

# Prevalence of Xerostomia and Hyposalivation Among Individuals Attending Oral Cancer Screening in Thailand: A Cross-Sectional Study

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## ABSTRACT

**Aim:** It has been speculated that the prevalence of xerostomia and hyposalivation might be higher among individuals attending oral cancer screening than among members of the general population. Therefore, this study investigated the prevalence of these conditions and their associated factors among individuals taking part in oral cancer screening and residing in the northeastern provinces of Thailand. **Materials and Methods:** This cross-sectional study recruited convenient individuals aged  $\geq 40$  years with at least one oral cancer risk factor. In total, 561 participants were included. Demographic characteristics and relevant oral cancer risk factors were recorded. A questionnaire comprising five items was used to assess xerostomia. Participants were then categorized into two groups based on the absence or presence of xerostomia. Subsequently, the stimulated salivary flow rate was assessed using the spitting technique to identify hyposalivation. Participants were then separated into two groups depending on the absence or presence of hyposalivation. Univariate and multivariate logistic regression analyses were then performed to identify factors associated with xerostomia or hyposalivation. **Results:** The mean age of participants was  $65.62 \pm 9.70$  years, and approximately 60% of participants were post-menopausal women. The prevalence of xerostomia was 43.85%, and the prevalence of hyposalivation was 61.50%. It was revealed that age  $\geq 65$  years (odds ratio [OR] = 1.57,  $P = 0.02$ ) and burning sensation in the mouth (OR = 5.36,  $P < 0.001$ ) were strongly associated with xerostomia. Female participants were more likely to exhibit hyposalivation (OR = 2.38,  $P = 0.001$ ). Oral cancer risk factors were not associated with xerostomia or hyposalivation. **Conclusions:** In this study, age  $\geq 65$  years and burning sensation were identified as risk factors for xerostomia, whereas female sex was a risk factor for hyposalivation. Dentists should be aware of both conditions. Various interventions to alleviate dry mouth symptoms might be useful for individuals with these risk factors.

**KEYWORDS:** Cancer, hyposalivation, oral cancer, prevalence, xerostomia

## INTRODUCTION

Saliva plays a significant role in maintaining oral and systemic health.<sup>[1]</sup> Xerostomia and hyposalivation are terms frequently used to describe oral dryness.<sup>[2]</sup> The definition of xerostomia is a perception of dry

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mouth; it is usually evaluated using a set of questions that evaluate whether individuals experience symptoms of dry mouth. In contrast, hyposalivation refers to an objective decrease in salivary flow, typically measured by sialometry.<sup>[2]</sup> In the literature, xerostomia and hyposalivation are not consistently correlated. A recent study by de Carvalho and colleagues<sup>[3]</sup> revealed a correlation between xerostomia and hyposalivation. In contrast, Morita and colleagues reported that there was no correlation between xerostomia and hyposalivation.<sup>[4]</sup> This discrepancy could be related to differences among the questionnaires used to assess xerostomia and the clinical examination methods used to identify hyposalivation.

There are multiple risk factors for xerostomia and hyposalivation. Xerostomia is more common among older adults and women.<sup>[5]</sup> The use of medications to treat systemic diseases is the most frequent risk factor for these conditions.<sup>[6]</sup> Factors associated with these conditions include radiation to the head and neck area, as well as other diseases that affect salivary gland function (e.g., diabetes mellitus and Sjogren's syndrome).<sup>[7,8]</sup>

Although many factors have been reported to induce hyposalivation, recent evidence suggests that oral cancer risk factors, including smoking and alcohol consumption, could also contribute to xerostomia. Meta-analyses have revealed that healthy smokers are more likely to experience xerostomia.<sup>[9,10]</sup> However, a recent study in Pakistan showed that the use of smokeless tobacco led to an increased salivary flow rate.<sup>[11]</sup> Moreover, a case-control study demonstrated that smoking and alcohol consumption were not associated with the presence of xerostomia.<sup>[12]</sup>

