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Brief communication (Original)

Risk factors for tooth loss among adults aged 18 to 64 years in Taiwan

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Background: In Taiwan, tooth loss increases with aging. However, little is known about the oral health of adults between ages 18 to 64 years and associated factors for tooth loss.
Objective: To identify associated independent factors for tooth loss among Taiwanese adults aged 18 to 64 years.
Methods: This cross-sectional study evaluated oral health and tooth loss among adults aged 18 to 64 years. Demographics, tooth loss data, and oral health-related variables were collected from a secondary database and were analyzed to determine risk factors for tooth loss.
Results: In adults aged 18 to 64, older age, unmarried status, lower income, higher BMI, and chronic disease were associated with tooth loss. Adults with disease histories (i.e., hypertension, diabetes, asthma, heart disease) or who smoked or chewed betel nut were more likely to have missing teeth. Adults who had regular dental hygiene practices such as using dental floss, mouthwash, and having regular professional scaling were less likely to have missing teeth.
Conclusions: Knowledge of associated risk factors for tooth loss in adults aged 18 to 64 years may help develop national programs and policies for dental care in Taiwan specific for younger and middle-aged adults and help to promote long-term oral health throughout adulthood.

Keywords: Adults, epidemiology, health survey, oral health, tooth loss

Globally, general health status, lifestyle factors and various demographic, social and economic influences have been found to contribute to tooth loss and poor oral health [1-8]. In middle-aged adults, tooth loss is most often associated with demographic and socioeconomic characteristics, overall health and oral health status and oral hygiene [2]. Adults' daily performance in Norway was associated with age, number of missing teeth, dental care and socio-demographic factors such as residential area, which may correspond to income level [9]. A longitudinal study of aging in the United States showed a relationship between the number of healthy teeth and mortality risk [10]. These studies emphasize that tooth loss is not simply a matter of oral health alone, but has greater implications for overall health, quality of life and mortality among adults of all ages.

In Taiwan, the proportion of adults needing prosthetics, which parallels the proportion of tooth loss, has been shown to increase with increasing age [11]. When Taiwanese adults aged 65 and older were surveyed, 12.6% were edentulous and, as their ages increased, the number of adults who needed prostheses increased from 39.7% to 61% [12]. However, even though aspects of tooth loss and oral health among older adults in Taiwan have been investigated [11, 12], no substantial nationwide evidence for the oral health status of adults of all ages is available and little is known about factors contributing to tooth loss in younger and middle-aged adults aged 18 to 64 years. Epidemiologic evidence as in the above studies is needed in Taiwan so that the increasing nationwide trend in tooth loss and risk factors for tooth loss in adults aged 18 to 64 years can be understood and addressed.

Taiwan conducted a National Health Interview Survey Original Database (NHIS) in 2005 to collect comprehensive demographic, health-related, and oral health-related data from a representative sample of the Taiwanese population [13]. We recognized that the comprehensive survey data would facilitate epidemiologic evaluation of tooth loss and oral health-related variables. We hypothesized that investigating the oral health-related variables of adults between the

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ages of 18 and 64 would help to identify independent risk factors that may contribute to the nationwide increase in tooth loss. Such nationwide epidemiological evidence may support the development of national programs and policies for dental care in Taiwan to improve the oral health of adults of all ages and to foster long-term retention of healthy natural teeth. Therefore, this study aimed to evaluate associated independent factors for tooth loss among Taiwanese adults aged 18 to 64 years.

Methods

This study applied cross-sectional design with secondary database analysis to evaluate data from the National Health Interview Survey Original Database (NHIS) provided by the Bureau of Health Promotion, National Health Research Institutes and Food and Drug Administration of the Department of Health, Executive Yuan, Taiwan [13]. The interpretation and conclusions contained herein do not represent those of the Bureau of Health Promotion or National Health Research Institutes and Food and Drug Administration, Department of Health, Executive Yuan.

