Relationship between Diabetes Mellitus and Tooth Loss in Adults Residing in Ubonratchathani Province, Thailand

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Background: *Diabetes mellitus is associated with oral diseases or oral complications leading to tooth loss. Prevalence of diabetes and tooth loss in Thailand is increasing.*
Objective: *Determine the relationship between diabetes mellitus and tooth loss in adults residing in Nachaluay district, Ubonratchathani province, Thailand during the year 2010.*
Material and Method: *A Cross-sectional analytic study included 605 adults (130 males and 475 females), aged 20 to 86 years, of which 226 subjects did not have diabetes mellitus, and 379 people were diabetic patients. The subjects received an interview and oral examination. Data analysis was performed using descriptive, bivariate, and multivariable logistic regression analyses.*
Results: *Findings from the final multivariable logistic regression model showed that tooth loss (defined as missing ≥ 1 teeth) was associated significantly with age, diabetes mellitus, dental caries, loss of clinical attachment level 6 mm ≥ 2 sides, and use of fluoride toothpaste, with the adjusted odds ratio (95% CI) being 1.067 (1.047,1.088), 1.729 (1.092,2.738), 1.149 (1.071, 1.232), 2.436 (1.575, 3.767), and 0.541 (0.321, 0.914), respectively.*
Conclusion: *Tooth loss was associated directly with diabetes mellitus in Thai adults. Therefore, prevention and promotion as well as early treatment of diabetes and oral diseases should be achieved to reduce occurrence, severity, and complications resulting from diabetes mellitus and tooth loss.*

Keywords: *Diabetes mellitus, Tooth loss, Periodontitis, Dental caries, Thailand*

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Diabetes mellitus is a chronic disease whereby the prevalence has been increasing worldwide. Recently, diabetes mellitus has become a major health problem in Thailand and research evidence from several nations has indicated that diabetes mellitus was associated with oral diseases and tooth loss[1-7]. Oral problems in diabetic patients include tooth loss, gingivitis, periodontitis, and oral soft-tissue pathology. Periodontal disease and dental caries are major causes of tooth loss. The relationship between diabetes and periodontitis has been confirmed to be a bi-directional connection[8,9], while the relationship between diabetes and dental caries is still unclear. Many studies also found that diabetes was a risk factor for gingivitis and periodontitis if the patients had poor glycemic control[10-12]. The prevalence as well as severity of gingivitis and destructive periodontal tissue in patients with poor glycemic control was higher compared to those with good control[13]. In a review of the literature in 2004, Taylor et al has reported some evidence of the relationship between type 2 diabetes and dental caries[14]. Kaur et al reported that diabetes mellitus type 1 was directly associated with tooth loss and type 2 was significantly associated with tooth loss only among females[15]. In addition, Patino et al in 2008 also confirmed that diabetes mellitus type 2 was related to tooth loss[16].

Some prior epidemiological research has reported a number of factors related to oral diseases and tooth loss among healthy Thai adults[17-20]. However, the research evidence regarding tooth loss and diabetes in Thailand is still scarce although the prevalence of diabetes mellitus has been increasing and severity of tooth loss is still a major oral health problem in Thailand.

Therefore, the purpose of the present cross-sectional study was to determine the association

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between tooth loss and diabetes mellitus adjusting for potential confounding factors in adults residing in Nachaluay district, Ubonratchathani province, Thailand.

Material and Method

Population and sample

The population consisted of diabetic and non-diabetic adults living in Nachaluay district, Ubonratchathani province, Thailand during the year 2010. The samples included 605 people (130 males and 475 females; 379 diabetic and 226 non-diabetic). Their ages ranged from 20 to 86 years. All the samples volunteered to participate in both the interview and oral health examination.

The 379 diabetic patients were classified as "known diabetes", who had fasting plasma glucose (FPG) value ≥ 126 mg/dl and had already been informed of their condition by a medical practitioner. These patients were followed-up routinely by a medical team. The check-up periods for these diabetic patients were scheduled every one, two, or three months, for fasting plasma glucose (FPG) level > 180 mg/dl, > 130-180 mg/dl, or 80-130 mg/dl, respectively. The non-diabetic people included 226 out-patients and healthy adults residing in Nachaluay district.