In the early 2010s, the age-standardized incidence of oral cancer in Thailand was 4.6 per 100,000 men and 3.2 per 100,000 women.<sup>[13]</sup> Previous studies in Khon Kaen, a northeastern province in Thailand, revealed a high prevalence of oral cancer in this region, particularly among women.<sup>[14-16]</sup> Oral cancer was significantly associated with alcohol use, tobacco smoking, and betel quid chewing; all three factors exhibited dose-response effects.<sup>[14]</sup> Although smoking is uncommon, betel quid chewing is a relatively common activity among women with oral cancer in northeastern Thailand.<sup>[14]</sup>

Considering the high prevalence of oral cancer in northeastern Thailand, oral cancer screening has been conducted to identify any suspicious lesions in individuals with at least one oral cancer risk factor.<sup>[17]</sup> As a component of the oral cancer screening program,

participants also underwent evaluations of possible xerostomia and hyposalivation. Some participants who reported experiencing dry mouth exhibited signs of hyposalivation. Consequently, the prevalence of xerostomia and hyposalivation was expected to be high among these individuals.

There remains disagreement regarding the association of oral cancer risk factors with the presence of xerostomia and hyposalivation. This study explored the prevalence of xerostomia and hyposalivation, along with their risk factors, among individuals with at least one oral cancer risk factor. A comprehensive screening approach for xerostomia and hyposalivation in these older individuals, in addition to oral cancer screening, may improve their quality of life.

## MATERIALS AND METHODS

### STUDY DESIGN AND POPULATION

This cross-sectional study was conducted as part of a project that screened for oral cancer among people residing in northeastern Thailand. Details of the screening have been published elsewhere.<sup>[17]</sup> This research received ethical approval from the Faculty of Dentistry/Faculty of Pharmacy Institutional Review Board, Mahidol University (MU-DT/PY-IRB 2019/050.3107 and MU-DT/PY-IRB 2019/041.0307).

This study included individuals aged  $\geq 40$  years with at least one of the following oral cancer risk factors: Betel quid chewing habit, alcohol consumption, tobacco smoking, usage of smokeless tobacco, and outdoor work in strong sunlight. Individuals who encountered any of the following criteria were excluded from this study: Inability to undergo stimulated salivary flow rate measurement (e.g., patients with no remaining teeth); receipt of treatment that could influence salivary secretion, such as salivary gland surgery, radiotherapy in the head and neck area, or chemotherapy; frailty or immobility with serious underlying systemic disease; inability to communicate or complete the questionnaire; and refusal to participate.

### DATA COLLECTION

Participant recruitment is depicted in Figure 1. In total, 561 individuals were enrolled in the study. Data were gathered regarding age, sex, marital status, occupation, history of systemic diseases, use of medications, use of removable dentures, and the presence of a burning sensation in the oral cavity. Information was also collected about oral cancer risk factors, as mentioned above in the study design and population section.

