between patients with and without posterior teeth decay. Further, chi-square and Fisher’s exact tests were employed to compare qualitative variables between groups. All variables, including age, gender, residence, occupation, education, income, smoking status, duration of ST use, and the number of family members, as well as a mouth wash, dental floss, and toothbrush use, were entered into the binary logistic regression model separately with posterior teeth decay as the dependent variable. Variables with \( P \) values < 0.2 were included in the final regression model. A receiver operating characteristic (ROC) curve was drawn to show the predictive power of variables included into the final regression model. The area under the curve (AUC) was calculated, and the sensitivity and specificity of this model were also determined for the prediction of posterior teeth decay. \( P \) values ≤0.05 were regarded as statistically significant.

Results
Of 150 patients included in this study, 136 (90.7%) were males and 14 (9.3%) were females. Their mean age and the mean duration of ST use were 37.95 ± 21.02 and 10.49 ± 8.82 years, respectively. Table 1 presents the general characteristics of the study participants. Most of the participants were urban dwellers, unemployed, and illiterate. Furthermore, the majority of patients had low incomes. In general, 48 patients (32%) were cigarette smokers.

Only 10 participants (6.7%) used mouth wash. Regular use of toothbrush and dental floss was reported by 31.3% and 4% of patients, respectively. Posterior teeth decay was found in 135 patients (90%). The mean number of decayed posterior teeth was 3.37 ± 2.58. The highest decayed tooth surface in the whole study population

| Variables | Results |
|-----------|---------|
| Age (y), mean ± SD | 37.95 ± 12.02 |
| Gender, No. (%) | Male 136 (90.7) |
| | Female 14 (9.3) |
| Residence, No. (%) | Urban 148 (98.7) |
| | Suburban 2 (1.3) |
| Occupation, No. (%) | Unemployed 56 (37.3) |
| | Laborer 15 (10.0) |
| | Farmer 9 (6.0) |
| | Civil servant 9 (6.0) |
| | Self-employed 61 (40.7) |
| Education, No. (%) | Illiterate 78 (52.0) |
| | High school diploma 58 (38.7) |
| | University 14 (9.3) |
| Income, No. (%) | Low 112 (74.7) |
| | Moderate 84 (22.7) |
| | High 4 (2.7) |
| Smoking cigarettes, No. (%) | Low 112 (74.7) |
| Duration of ST use (years), mean ± SD | 10.49 ± 8.82 |
| Number of family members, mean ± SD | 5.40 ± 1.94 |

Note. SD: Standard deviation; ST: Smokeless tobacco.
Teeth decay in smokeless tobacco users

was the mesial surface (78.7%), followed by the occlusal (77.3%), and the distal (76.7%), the details of which are provided in Table 2.

The comparison of various study variables between patients with and without posterior teeth decay showed a significant difference in occupation ($P = 0.048$). A significantly higher number of patients with posterior teeth decay were self-employed compared to patients without decay (Table 3).

The binary logistic regression model revealed that the odds of posterior teeth decay were approximately 4-folds higher in employed participants compared to the unemployed ($OR = 4.29$, 95% CI: 1.19-15.49, $P = 0.026$, Table 4). In general, occupation, income, duration of ST use, number of family members, and dental floss use could predict posterior teeth decay with an area under the ROC curve of 0.787 (95% CI: 0.671-0.902, $P < 0.001$), sensitivity of 85.9%, and specificity of 60% (Figure 1).

Discussion

Overall, posterior teeth decay was found in 90% of patients with ≥ 2 years of consistent ST use. The prevalence of dental caries was 71.53% among the tobacco chewers in the study by Nishat et al (2). The increased prevalence of dental caries in individuals using ST was also reported by Campus et al (7). However, tooth decay was only observed in 11.11% of individuals using ST in one study (8). Similarly, Sen et al showed higher mean decayed, missing, and filled teeth scores in ST users compared to controls (9). Hans et al and Lashkari and Shukla reported comparable results in this regard (10, 11). The

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Table 2. Tooth-Related Characteristics of the Study Population

| Variables                          | Results           |
|-----------------------------------|-------------------|
| Mouth wash use, No. (%)           | 10 (6.7)          |
| Toothbrush use, No. (%)           | 54 (36.0)         |
| None                              | 49 (32.7)         |
| Regular                           | 47 (31.3)         |
| Dental floss use, No. (%)         | 129 (86.0)        |
| None                              | 15 (10.0)         |
| Regular                           | 6 (4.0)           |
| Posterior teeth decay             | 135 (90.0)        |
| Number of decayed posterior teeth, mean ± SD | 3.37 ± 2.58 |
| No. (%)                           | 118 (78.7)        |
| Mean ± SD                         | 1.87 ± 2.14       |
| Distal surface                    | 115 (76.7)        |
| Mean ± SD                         | 1.87 ± 2.14       |
| Buccal surface                    | 103 (68.7)        |
| Mean ± SD                         | 1.72 ± 2.08       |
| Lingual surface                   | 61 (40.7)         |
| Mean ± SD                         | 1.15 ± 2.11       |
| Occlusal surface                  | 116 (77.3)        |
| Mean ± SD                         | 2.13 ± 2.20       |

Note. SD: Standard deviation.