The present study protocol was approved by the Human Research Ethics Committee of Khon Kaen University, Thailand (HE532162).

Data collection

Interview

The subjects received an interview on baseline characteristics including gender (male/female), age (year), marital status (single/married/divorced/widowed), weight (kilogram), height (meter), waist (inch), body mass index (kg/m^2), education level (no schooling/lower primary (prathom 4)/lower primary (prathom 6)/lower secondary/upper secondary or vocational school/bachelor diploma/bachelor degree/others), occupation (unemployed/labor/agricultural/civil/merchant/others), income (monthly/yearly), having diabetes mellitus and/or other diseases (yes/no), duration of having diabetes mellitus (year), level of fasting blood sugar during the past three months (mg/dl), treatment of diabetes (yes/no), xerostomia (yes/no), diet control (yes/no), alcohol use, smoking and betel chewing (non-user/ex-user/occasional user/regular user), duration of alcohol use, tobacco smoking and betel chewing (year), exercise (none/sometime/regularly), food intake inducing diabetes mellitus (yes/no), tooth brushing (none/sometimes/once daily/twice a day/more than twice a day), oral cleansing aids other than brushing, oral care problem, history of tooth loss, denture wearing and cleaning as well as knowledge and attitude about relationship between diabetes mellitus and tooth loss (yes/no).

Oral examination

The oral examination was done for periodontal conditions as well as dental caries status and treatment need based on WHO criteria. Mouth mirror, explorer, and WHO periodontal probe were used to assess the conditions.

Indices to measure oral health status

Dental caries status was measured using decayed, missing and filled teeth (DMFT) index whereby the criteria were coded as follows: 0 = normal tooth without caries (sound tooth), 1 = decayed, 2 = filled with decayed, 3 = filled with no decayed, 4 = missing due to caries, 5 = missing due to other reasons, 6 = fissure sealant, 7 = crown or bridge abutment, 8 = unseen in the oral cavity, 9 = fracture, 10 = abrasion or erosion, and 11 = status of teeth not included in the above.

Treatment need was coded as 0 = no need for treatment, 1 = prevention of caries, 2 = fissure sealant, 3 = one surface filling, 4 = two or more surface filling, 5 = crown, 6 = veneer, 7 = root canal treatment, 8 = extraction, 9 = need for other care (specify type of treatment).

Periodontal conditions were determined for periodontal pocket as well as clinical attachment loss (CAL) using WHO periodontal probe. The Community Periodontal Index (CPI) was used based on the following criteria: 0 = healthy gingiva, 1 = bleeding gingiva, 2 = calculus, 3 = calculus with bleeding, 4 = pocket 4-5 mm, 5 = pocket 6 mm or more, 9 = cannot be determined, 10 = missing sextant/excluded.

Debris Index Simplified (DI-S) was used to measure deposition of food debris based on the following criteria: 0 = no debris, 1 = debris deposit 1/3 of tooth surface, 2 = debris deposit 1/3-2/3 of tooth surface, 3 = debris deposit > 2/3 of tooth surface.

Data quality control, data management, and data analysis

Control of data quality

The dentist who conducted the examination had previously been trained for assessing oral health indices validly and had acceptable kappa values for

repeatability of the examination of at least 80%. To ensure consistency in performing the oral examination in the field, repeated measurements in 10% of the samples were done and the kappa statistics throughout the whole examination were higher than 80%. The research team who conducted the interview also had been well-trained to do it. To reduce errors in the process of data entry, double data entry was done independently by two well-trained research staff.