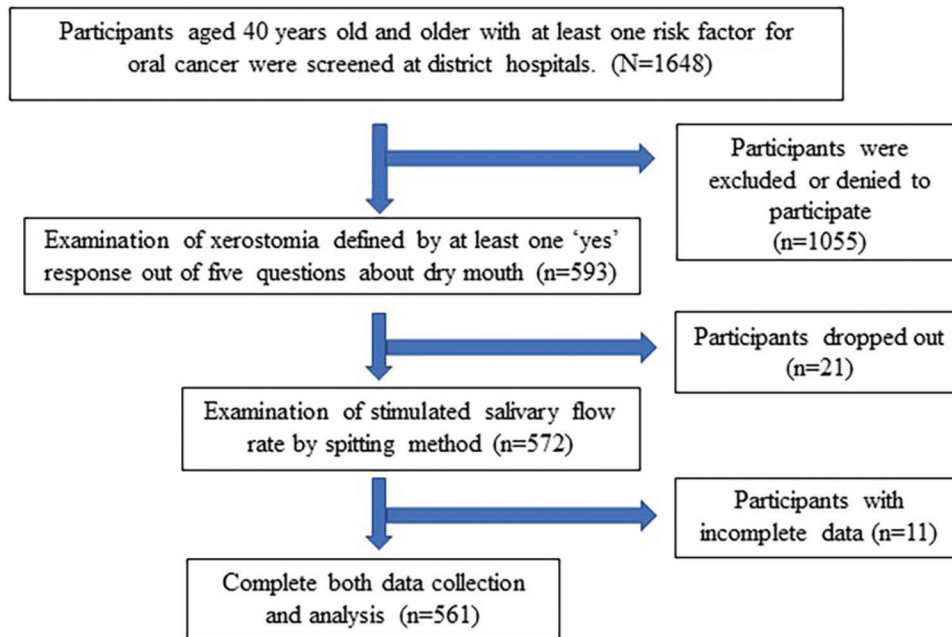


Figure 1: Flow chart of the study protocol

Participants were separated into two age groups depending on the age used to identify elderly adults: 40–64 years and  $\geq 65$  years.<sup>[18]</sup> Additionally, individuals who had ceased smoking for  $\geq 12$  months prior to the interview or had never smoked were categorized as nonsmokers. Individuals who had not engaged in betel quid chewing, smokeless tobacco use, or alcohol consumption for  $\geq 12$  months before recruitment were categorized as non-participants in the respective activities.

#### EVALUATION OF XEROSTOMIA

A modified xerostomia questionnaire consisting of five questions was used to identify individuals with xerostomia. Participants with a “yes” response to at least one item on the study questionnaire were considered to have xerostomia. The screening questions are listed below:

- 1) Does your mouth usually feel dry?
- 2) Do you sip liquid to help swallow dry food?
- 3) Is there too little saliva in your mouth most of the time?
- 4) Do you have difficulty speaking because of a dry mouth?
- 5) Have you experienced any taste disturbances?

#### EVALUATION OF HYPOSALIVATION

The stimulated salivary flow rate was assessed using the spitting technique. To stimulate salivary secretion, participants were instructed to chew a piece of paraffin wax (size:  $5 \times 5 \times 5 \text{ mm}^3$ ) for 5 min, then spit the saliva

into a plastic cup. The volume of saliva was assessed using a plastic syringe with a volume measurement scale. Participants with a stimulated whole salivary flow rate of  $< 0.7 \text{ mL/min}$  were considered to have hyposalivation.<sup>[3]</sup>

#### STATISTICAL ANALYSIS

All statistical analyses were performed with SPSS software (version 25.0 for Mac; SPSS Inc., Chicago, IL). Descriptive statistical methods were applied. The data were depicted using frequencies and percentages for categorical variables, while means and standard deviations were employed for continuous variables. The baseline characteristics of participants with and without the outcomes of interest (e.g., xerostomia and hyposalivation) were compared using the Student's *t*-test, chi-squared test, or Wilcoxon rank-sum test, as appropriate. Associations of demographic data with oral cancer risk factors and xerostomia/hyposalivation were investigated using univariate and multivariate logistic regression. All multivariate models were adjusted for age (40–64 years and  $\geq 65$  years), sex, systemic diseases, medications, removable denture use, burning sensation, alcohol consumption, betel quid chewing, smoking, smokeless tobacco, and sunlight exposure. Independent variables showing a *P* value of  $\leq 0.2$  in univariate analyses were incorporated into the multivariate models, along with variables considered relevant based on background knowledge. Odds ratios (ORs) were calculated with 95% confidence intervals (CIs). Values of  $P < 0.05$  were regarded as statistically significant.

## RESULTS

### PARTICIPANT CHARACTERISTICS

This study included 561 participants (381 [67.91%] women and 180 [32.09%] men) with a mean age of  $65.62 \pm 9.70$  years (range: 41–95 years) [Table 1]. Approximately half of the participants had been diagnosed with at least one systemic disease (56.33%), were taking medication(s) for their medical conditions (51.69%), or had been exposed to strong sunlight (53.83%). Other risk factors are shown in Table 1.