The National Health Interview Survey (NHIS)

In 2005, a multi-stage stratified systematic sampling design was applied to collect data representing the national population of Taiwan [13]. The original survey was completed by 27,726 Taiwanese adults aged 12 and older (response rate 80.6%) and each subject provided signed informed consent before completing the questionnaires. Family members in selected households were interviewed by trained interviewers. All data were released to the public. Comprehensive variables measured by the NHIS questionnaire included demographics (age, gender, education, marital status, income, and body mass index [BMI]); disease history; lifestyle behavior (tobacco smoking, alcohol consumption, betel nut chewing); oral hygiene behavior (number of times brushing teeth daily, timing of brushing teeth, and frequency of using dental floss, mouthwash, and having dental scaling); self-reported oral health (number of lost teeth, dental prostheses, oral health status, self-limitation of food due to oral health status); and use of dental care (dental visits in last year, reason for latest dental visit, dental fees paid, category of dental care services).

Data collection

A total of 27,726 Taiwanese subjects in three age groups (<12 years, 12 to 64 years, and >65 years) completed the NHIS. In this cross-sectional study, data of oral health status and tooth loss were collected from the NHIS database for adults aged 18 to 64 years. First, the data of 18,099 adult subjects with ages ranging from 12 to 64 years were collected and screened; then, 15,501 adults aged from 18 to 64 years were included and were retained for data analysis. Institutionalized individuals or those receiving nursing care at home, subjects who did not complete the NHIS questionnaire themselves, and those who had missing or incomplete records were excluded. Variables measured included: (1) demographics, lifestyle habits and disease history; and (2) self-reported oral health status, oral hygiene and dental care utilization.

Statistical analysis

General data are expressed as mean ± standard deviation (SD) for continuous data and n (%) for categorical data by number of teeth. Univariate logistic regression analysis was performed to identify risk factors associated with tooth loss. Variables with a significance level of $p < 0.05$ in univarate logistic regression analysis were put into multivariate logistic regression analysis with backward selection (method: conditional). Results were presented as odds ratio (OR) with respective 95% confidence internal (95% CI.) for logistic regression analyses. All statistical assessments were two-tailed and considered significant at $p < 0.05$. All statistical analyses were performed using SPSS 18.0 statistics software (SPSS, Chicago, IL, USA).

Results

A total of 15501 adults aged 18–64 were enrolled in this study. **Table 1** summarizes the subjects' characteristics, including demographic data, disease history, life style, tooth cleaning behavior, and oral health status. Subjects included 51.1% males and 48.9% females, with a mean age of 38.8 years (range: 18.0–64.0 years).

Table 1. Subject characteristics: demographics, medical history, and oral health status

Variables	No of subjects (n = 15,501)
Demographics	
Age (years)	38.8 ± 12.7
Gender	
Male	7,918 (51.1%)
Female	7,583 (48.9%)
BMI (kg)	23.9 ± 14.8
Marital status	
Single	4,896 (31.6%)
Married	9,500 (61.3%)
Widower/widow	440 (2.8%)
Divorced and other	664 (4.3%)
Education	
Illiterate	407 (2.6%)
Elementary	4,615 (29.8%)
Junior high	5,089 (32.8%)
Senior high	4,762 (30.7%)
University graduate	538 (3.5%)
Other	89 (0.6%)
Monthly income in the last year (NTD)	
<5,000	3,500 (22.7%)
5,000–20,000	3,280 (21.3%)
20,000–80,000	8,090 (52.6%)
>80,000	523 (3.4%)
Medical history	
Hypertension	1,467 (9.5%)
Diabetes	578 (3.7%)
Hyperlipidemia	1,820 (11.7%)
Stroke	72 (0.5%)
Asthma in current one year	291 (1.9%)
Kidney disease	544 (3.5%)
Heart disease	552 (3.6%)
Life style	
Current drinking	5,994 (38.7%)
Ever smoked	5,430 (35.1%)
Ever chewed betelnut	3,361 (21.7%)
Tooth cleaning behavior	
Daily frequency of tooth brushing	
0–1	3,437 (22.3%)
2	10,353 (67.2%)
≥3	1,607 (10.4%)
When are teeth brushed	
Brush teeth after getting up	14,537 (94.3%)
Brush teeth after breakfast	586 (3.8%)
Brush teeth after lunch	1,382 (9.0%)
Brush teeth after dinner	800 (5.2%)
Always brush teeth after eating	224 (1.5%)
Brush teeth before sleep	11,958 (77.6%)
Use dental floss	
No	7,987 (51.5%)
Occasionally	3,920 (25.3%)
Almost every day	3,591 (23.2%)
Use mouthwash	
No	13,293 (85.8%)
Occasionally	1,732 (11.2%)
Almost every day	466 (3.0%)
Have dental scaling per six months	2,412 (15.6%)