Data management and data analysis

The data were analyzed using SPSS for Windows 16.0. Results were obtained by means of descriptive, bivariate, and multivariable logistic regression. Descriptive statistics using mean, standard deviation and proportion were used to analyze the basic information such as age, sex, marital status, education level, main occupation, income and oral health status, both periodontal diseases and dental caries. Bivariate statistics using chi-square test and independent t-test were employed, based on the assumptions of the statistics being used, to assess the preliminary relationship between tooth loss (defined as missing $\geq$ 1 teeth) and potential predictors, not yet adjusting for confounding factors. The final multivariable logistic regression model having tooth loss as an outcome was achieved to define a set of variables related to tooth loss. The adjusted odds ratios along with their 95% CIs were reported and p-value of less than 0.05 was considered statistically significant.

Results

The present study had a total sample of 605 people (130 males and 475 females). About 65.5% had tooth loss (missing $\geq$ 1 teeth). The ages ranged from 20 to 86 years with the mean age 50.5 years. Mostly, people were married (88.9%) and 56% attained lower primary education, 9.4% had not received any formal education. Average yearly income was 43,148 Thai baht. The main occupation was agriculture (82%). Among all samples, 379 people (62.6%) had diabetes mellitus and 226 people (37.4%) were normal people. The patients had diabetes for 7.1 years on average and had average fasting plasma glucose 148.9 mg/dl.

Table 1 presents bivariate relationship of the characteristics related to tooth loss. It can be seen that people who had tooth loss were older and had more fat deposit around the waist. Mostly, people with tooth loss were unemployed and did not have any formal education. They also had more systemic diseases including hypertension, nephropathy, retinopathy, and diabetes. In addition, people who had tooth loss also chewed more betel quid, brushed their teeth less often and used less of fluoride toothpaste.

Table 2 shows the bivariate relationship between tooth loss and dental health variables. As can be seen, people who had tooth loss also had more dental caries, deeper periodontal pocket, and higher loss of periodontal clinical attachment level.

Tables 3 and 4 are the bivariate relationships between tooth loss and several variables. Findings in Table 3 suggest that age, BMI, waist circumference, income, education, occupation, systemic diseases, alcohol use, betel chewing, exercise, eating sweet fruits, sticky rice, sweet drinks and soda, ice cream, foods rich in fat and carbohydrates, tooth brushing, and problems accessing to dental services might be associated with diabetes. While the results in Table 4 show that the diabetic patients lost more teeth, had deeper periodontal pockets, and had higher loss of periodontal clinical attachment level.

Table 5 presents findings from the final multivariable logistic regression model. Based on this model, tooth loss was associated significantly with age, dental caries, diabetes mellitus, use of fluoride toothpaste and loss of CAL 6 millimeter $\geq$ 2 sides, with the adjusted odds ratios and 95% CIs shown in the Table. The relationship between tooth loss and age, dental caries, diabetes mellitus and loss of clinical attachment level were direct, but the association of tooth loss with use of fluoride toothpaste was indirect. Patients with diabetes mellitus were prone to tooth loss than their non-diabetic counterparts. The ones who were older had higher tooth loss. Those who had more decayed teeth also were at increased risk of having tooth loss. People who had loss of CAL 6 mm $\geq$ 2 sides also had higher tooth loss. In addition, people who used fluoride toothpaste had lower tooth loss compared to those using toothpaste without fluoride.

Discussion

Findings from the present study showed that after adjusting for several confounding factors, diabetes mellitus was associated significantly with tooth loss in adults residing in Nachaluay district, Ubonratchathani province, Thailand. The results are in agreement with several studies. Guglieimo et al[21] studied among Sardinian adults and found that there were a significant lower number of teeth present in type 2 diabetes mellitus compared to non-diabetes controls. Jung et al[22] evaluated in Korean elderly using national database and concluded that total tooth loss was associated with

Table 1. Bivariate relationship between tooth loss and selected variables[a]