### XEROSTOMIA PREVALENCE AND ASSOCIATED FACTORS

The prevalence of xerostomia was 43.85% (246 of 561 participants). The responses to each item on the questionnaire are presented in Table 2. The item with the highest percentage of positive responses

was “Does your mouth usually feel dry?” (72.36%), followed by “Do you sip liquid to help swallow dry food?” (57.32%). Fewer than 50% of the participants had a positive response for each of the remaining items.

Univariate analysis revealed that age  $\geq 65$  years (OR = 1.68, 95% CI: 1.20–2.35,  $P = 0.003$ ), presence of systemic disease (OR = 2.21, 95% CI: 1.57–3.13,  $P < 0.001$ ), use of medications (OR = 2.07, 95% CI: 1.48–2.91,  $P < 0.001$ ), and presence of a burning sensation (OR = 5.57, 95% CI: 3.55–8.75,  $P < 0.001$ ) were significantly associated with xerostomia [Table 3]. However, after adjustments for potential confounding factors in multivariate analysis, only age  $\geq 65$  years (OR = 1.57, 95% CI: 1.07–2.32,  $P = 0.022$ ) and the presence of a burning sensation (OR = 5.36, 95% CI: 3.35–8.60,

**Table 1: Demographic and clinical characteristics of individuals attending oral cancer screening ( $n = 561$ )**

Variables	Xerostomia, n (%)		Hyposalivation, n (%)		Total n (%)
	Yes ( $n = 246$ )	No ( $n = 315$ )	Yes ( $n = 345$ )	No ( $n = 216$ )	
Age (years)					
40–64	102 (41.5)	171 (54.3)	155 (44.9)	118 (54.6)	273 (48.67)
$\geq 65$	144 (58.5)	144 (45.7)	190 (55.1)	98 (45.4)	288 (51.33)
Sex					
Male	71 (28.9)	109 (34.6)	75 (21.7)	105 (48.6)	180 (32.09)
Female	175 (71.1)	206 (65.4)	270 (78.3)	111 (51.4)	381 (67.91)
Systemic diseases					
No	81 (32.9)	164 (52.1)	153 (44.3)	92 (42.6)	245 (43.67)
Yes	165 (67.1)	151 (47.9)	192 (55.7)	124 (57.4)	316 (56.33)
Medications					
No	94 (38.2)	177 (56.2)	167 (48.4)	104 (48.1)	271 (48.31)
Yes	152 (61.8)	138 (43.8)	178 (51.6)	112 (51.9)	290 (51.69)
Removable dentures					
No	222 (90.2)	268 (85.1)	298 (86.4)	192 (88.9)	490 (87.34)
Yes	24 (9.8)	47 (14.9)	47 (13.6)	24 (11.1)	71 (12.66)
Burning sensation					
No	153 (62.2)	284 (90.2)	273 (79.1)	164 (75.9)	437 (77.90)
Yes	93 (37.8)	31 (9.8)	72 (20.9)	52 (24.1)	124 (22.10)
Smoking status					
None	190 (77.2)	242 (76.8)	294 (85.2)	138 (63.9)	432 (77.01)
Current	56 (22.8)	73 (23.2)	51 (14.8)	78 (36.1)	129 (22.99)
Alcohol consumption					
None	206 (83.7)	244 (77.5)	288 (83.5)	162 (75.0)	450 (80.21)
Current	40 (16.3)	71 (22.5)	57 (16.5)	54 (25.0)	111 (19.79)
Betel quid chewing habit					
None	166 (67.5)	210 (66.7)	209 (60.6)	167 (77.3)	376 (67.02)
Current	80 (32.5)	105 (33.3)	136 (39.4)	49 (22.7)	185 (32.98)
Smokeless tobacco use					
None	219 (89.0)	276 (87.6)	304 (88.1)	191 (88.4)	495 (88.24)
Current	27 (11.0)	39 (12.4)	41 (11.9)	25 (11.6)	66 (11.76)
Sunlight exposure					
None	124 (50.4)	135 (42.9)	171 (49.6)	88 (40.7)	259 (46.17)
Current	122 (49.6)	180 (57.1)	174 (50.4)	128 (59.3)	302 (53.83)

**Table 2: Distribution of participants with xerostomia according to their responses to each item on the xerostomia questionnaire (n = 246)**