Table 1. Subject characteristics: demographics, medical history, and oral health status (Continue)

Variables	No of subjects (n = 15,501)
Oral health status	
Number of teeth	
No. missing teeth	9,126 (59.2%)
One or more missing teeth	6,302 (40.8%)
Have dental prosthesis	7,905 (51.0%)
Self-reported oral health	
Very poor	459 (3.0%)
Poor	2,351 (15.2%)
Average	5,972 (38.5%)
Good	4,831 (31.2%)
Very good	1,888 (12.2%)
Self limitation for food cause of dental function	
Never	10,722 (69.2%)
Occasionally	1,978 (12.8%)
Sometimes	2,062 (13.3%)
Frequently	492 (3.2%)
Always	247 (1.6%)
Dental utilization in past one year	
No	9,417 (60.5%)
Yes	6,084 (39.5%)

Data are summarized as mean ± SD for age and BMI, n (%) for other categorical variables.
Missing values: BMI: 4 (0.03%), marriage status: 1 (0.01%), education: 1 (0.01%), monthly income in the last year: 108 (0.70%), kidney disease: 2 (0.01%), heart disease: 7 (0.05%), current drinking: 3 (0.02%), ever smoking: 11 (0.07%), ever chewed betel nut: 2 (0.01%), daily frequency of tooth brushing: 104 (0.67%), when are teeth brushed: 84 (0.54%), use dental floss: 3 (0.02%), use mouthwash: 10 (0.06%), have dental scaling per six month: 22 (0.14%), number of missing teeth: 73 (0.47%), have dental prosthesis: 14 (0.09%).

Associated factors for tooth loss among adults aged 18–64 years

Table 2 shows the univariate analysis of demographics, disease histories, lifestyle behavior, oral hygiene behavior, oral health status, and dental visits in the last year. Multivariate analysis included 18 variables: age, marriage status, monthly income, disease histories (hypertension, diabetes, hyperlipidemia, asthma, heart disease), history of smoking or chewing betel nut, brushing teeth after lunch and before sleep, frequency of using dental floss and mouth wash, have dental scaling per six months, with/without dental prosthesis, self-limitation of food due to oral health, and dental visits in the last year (**Table 3**). After controlling for other covariates, age increase in this group were more likely to have missing teeth (OR = 1.02); those divorced or separated were more likely to have missing teeth than those married or cohabited (OR = 1.302); those widowed were less likely to have missing teeth than those married or cohabited (OR = 0.789); subjects with monthly income over 80000 New Taiwan Dollars (NTD) were less likely to have missing teeth than those with monthly income of less than 5000 NTD (OR = 0.746); people with higher BMI were more likely to have missing teeth than those with lower BMI (OR = 1.004); people with histories of hypertension (OR = 1.138), diabetes (OR = 1.440), asthma (OR = 1.308), and heart disease (OR = 1.285) were more likely to have missing teeth than those without these diseases; and people who smoked and chewed betel nut were more likely to have missing teeth (OR = 1.470 and 1.249, respectively) (**Table 3**). Those adults less likely to have missing teeth included people who brushed teeth after lunch and before sleep (OR = 0.833 and 0.889); those who used dental floss (OR = 0.845 and 0.844); those who used mouthwash almost every day (OR = 1.261); those who had dental scaling every 6 months (OR = 0.592); those with dental prostheses were more likely to have missing teeth (OR = 1.182); those who self-reported limiting food choices because of poor oral health were more likely to have missing teeth (OR=1.651 for occasionally, 2.704 for sometimes, 4.930 for frequently, and 5.998 for always); and those who had dental visit in last year (OR = 1.183) (**Table 3**).