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Table 3. Comparison of Study Variables Between Patients With and Without Posterior Teeth Decay

| Variables                             | Without Decay (n = 15) | With Decay (n = 135) | $P$ value$	ext{a}$ |
|---------------------------------------|------------------------|----------------------|--------------------|
| Age (y), mean ± SD                    | 38.07 ± 16.15          | 37.93 ± 11.55        | 0.829              |
| Gender, No. (%)                       |                        |                      | 1.000              |
| Male                                  | 14 (93.3)              | 122 (90.4)           |                    |
| Female                                | 1 (6.7)                | 13 (9.6)             |                    |
| Residence, No. (%)                   |                        |                      | 1.000              |
| Urban                                 | 15 (100.0)             | 131 (98.5)           |                    |
| Suburban                              | 0 (0.0)                | 2 (1.5)              |                    |
| Occupation, No. (%)                  |                        |                      | 0.048              |
| Unemployed                            | 11 (73.3)              | 45 (33.3)            |                    |
| Laborer                               | 0 (0.0)                | 15 (11.1)            |                    |
| Farmer                                | 1 (6.7)                | 8 (5.9)              |                    |
| Civil servant                         | 0 (0.0)                | 9 (6.7)              |                    |
| Self-employed                         | 3 (20.0)               | 58 (43.0)            |                    |
| Education, No. (%)                   |                        |                      | 0.469              |
| Illiterate                            | 6 (40.0)               | 72 (53.3)            |                    |
| High school diploma                  | 8 (53.3)               | 50 (37.0)            |                    |
| University                            | 1 (6.7)                | 13 (9.6)             |                    |
| Income, No. (%)                      |                        |                      | 0.270              |
| Low                                   | 14 (93.3)              | 98 (72.6)            |                    |
| Moderate                              | 1 (6.7)                | 33 (24.4)            |                    |
| High                                  | 0 (0.0)                | 4 (3.0)              |                    |
| Smoking cigarettes, No. (%)          | 3 (20.0)               | 45 (33.3)            | 0.389              |
| Duration of ST use (y), mean ± SD    | 13.87 ± 13.07          | 10.12 ± 8.20         | 0.801              |
| Number of family members, mean ± SD  | 6.27 ± 2.40            | 5.30 ± 1.87          | 0.070              |
| Mouth wash use, No. (%)              | 0 (0.0)                | 10 (7.4)             | 0.599              |
| Toothbrush use, No. (%)              | 3 (20.0)               | 46 (34.1)            | 0.384              |
| Dental floss use, No. (%)            | 8 (46.7)               | 40 (29.6)            |                    |
| None                                  | 5 (33.3)               | 49 (36.3)            |                    |
| Regular                               | 3 (20.0)               | 46 (34.1)            |                    |
| Irregular                             | 8 (46.7)               | 40 (29.6)            |                    |
| Number of family members, mean ± SD  | 11 (73.3)              | 118 (87.4)           | 0.117              |
| Mouth wash use, No. (%)              | 2 (13.3)               | 13 (9.6)             |                    |
| Toothbrush use, No. (%)              | 2 (13.3)               | 4 (3.0)              |                    |

Note. N: Number; SD: Standard deviation; ST: Smokeless tobacco.

* Analyzed by Chi-square test. † Analyzed by Mann-Whitney test. ‡ Analyzed by Fisher’s exact test.
lower rate of dental caries observed in some of these studies, compared to our findings, can be justified by the difference in sociodemographic features, the type of STs and their methods of use, and the overall oral health of the study populations.

Interestingly, Chaitanya et al assessed the prevalence of dental caries in ST users and smokers and concluded that tooth decay was significantly more prevalent in the control group, followed by the ST group and the smokers. They attributed the lower prevalence of dental caries in smokers to the potential anticarcinogenic activity of thiocyanate in the saliva. Additionally, they associated the higher prevalence of tooth decay in ST users, compared to smokers, with the presence of sweeteners in ST products, especially chewing tobacco (12).

The majority of ST users in our study, in the groups with and without posterior dental caries, were males.

According to previous studies, men appear to be the predominant users of ST (9, 10, 12-14). The reason behind this predilection might be the cultural boundaries for women; even if they use ST, they have a tendency to hide it, which accounts for the demographic findings of our study with very few females engaged in ST use.

Importantly, dental caries is a multifactorial disease with socioeconomic, lifestyle, and sociodemographic elements as influential factors. Meanwhile, tobacco use has been suggested as a confounding factor rather than having a direct causal effect on tooth decay (15, 16). To assess the plausible effects of the aforementioned factors, a logistic regression analysis was performed, and the results revealed that a set of features, including occupation, income, duration of ST use, number of family members, and dental floss use were able to predict posterior teeth decay with 85.9% sensitivity and 60% specificity. This confirms the findings of previous studies; nevertheless, considering that all participants in the current study were ST users, it was impossible to ascertain whether ST use has a causal relationship with dental caries or acts as a confounder.

It was also found that the highest decayed tooth surfaces were the mesial, occlusal, and distal surfaces, respectively. This can largely depend on the placement site of ST as has been reported by Muthukrishnan and Warnakulasuriya, demonstrating an increased risk of mucosal changes and periodontal diseases at the ST placement sites in ST users (6).

This study had some limitations. One limitation was that we had no control group, (i.e., individuals with no smokeless or smoked tobacco use). Therefore, we could not compare the frequency of posterior teeth decay between ST users and non-ST users, which would have shown the true effect of ST on tooth decay.

**Conclusion**
The result of the current study represented a very high frequency of posterior teeth decay in individuals with ≥ 2 years of consistent ST use. Being employed (compared to having no job) significantly influenced the occurrence of posterior teeth decay. Future studies with different designs and larger sample sizes are required to confirm the findings of this study.

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**Authors’ Contribution**
The idea of this research: FA and AA; data collection: SSH, AKH, KN and ZM ; original draft preparation: SSH; final approval of article: MM and FA; data analysis: SSH.

**Conflict of Interest Disclosures**
The authors declare no competing interests.
Ethical Statement
This study was approved by the Ethics Committee of Hormozgan university of medical sciences (ethical code: IR.HUMS.REC.1397.233).

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Informed Consent
The present study was carried out after obtaining informed consent.

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