Questions	Xerostomia (n = 246)	
	Yes, n (%)	No, n (%)
1 Does your mouth usually feel dry?	178 (72.36)	68 (27.64)
2 Do you sip liquid to help swallow dry food?	141 (57.32)	105 (42.68)
3 Is there too little saliva in your mouth most of the time?	95 (38.62)	151 (61.38)
4 Do you have difficulty speaking because of a dry mouth?	80 (32.52)	166 (67.48)
5 Have you experienced any taste disturbances?	107 (43.50)	139 (56.50)

**Table 3: Univariate and multivariate logistic regression of factors associated with the presence of xerostomia (n = 561)**

Variables	Presence of xerostomia			
	Crude OR (95% CI)	P value	Adjusted OR (95% CI)	P value
Age (years)				
40–64	1.00		1.00	
≥ 65	<b>1.68 (1.20–2.35)</b>	<b>0.003*</b>	<b>1.57 (1.07–2.32)</b>	<b>0.022*</b>
Sex				
Male	1.00		1.00	
Female	1.30 (0.91–1.87)	0.148	1.02 (0.78–2.36)	0.284
Systemic diseases				
No	1.00		1.00	
Yes	<b>2.21 (1.57–3.13)</b>	<b>&lt; 0.001*</b>	1.52 (0.76–3.02)	0.236
Medications				
No	1.00		1.00	
Yes	<b>2.07 (1.48–2.91)</b>	<b>&lt; 0.001*</b>	1.33 (0.67–2.63)	0.413
Removable dentures				
No	1.00		1.00	
Yes	0.62 (0.37–1.04)	0.068	0.57 (0.32–1.01)	0.052
Burning sensation				
No	1.00		1.00	
Yes	<b>5.57 (3.55–8.75)</b>	<b>&lt; 0.001*</b>	<b>5.36 (3.35–8.60)</b>	<b>&lt; 0.001*</b>
Smoking status				
None	1.00		1.00	
Current	0.98 (0.66–1.45)	0.909	1.44 (0.79–2.64)	0.234
Alcohol consumption				
None	1.00		1.00	
Current	0.67 (0.43–1.03)	0.064	0.85 (0.51–1.42)	0.543
Betel quid chewing habit				
None	1.00		1.00	
Current	0.96 (0.68–1.38)	0.839	0.81 (0.51–1.28)	0.365
Smokeless tobacco use				
None	1.00		1.00	
Current	0.87 (0.52–1.47)	0.608	0.92 (0.50–1.66)	0.769
Sunlight exposure				
None	1.00		1.00	
Current	0.74 (0.53–1.03)	0.075	0.75 (0.51–1.10)	0.137

OR = odds ratio, CI = confidence interval, \*Bold values indicate statistical significance ( $P < 0.05$ )

$P < 0.001$ ) remained significantly associated with xerostomia.

#### HYPOSALIVATION PREVALENCE AND ASSOCIATED FACTORS

The prevalence of hyposalivation was 61.50% (345 of 561 participants). Univariate analysis revealed that age  $\geq 65$  years (OR = 1.48, 95% CI: 1.05–2.08,  $P = 0.025$ ),

female sex (OR = 3.41, 95% CI: 2.35–4.93,  $P < 0.001$ ), current smoker status (OR = 0.31, 95% CI: 0.20–0.46,  $P < 0.001$ ), ongoing alcohol consumption (OR = 0.59, 95% CI: 0.39–0.90,  $P = 0.014$ ), active betel quid chewing (OR = 2.2, 95% CI: 1.51–3.26,  $P < 0.001$ ), and sunlight exposure (OR = 0.70, 95% CI: 0.49–0.99,  $P = 0.041$ ) were significantly associated with hyposalivation