Table 2. Univariate logistic regression analysis of tooth loss factors in adults aged 18 to 64 years

		Univariate analysis	
		OR (95% CI)	***p***
Demographics			
Age (years)		1.041 (1.038, 1.044)	<0.001*
Gender (females vs males)		1.180 (1.107, 1.258)	<0.001*
Education[a]	Illiterate	Ref.	
	Junior high school or below	0.561 (0.452, 0.696)	<0.001*
	Senior high school	0.316 (0.255, 0.392)	<0.001*
	University	0.182 (0.147, 0.227)	<0.001*
	Graduate school or above	0.160 (0.120, 0.213)	<0.001*
	Other	0.602 (0.377, 0.960)	0.033*
Marriage status	Married/cohabited	Ref.	
	Single	1.299 (1.105, 1.527)	0.002*
	Divorced/separated	1.928 (1.583, 2.348)	<0.001*
	Widowed	0.465 (0.432, 0.501)	<0.001*
	Other	2.094 (1.060, 4.139)	0.033*
Monthly income in the last year	<5,000	Ref.	
	5,000–20,000	1.156 (1.050, 1.273)	0.003*
	20,000–80,000	0.912 (0.841, 0.988)	0.025*
	>80,000	0.829 (0.686, 1.003)	0.053
BMI (kg/m^2)		1.019 (1.011, 1.028)	<0.001*
Disease history			
Hypertension		2.088 (1.872, 2.328)	<0.001*
Diabetes mellitus		2.966 (2.488, 3.536)	<0.001*
Hyperlipidemia		1.371 (1.243, 1.512)	<0.001*
Stroke		4.037 (2.388, 6.826)	<0.001*
Asthma		1.576 (1.249, 1.989)	<0.001*
Kidney disease		1.666 (1.404, 1.979)	<0.001*
Heart disease		2.150 (1.808, 2.555)	<0.001*
Life style			
Current drinking		1.259 (1.179, 1.345)	<0.001*
Ever smoked		1.710 (1.599, 1.828)	<0.001*
Ever chewed betel nut		1.787 (1.655, 1.930)	<0.001*
Tooth cleaning behavior			
Daily frequency of tooth brushing[a]	0–1	Ref.	
	2	0.684 (0.633, 0.739)	<0.001*
	≥3	0.641 (0.567, 0.723)	<0.001*
Brush teeth after getting up		0.960 (0.836, 1.102)	0.563
Brush teeth after breakfast		0.970 (0.819, 1.147)	0.719
Brush teeth after lunch		0.826 (0.737, 0.927)	0.001*
Brush teeth after dinner		0.908 (0.784, 1.051)	0.195
Always brush teeth after eating		1.261 (0.968, 1.642)	0.086
Brush teeth before sleep		0.683 (0.633, 0.737)	<0.001*
Use dental floss	No	Ref.	
	Occasionally	0.672 (0.621, 0.727)	<0.001*
	Almost every day	0.693 (0.639, 0.752)	<0.001*
Use mouthwash	No	Ref.	
	Occasionally	1.018 (0.919, 1.127)	0.732
	Almost every day	1.131 (0.939, 1.363)	0.196
Have dental scaling per six months		0.527 (0.479, 0.579)	<0.001*

Table 2. Univariate logistic regression analysis of tooth loss factors in adults aged 18 to 64 years (Continue)