Variable	No tooth loss (n = 209)	Tooth loss ≥ 1 (n = 396)	p-value
Age (mean ± SD in year)	44.16 ± 10.96	53.92 ± 12.78	<0.001[b]
Waist (mean ± SD in inch)	33.20 ± 3.69	34.07 ± 4.96	0.027[b]
Income (mean ± SD baht/year)	45,600.00 ± 44,093.97	41,800.00 ± 58,106.25	0.410[b]
Sex			
Female	169 (80.9%)	306 (77.3%)	0.307[c]
Male	40 (19.1%)	90 (22.7%)	
Marital status			
Married	186 (90.7%)	344 (88.0%)	0.021[c]
Single	9 (4.4%)	7 (1.8%)	
Divorced	4 (2.0%)	7 (1.8%)	
Widowed	6 (2.9%)	33 (8.4%)	
Body mass index (kg/m^2)			
0-18.49	10 (4.8%)	23 (5.8%)	0.927[c]
18.50-24.99	108 (52.2%)	209 (53.0%)	
25.00- 29.99	69 (33.3%)	128 (32.5%)	
≥ 30.00	20 (9.7%)	34 (8.6%)	
Education			
Did not go to school	11 (5.3%)	46 (11.6%)	<0.001[c]
Prathom 4	100 (47.8%)	239 (60.4%)	
Prathom 6	54 (25.8%)	62 (15.7%)	
Lower secondary level	24 (11.5%)	11 (2.8%)	
Upper secondary level/vocational certificate	14 (6.7%)	16 (4.0%)	
Higher vocational school/diploma	2 (1.0%)	4 (1.0%)	
Bachelor's degree	3 (1.4%)	5 (1.3%)	
Others	1 (0.5%)	13 (3.3%)	
Occupation			
Unemployed	7 (3.3%)	52 (13.1%)	0.009[c]
Laborer	5 (2.4%)	13 (3.3%)	
Agricultural	187 (89.5%)	309 (78.0%)	
Civil servant	3 (1.4%)	4 (1.0%)	
Merchant	4 (1.9%)	10 (2.5%)	
Others	3 (1.4%)	8 (2.1%)	
Hypertension			
No	154 (74.4%)	255 (65.1%)	0.019[c]
Yes	53 (25.6%)	137 (34.9%)	
Nephropathy			
No	201 (97.1%)	362 (92.3%)	0.020[c]
Yes	6 (2.9%)	30 (7.7%)	
Retinopathy			
No	204 (98.6%)	372 (94.6%)	0.027[c]
Yes	3 (1.4%)	20 (5.1%)	
Diabetes mellitus			
No	78 (40.6%)	123 (31.7%)	0.034[c]
Yes	114 (59.4%)	265 (68.3%)	

[a] Number of samples for some variables may not be 100%
[b] Test of difference between means (t-test), $p < 0.05$
[c] Test of difference between proportions (Chi-square test), $p < 0.05$

Table 1. (cont.)

Variable	No tooth loss (n = 209)	Tooth loss ≥ 1 (n = 396)	p-value
Duration of diabetes (mean ± SD in years)	6.58 ± 5.46	7.35 ± 6.31	0.257[b]
Fasting plasma glucose during the past 3 months (n = 379)			
< 119 mg/dl	23 (20.5%)	88 (33.7%)	0.027[c]
120-180 mg/dl	69 (61.6%)	126 (48.3%)	
> 180 mg/dl	117 (17.9%)	182 (18.0%)	
How to treated diabetes mellitus			
Had been treated continuously	108 (94.7%)	245 (92.5%)	0.420[c]
Not treated consistently	6 (5.3%)	20 (7.5%)	
Diet control			
No control	5 (4.4%)	16 (6.0%)	0.806[c]
Not strictly controlled	94 (82.5%)	216 (81.5%)	
Strictly controlled	15 (13.2%)	33 (12.5%)	
Xerostomia			
No	78 (68.4%)	203 (76.6%)	0.095[c]
Yes	36 (31.6%)	62 (23.4%)	
Betel chewing			
Non-user	170 (81.3%)	264 (66.7%)	0.001[c]
Ex-user	9 (4.3%)	38 (9.6%)	
Occasional user	13 (6.2%)	30 (7.6%)	
Regular user	17 (8.1%)	64 (16.2%)	
Smoking			
Non-user	174 (83.3%)	311 (78.5%)	0.566[c]
Ex-user	15 (7.2%)	35 (9.1%)	
Occasional user	7 (3.3%)	15 (3.8%)	
Regular user	13 (6.2%)	34 (8.26%)	
Alcohol use			
Non-user	104 (50.0%)	201 (50.8%)	0.757[c]
Ex-user	31 (14.9%)	67 (16.9%)	
Occasional user	70 (33.7%)	125 (31.6%)	
Regular user	3 (1.4%)	3 (0.8%)	
Tooth brushing			
None	1 (0.5%)	27 (6.8%)	0.012[c]
Sometimes	3 (1.4%)	5 (1.3%)	
Once daily	65 (31.1%)	124 (31.3%)	
Twice a day	135 (64.6%)	232 (58.6%)	
More than twice a day	5 (2.4%)	8 (2.0%)	
Type of toothpaste			
Without fluoride	25 (12.0%)	91 (23.0%)	0.001[c]
With fluoride	184 (88.0%)	305 (77.0%)	