**Table 4: Univariate and multivariate logistic regression of factors associated with hyposalivation (n = 561)**

Variables	Presence of hyposalivation			
	Crude OR (95% CI)	P value	Adjusted OR (95% CI)	P value
Age (years)				
40–64	1.00		1.00	
≥ 65	<b>1.48 (1.05–2.08)</b>	<b>0.025*</b>	1.37 (0.93–2.00)	0.108
Sex				
Male	1.00		1.00	
Female	<b>3.41 (2.35–4.93)</b>	<b>&lt; 0.001*</b>	<b>2.38 (1.44–3.96)</b>	<b>0.001*</b>
Systemic diseases				
No	1.00		1.00	
Yes	0.93 (0.66–1.31)	0.683	0.76 (0.38–1.53)	0.443
Medications				
No	1.00		1.00	
Yes	0.99 (0.70–1.39)	0.953	1.10 (0.55–2.20)	0.799
Removable dentures				
No	1.00		1.00	
Yes	1.26 (0.75–2.13)	0.384	1.24 (0.71–2.18)	0.453
Burning sensation				
No	1.00		1.00	
yes	0.83 (0.55–1.25)	0.373	0.77 (0.50–1.19)	0.240
Smoking status				
None	1.00		1.00	
Current	<b>0.31 (0.20–0.46)</b>	<b>&lt; 0.001*</b>	0.59 (0.34–1.01)	0.056
Alcohol consumption				
None	1.00		1.00	
Current	<b>0.59 (0.39–0.90)</b>	<b>0.014*</b>	1.01 (0.62–1.65)	0.967
Betel quid chewing habit				
None	1.00		1.00	
Current	<b>2.22 (1.51–3.26)</b>	<b>&lt; 0.001*</b>	1.23 (0.78–1.95)	0.378
Smokeless tobacco use				
None	1.00		1.00	
Current	1.03 (0.60–1.75)	0.912	1.19 (0.66–2.15)	0.566
Sunlight exposure				
None	1.00		1.00	
Current	<b>0.70 (0.49–0.99)</b>	<b>0.041*</b>	0.96 (0.66–1.40)	0.838

OR = odds ratio; CI = confidence interval, \*Bold values indicate statistical significance ( $P < 0.05$ )

[Table 4]. Multivariate analysis showed that the positive association between sex and hyposalivation persisted after adjustment for potential confounders; women exhibited a 2.38-fold greater likelihood of hyposalivation (OR = 2.38, 95% CI: 1.44–3.96;  $P = 0.001$ ).

#### ASSOCIATION BETWEEN XEROSTOMIA AND HYPOSALIVATION

In total, 246 participants (43.85%) exhibited xerostomia, whereas 345 participants (61.50%) displayed hyposalivation. However, no statistically significant association was observed between xerostomia and hyposalivation ( $P = 0.20$ ). Table 5 shows the participant distribution based on the number of positive responses on the xerostomia questionnaire. Notably, no item on the xerostomia questionnaire was significantly associated with the presence of hyposalivation.

#### DISCUSSION

The prevalence of xerostomia and hyposalivation has previously been analyzed in specific populations, such as older adults or patients with Sjogren's syndrome.<sup>[19,20]</sup> The present study examined the prevalence of these conditions among individuals with oral cancer risk factors. The results provide insights into the prevalence of xerostomia and hyposalivation and associated risk factors among individuals with oral cancer risk factors. The prevalence of xerostomia was 43.85%, and the prevalence of hyposalivation was 61.50% in this cohort. Notably, older age and the presence of a burning sensation were key risk factors for xerostomia, whereas female sex was a risk factor for hyposalivation.

The prevalence of xerostomia in the present study (43.85%) was similar to the prevalence found in a recent study of Swedish adults (43.6%).<sup>[21]</sup> Factors