		Univariate analysis	
		OR (95% CI)	***p***
Oral health status			
Have dental prosthesis		1.513 (1.418, 1.613)	<0.001*
Self evaluation of oral health	Very poor	Ref.	
	Poor	1.354 (1.104, 1.661)	0.004*
	Fair	0.580 (0.478, 0.703)	<0.001*
	Good	0.339 (0.279, 0.412)	<0.001*
	Very good	0.148 (0.119, 0.184)	<0.001*
Self limitation of food	Never	Ref.	
choices because of oral health	Occasionally	1.945 (1.765, 2.143)	<0.001*
status	Sometimes	3.504 (3.176, 3.865)	<0.001*
	Frequently	7.790 (6.246, 9.716)	<0.001*
	Always	11.345 (8.011, 16.067)	<0.001*
Had dental visit in the last year		1.040 (0.974, 1.111)	0.240

[a]The variable was excluded in the multivariable analysis because of multi-colinearity. 15107 (97.5%) cases were analyzed in the multivariable analysis.

Table 3. Multivariate logistic regression analysis of tooth loss factors in adults aged 18 to 64 years (n = 15,501)

	OR (95% CI)	***p***
Demographics		
Age (years)	1.020 (1.015, 1.024)	<0.001*
BMI (kg/m2)	1.004 (1.001, 1.007)	0.009*
Marriage status		
Married/cohabited	reference	
Single	1.086 (0.911, 1.295)	0.356
Divorced/separated	1.301 (1.048, 1.614)	0.017*
Widowed	0.789 (0.711, 0.875)	<0.001*
Other	1.920 (0.915, 4.029)	0.085
Monthly income in the last year		
<5,000	reference	
5,000-20,000	1.102 (0.990, 1.227)	0.075
20,000-80,000	0.984 (0.896, 1.079)	0.725
>80,000	0.746 (0.606, 0.918)	0.006*
Disease history		
Hypertension	1.138 (1.002, 1.292)	0.046*
Diabetes mellitus	1.440 (1.181, 1.756)	<0.001*
Asthma	1.308 (1.009, 1.695)	0.043*
Heart disease	1.285 (1.056, 1.563)	0.012*
Life style		
Have ever smoked	1.470 (1.342, 1.611)	<0.001*
Have ever chewed betel nut	1.249 (1.126, 1.386)	<0.001*
Tooth cleaning behavior		
Brush teeth after lunch	0.833 (0.733, 0.947)	0.005*
Brush teeth before sleep	0.889 (0.816, 0.969)	0.007*
Use of dental floss		
No	reference	
Occasionally	0.845 (0.775, 0.922)	<0.001*
Almost every day	0.844 (0.770, 0.924)	<0.001*
Use of mouthwash		
No	reference	
Occasionally	1.084 (0.969, 1.213)	0.160
Almost every day	1.261 (1.024, 1.553)	0.029*
Have dental scaling per six months	0.592 (0.530, 0.660)	<0.001*

Table 3. Multivariate logistic regression analysis of tooth loss factors in adults aged 18 to 64 years (n = 15,501) (Continue)

	OR (95% CI)	*p*
Dental health status		
Have dental prosthesis	1.182 (1.098, 1.274)	<0.001*
Self-limited food choices because of dental health		
Never	reference	
Occasionally	1.651 (1.490, 1.830)	<0.001*
Sometimes	2.704 (2.434, 3.005)	<0.001*
Frequently	4.930 (3.894, 6.243)	<0.001*
Always	5.998 (4.149, 8.673)	<0.001*
Had dental visit in the last year	1.183 (1.096, 1.278)	<0.001*

BMI = body mass index. OR (95%CI.), odds ratio (OR) with respective 95% confidence internal of OR, which were derived through multivariate logistic regression model analysis.*$p < 0.05$, indicated significance of OR

Discussion

This study evaluated the oral health of adults aged from 18 to 64 years who had completed the NHIS. Variables were analyzed to identify risk factors for tooth loss among younger and middle-aged adults. The underlying goal was to better understand Taiwan's increasing trend of tooth loss. Questions to be answered include. In what age bracket does tooth loss begin? What are the primary risk factors and in what segment of the adult population do they occur? And what can possibly be done to change the nationwide trend?