[a] Number of samples for some variables may not be 100%
[b] Test of difference between means (t-test), $p < 0.05$
[c] Test of difference between proportions (Chi-square test), $p < 0.05$

diabetes mellitus. Botero et al[23] studied in patients with and without diabetes mellitus among a population of the United States of America and found that diabetic patients had more tooth loss as well as periodontal clinical attachment loss, of which were increased by hyperglycemia among diabetic patients. Kapp et al[6] studied the association between diabetes and tooth loss among a population reporting an annual dental visit of

Table 2. Bivariate relationship between tooth loss and dental health variables[a]

Variable	No tooth loss (n = 209)	Tooth loss ≥ 1 (n = 396)	p-value
Periodontal pocket 5 mm or more			
No	128 (61.2%)	209 (52.8%)	0.046[c]
Yes	81 (38.8%)	187 (47.2%)	
Periodontal pocket 6 mm or more			
No	178 (85.2%)	292 (73.7%)	0.001[c]
Yes	31 (14.8%)	104 (26.3%)	
Loss of clinical attachment level 3 mm 1 side or more			
No	27 (12.9%)	49 (12.4%)	0.848[c]
Yes	182 (87.1%)	347 (87.6%)	
Loss of clinical attachment level 5 mm 1 side or more			
No	81 (38.8%)	103 (26.0%)	0.001[c]
Yes	128 (61.2%)	293 (74.0%)	
Loss of clinical attachment level 6 mm 1 side or more			
No	128 (61.2%)	153 (38.6%)	<0.001[c]
Yes	81 (38.8%)	243 (61.4%)	
Loss of clinical attachment level 6 mm 2 sides or more			
No	155 (74.2%)	183 (46.2%)	<0.001[c]
Yes	54 (25.8%)	213 (53.8%)	
Mild debris			
No	31 (14.8%)	104 (26.3%)	0.001[c]
Yes	178 (85.2%)	292 (73.7%)	
Moderate debris			
No	43 (20.6%)	136 (34.3%)	<0.001[c]
Yes	166 (79.4%)	260 (65.7%)	
Severe debris			
No	47 (22.5%)	123 (31.1%)	0.026[c]
Yes	162 (77.5%)	273 (68.9%)	
Bleeding on probing (mean ± SD in sextant)	0.38 (± 0.84)	0.31 (± 0.81)	0.273[b]
Calculus (mean ± SD in sextant)	0.28 (± 0.65)	0.25 (± 0.67)	0.545[b]
Calculus with bleeding (mean ± SD in sextant)	3.68 (± 1.64)	2.51 (± 1.89)	<0.001[b]
Dental caries (mean ± SD of teeth number)	2.54 (± 2.60)	3.58 (± 3.89)	0.001[b]