**Table 5: Relationships between xerostomia and hyposalivation (n = 561)**

Presence of xerostomia	Hyposalivation		P value <sup>a</sup>
	Yes (n = 345), n (%)	No (n = 216), n (%)	
No xerostomia (n = 315)	201 (63.81)	114 (36.19)	0.20
Xerostomia (n = 246)	144 (58.53)	102 (41.46)	
<b>Responses to each item on the modified xerostomia questionnaire</b>			
1. Does your mouth usually feel dry?			0.078
No	245 (71.0)	138 (63.9)	
Yes	100 (29.0)	78 (36.1)	
2. Do you sip liquid to help swallow dry food?			0.097
No	250 (72.5)	170 (78.7)	
Yes	95 (27.5)	46 (21.3)	
3. Is there too little saliva in your mouth most of the time?			0.551
No	284 (82.3)	182 (84.3)	
Yes	61 (17.7)	34 (15.7)	
4. Do you have difficulty speaking because of a dry mouth?			0.655
No	294 (85.2)	187 (86.6)	
Yes	51 (14.8)	29 (13.4)	
5. Have you experienced any taste disturbances?			0.965
No	279 (80.9)	175 (81.0)	
Yes	66 (19.1)	41 (19.0)	
<b>Number of positive responses</b>			
1 item	42 (12.2)	37 (17.1)	0.28
2 items	40 (11.6)	33 (15.3)	
3 items	21 (6.1)	12 (5.8)	
4 items	17 (4.9)	11 (5.1)	
5 items	24 (7.0)	9 (4.2)	

<sup>a</sup>Chi-squared test

associated with xerostomia included age  $\geq 65$  years, in accordance with the findings of longitudinal cohort studies in which xerostomia prevalence increased with age.<sup>[22,23]</sup>

The presence of a burning sensation was identified as a risk factor for xerostomia in the present study; participants who experienced a burning sensation were fivefold more likely to exhibit xerostomia [Table 3]. This finding is consistent with a recent study, which indicated that participants with a burning sensation more frequently exhibited xerostomia. The burning sensation diminished upon application of a dry mouth management protocol.<sup>[24]</sup> In contrast, another study showed that dry mouth and burning sensations were rarely observed simultaneously.<sup>[25]</sup> The presence of a burning sensation has been associated with many local factors, including oral candidiasis and various irritants that can cause microtrauma to the oral mucosa. Individuals with a burning sensation might experience salivary changes. Saliva composition may play an important role in burning mouth syndrome; cellular studies have revealed multiple saliva-related pathways with immunomodulatory effects.<sup>[26]</sup> These effects might contribute to the presence of a burning sensation in the oral cavity.

The prevalence of hyposalivation in the present study (61.50%) is comparable to the prevalence in a Japanese population with similar demographic characteristics (66.0%).<sup>[4]</sup> Moreover, the present study showed that women were more likely to exhibit hyposalivation, consistent with previous findings.<sup>[21,27]</sup>

Medications can influence a patient's salivary flow rate. Antihypertensive and lipid-lowering agents, commonly prescribed to elderly patients, have well-documented links with hyposalivation.<sup>[28]</sup> No association between the use of medications and hyposalivation was observed in the present study. However, more than half of the participants with hyposalivation (51.6%) were taking medication. The absence of such an association may be related to the lack of assessment regarding the total number and groups of medications. Future studies could consider these factors to deeply understand the association (if any) between the use of medications and hyposalivation.

It has been speculated that elderly people and post-menopausal women are at higher risk of xerostomia and hyposalivation. The present study revealed a robust association between female sex and hyposalivation, along with an association between older age and

xerostomia. Saliva production may be reduced during menopause in older women.<sup>[29]</sup> This phenomenon may be related to hormonal changes observed among such women.<sup>[20]</sup> In the present study, most female participants were post-menopausal women (92.1%). Therefore, female sex was expected to be associated with hyposalivation. The present findings support the notion that sialometry should be performed in post-menopausal women to facilitate early clinical detection of hyposalivation. Such detection may allow earlier clinical intervention, which is an important predictor of improved patient outcomes compared with outcomes after delayed clinical intervention.<sup>[20]</sup>