Among adults aged from 18 to 64 years, those of older age, divorced or separated, having higher BMI, history of hypertension and other chronic diseases, and who have smoked and chewed betel nut were more likely to have missing teeth. Subjects with higher monthly income or widowed were less likely to have missing teeth.

In this study, although older age was a factor for tooth loss among adults aged 18 to 64 years, these adult subjects overwhelmingly retained their natural teeth (396 or 2.6% with <20 teeth; 15,027, 97.4% with ≥20 teeth). By contrast, previous studies of older adults in Taiwan showed that the percentage of those with missing teeth was markedly higher in adults over age 65 years [11]. However, because we studied a continuum from early- to mid-adulthood, we learned that risk factors in earlier years may contribute to the marked difference in tooth loss in later years. This is consistent with findings from previous studies. A study of older adults in Brazil revealed that loss of more than four teeth was associated with low socioeconomic status and heavy smoking, and adults with a history of dental caries or filled teeth were more likely to lose teeth [4]. It was also noted in that study, that heavy smokers were more likely to lose teeth than nonsmokers. Similarly, in the present study, smoking tobacco and chewing betel nut were risk factors for tooth loss in adults aged from 18 to 64 years. Among older adults, alcohol was also a factor along with using tobacco and betel nut [4]. Significant linear trends were observed between cigarette smoking and tooth loss in older adult males and alcohol drinking and tooth loss in younger adult males (ages 30–39 years) [14]. Clearly, reducing these lifestyle behaviors may have a positive impact on reducing tooth loss in adults of all ages.

Overall health was associated with tooth loss in adults in this study. Higher BMI as a sign of increased weight among adults aged 18 to 64 was a risk factor for tooth loss. Self-reported general health was better in adults without missing teeth and those with hypertension, diabetes mellitus, asthma and heart disease were more apt to have missing teeth or poor oral health. Similar associations were found between general health parameters and tooth loss among older adults [15].

Good oral hygiene habits such as brushing teeth on rising and before bed, using dental floss or mouth wash and having dental scaling at least every six months were found in adults who had retained more natural healthy teeth. Correspondingly, those who had more frequent dental visits and had utilized more dental services had more natural teeth, fewer dentures and fewer reported limitations in food choices due to

oral health status. In a Danish study of adults aged 16 years and older, an interesting relationship was found between brushing teeth twice every day and having regular dental visits; good oral hygiene habits were reported more often by women than men; and frequency of cleaning dentures (prostheses) was significantly associated with gender, younger age of denture wearer, education level, and number of natural teeth retained [16]. Among older dentate adults receiving dental care in Lithuania, those with more teeth described better habits such as brushing twice daily, eating less sugar, and having regular dental services; however, frequent brushing of teeth was the only significant factor [17]. In contrast, another study showed that not receiving dental care in a three-year period accounted for substantial increases in risk of tooth loss [4]. It is reasonable to suggest that if adults of any age who have better oral hygiene habits and regular dental care also have more natural healthy teeth, the benefits of those individual measures may be goals for nationwide programs to prevent tooth loss. These may be the type of education initiatives that, if adopted nationally, would help to curb the increasing trend in tooth loss in Taiwan.

Limitations

This study has several limitations, including that it applied secondary database analysis, which cannot be tailored to provide all the data that might be helpful in the study. Only cross-sectional study design is applicable to analyzing the database, but it does limit generalizability of results by not identifying causal effects. Another limitation is that all data were self-reported and subjects were not examined by a dentist as part of the NHIS; this interjects the subjects' own perceptions of their oral health status into the data and accuracy of this data cannot be verified. Future research is needed to further examine risk factors for tooth loss across the full span of adulthood.

Conclusions

Risk factors for tooth loss in adults aged 18–64 years include older age, unmarried status, lower income, higher BMI, substance use (smoking, betel nut) and chronic disease. Knowledge of associated risk factors for tooth loss in adults aged may help Taiwan develop national programs and policies for dental care specific to these adults, which may help to promote long-term oral health and retention of healthy teeth throughout adulthood.

The authors have no conflict of interest to report.

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