[a] Number of samples for some variables may not be 100%
[b] Test of difference between means (t-test), $p < 0.05$
[c] Test of difference between proportions (Chi-square test), $p < 0.05$

the USA and reported that people with diabetes mellitus had a significantly higher prevalence of tooth removal and a strong association between diabetes and tooth loss existed among younger people. Ueno et al[24] found that diabetes mellitus was associated with higher risk of being edentulism in Mexican elders aged 60 years and older. In addition, the study of Bole et al[25] confirmed that history of diabetes mellitus was a significant risk factor of increased tooth loss in postmenopausal women of the Buffalo, New York. Tanwir et al[26] studied in a population in Pakistani and found that diabetic patients had fewer teeth than non-diabetic people. While association of tooth loss and edentulism with diabetes mellitus had been previously reported in many countries[27-35], some studies found only slightly and not significant association[12,36-38]. The difference in the findings may be explained by the fact that the samples may differ regarding their background characteristics (race, age, sex, social status, etc) as well as severity of diabetes

Table 3. Bivariate relationship between diabetes and selected variables[a]

Variable	Non DM (n = 226)	DM (n = 379)	p-value
Age (mean ± SD in year)	43.59 ± (12.6)	54.70 ± (11.4)	<0.001[b]
Age range	20-80	27-86	
Waist (mean ± SD in inch)	32.8 ± (3.7)	34.3 ± (4.9)	<0.001[b]
BMI (mean ± SD)	23.9 ± (3.7)	24.9 ± (4.0)	0.003[b]
Income (mean ± SD baht/year)	55,900 ± (63,722)	35,500 ± (45,024)	<0.001[b]
Sex			
Female	168 (74.3%)	307 (81.0%)	0.053[c]
Male	58 (25.7%)	72 (19.0%)	
Marital status			
Married	197 (87.6%)	333 (89.8%)	0.054[c]
Single	8 (3.6%)	8 (2.2%)	
Divorced	8 (3.6%)	3 (0.7%)	
Widowed	12 (5.2%)	27 (7.3%)	
Education			
Did not go to school/others	11 (4.9%)	60 (15.8%)	<0.001[c]
Prathom 4	85 (37.6%)	254 (67.0%)	
Prathom 6	65 (28.8%)	51 (13.5%)	
Lower secondary level	30 (13.3%)	5 (1.3%)	
Upper secondary level/vocational certificate	29 (12.8%)	7 (1.8%)	
Higher vocational school/diploma/Bachelor's degree	6 (2.7%)	2 (0.5%)	
Occupation			
Unemployed	11 (4.9%)	48 (12.7%)	0.001[c]
Laborer	8 (3.5%)	10 (2.6%)	
Agricultural	187 (82.7%)	309 (81.5%)	
Civil servant	7 (3.1%)	7 (1.8%)	
Merchant/others	13 (5.8%)	5 (1.3%)	
Systemic diseases			
No	142 (62.8%)	98 (25.9%)	<0.001[c]
Yes	84 (37.2%)	280 (74.1%)	
Tobacco smoking			
Non-user	176 (77.9%)	309 (81.5%)	0.157[c]
Ex-user	16 (7.1%)	51 (8.4%)	
Occasional user	11 (4.9%)	11 (2.9%)	
Regular user	23 (10.2%)	47 (7.8%)	
Alcohol use			
Non-user	80 (36.6%)	225 (59.4%)	<0.001[c]
Ex-user	24 (10.7%)	74 (19.5%)	
Occasional user	116 (51.6%)	79 (20.8%)	
Regular user	5 (2.2%)	1 (0.3)	
Betel chewing			
Non-user	199 (88.1%)	235 (62.0%)	<0.001[c]
Ex-user	5 (2.2%)	42 (11.1%)	
Occasional user	13 (5.8%)	30 (7.9%)	
Regular user	9 (4.0%)	72 (19.0%)	

[a] Number of samples for some variables may not be 100%
[b] Test of difference between means (t-test), $p < 0.05$
[c] Test of difference between proportions (Chi-square test), $p < 0.05$

Table 3. (cont.)