It has been speculated that oral cancer risk factors such as alcohol consumption, smoking, smokeless tobacco use, and betel quid chewing might also be associated with xerostomia or hyposalivation. The present study did not show an association of smoking with xerostomia or hyposalivation, similar to a previous study that revealed no significant difference in xerostomia prevalence between smokers and nonsmokers.<sup>[30]</sup> However, previous meta-analyses have suggested that healthy smokers are susceptible to xerostomia.<sup>[9,10]</sup> Controversy remains concerning whether smoking affects salivary flow rates. Future studies are needed to specify the relationships (if any) between smoking and xerostomia and hyposalivation. Furthermore, the present study demonstrated that betel quid chewing and the use of smokeless tobacco were not associated with xerostomia or hyposalivation. Conversely, a recent study in a Pakistani population showed that the tobacco components of smokeless tobacco increased the salivary flow rate.<sup>[11]</sup> Finally, the present study indicated that oral cancer risk factors were not associated with xerostomia or hyposalivation. This result could have been a consequence of the cross-sectional design and the fact that all participants had at least one oral cancer risk factor. These relationships should be further explored in cohort or case-control studies.

In terms of practical implications, the present findings suggest that older women who report a burning sensation should be screened for hyposalivation. Similar to previous research,<sup>[4]</sup> the present study found no correlation between xerostomia and hyposalivation [Table 5]. Intriguingly, it was disclosed in this study that the prevalence of hyposalivation exceeded the prevalence of xerostomia. Although individuals with hyposalivation might not experience the sensation of a dry mouth, they could exhibit oral lesions or other conditions (e.g., dental caries, oral infection, or periodontitis) caused by reduced saliva production. It is important to note that a dry mouth sensation

alone may not adequately indicate whether an individual has reduced saliva production. Therefore, dental practitioners should assess salivary flow rates in individuals who present with any clinical signs of oral dryness to confirm the diagnosis and address hyposalivation, thereby preserving good oral health.

In summary, a high prevalence of hyposalivation was discovered among participants taking part in oral cancer screening in the northeastern provinces of Thailand. Hyposalivation should not be ignored in any individual to prevent the potential consequences, which include dental caries, periodontal disease, and oral infections. The strength of our study lies in its comparatively large sample size (561 participants). However, despite the large sample size, some limitations of this study should be acknowledged. First, data were not gathered about the details of systemic diseases and the number of medications taken (e.g., xerogenic medications). These factors should be considered in future studies to clearly determine associations between risk factors for oral cancer and risk factors for dry mouth. Second, this study focused on individuals with oral cancer risk factors who underwent oral cancer screening at district hospitals, which might have introduced selection bias. Third, the inclusion criteria limited the participants to individuals aged  $\geq 40$  years; thus, most participants were older people who might not be representative of the general population. To address this issue, future studies should include individuals with a wider age range.

## CONCLUSION

This study revealed a high prevalence of hyposalivation among individuals attending oral cancer screening in northeastern Thailand. Aging and the presence of a burning sensation were associated with xerostomia, whereas female sex was associated with hyposalivation. The findings highlight the importance of routine clinical assessments focused on hyposalivation so that treatment can be implemented to improve oral and systemic health.

## CONFLICT OF INTEREST

There are no conflicts of interest.

## ETHICAL POLICY AND INSTITUTION REVIEW BOARD STATEMENT

This research received ethical approval from the Ethical Committee of the Faculty of Dentistry/Faculty of Pharmacy, Mahidol University, COA.NO.MU-DT/PY-IRB 2019/050.3107 and COA.NO.MU-DT/PY-IRB 2019/041.0307.

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#### AUTHOR CONTRIBUTIONS

S. E.: conducted experiments, analyzed data, and prepared the original draft. K. D.: conducted experiments. B. K.: recruited subjects and acquired funding. V. S.: acquired funding. K. P.: analyzed data, partially contributed to conceptualization, and reviewed the manuscript. S. P. K.: supervised the project, was responsible for the overall concept, supplied research funding, and reviewed and corrected the manuscript.

#### PATIENT DECLARATION OF CONSENT

Every participant provided informed consent.

#### DATA AVAILABILITY STATEMENT

The data are not accessible to the public because of participant confidentiality concerns. However, they can be obtained from the corresponding author upon request.

#### List of Abbreviations

CI: confidence interval  
 min: minute  
 mL: milliliter  
 mm<sup>3</sup>: cubic meter  
 OR: odds ratio  
 SD: standard deviation  
 SPSS: Statistics Package for Social Sciences

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