Variable	Non DM (n = 226)	DM (n = 379)	p-value
Exercise			
None	94 (41.8%)	107 (28.2%)	0.003[c]
Occasionally	93 (41.3%)	197 (52.0%)	
Regularly	38 (16.9)	75 (19.8%)	
Eating sweet fruits			
None	2 (0.9%)	49 (13.0%)	<0.001[c]
Occasionally	192 (85.0%)	311 (82.5%)	
Regularly	32 (14.2%)	17 (4.5%)	
Eating sticky rice			
None	0 (0%)	9 (2.4%)	0.005[c]
Occasionally	13 (5.8%)	41 (10.9%)	
Regularly	213 (94.2%)	327 (86.7%)	
Drinking sweet drinks and soda			
None	18 (8.0%)	137 (36.3%)	<0.001[c]
Occasionally	192 (85.0%)	234 (62.1%)	
Regularly	16 (7.1%)	6 (1.6%)	
Eating sweet desserts and ice-cream			
None	10 (4.4%)	113 (30.0%)	<0.001[c]
Occasionally	199 (88.1%)	258 (68.4%)	
Regularly	17 (7.5%)	6 (1.6%)	
Eating foods rich in fat and carbohydrates			
None	13 (5.8%)	114 (30.2%)	<0.001[c]
Occasionally	176 (77.9%)	245 (65.0%)	
Regularly	37 (16.4%)	18 (4.8%)	
Eating sweet beverages			
None	21 (9.3%)	169 (44.8%)	<0.001[c]
Occasionally	123 (54.4%)	165 (43.8%)	
Regularly	82 (36.3%)	43 (11.4%)	
Eating other fat and carbohydrate foods			
None	11 (4.9%)	69 (18.3%)	<0.001[c]
Occasionally	171 (75.7%)	286 (75.9%)	
Regularly	44 (19.5%)	22 (5.8%)	

[a] Number of samples for some variables may not be 100%
[b] Test of difference between means (t-test), $p < 0.05$
[c] Test of difference between proportions (Chi-square test), $p < 0.05$

or other systemic diseases, which then could influence the results of the studies.

Patients with diabetes mellitus had higher prevalence and severity of periodontal diseases[26,31,38] and dental caries[27]. Studies among several nations confirmed that periodontal disease and dental caries were major causes of tooth loss[39-41] especially periodontal disease was a significant cause of tooth loss in patients having diabetes mellitus[15]. The diabetic patients with poorly controlled diabetes were at risk for severe periodontitis[42,43] and dental caries[44] leading ultimately to tooth loss. Awartani[45] found that poorly controlled diabetic patients had a significantly higher calculus, PD $\geq$ 4 mm and loss of CAL (3-4 mm) compared to the better controlled groups. Therefore, preventing oral complications and tooth loss in patients having diabetes mellitus is important in helping to decrease tooth loss.

The finding that diabetes status (defined as yes vs. no) and duration of diabetes demonstrated some relations with tooth loss while FPG did not show any trend of association might reflect that the validity of

Table 4. Bivariate relationship between diabetes and dental health variables[a]

Variable	Non DM (n = 226)	DM (n = 379)	p-value
Tooth brushing			
None/sometimes	5 (2.2%)	31 (8.2%)	0.003[c]
Everyday	221 (97.8%)	348 (91.8%)	
Toothpaste			
Fluoride toothpaste	194 (85.8%)	295 (77.8%)	0.102[c]
Herbal toothpaste	23 (10.2%)	48 (12.7%)	
Salt only	4 (1.8%)	14 (3.7%)	
Did not use toothpaste	3 (1.3%)	13 (3.4%)	
Others	2 (0.9%)	9 (2.4%)	
Dental visit during the past year			
No	130 (57.5%)	235 (62.0%)	0.276[c]
Yes	96 (42.5%)	144 (38.0%)	
Having problems accessing to dental care			
No	202 (89.4%)	313 (82.8%)	0.027[c]
Yes	24 (10.6%)	65 (17.2%)	
Denture wearing			
No	214 (97.7%)	355 (93.7%)	0.607[c]
Yes	12 (5.3%)	24 (6.3%)	
Dental caries (mean ± SD of teeth number)	3.47 ± (3.30)	3.07 ± (3.60)	0.181[b]
Missing teeth (mean ± SD of teeth number)	3.07 ± (6.00)	6.37 ± (8.80)	<0.001[b]
Filled teeth (mean ± SD of teeth number)	0.25 ± (0.90)	0.07 ± (0.40)	0.002[b]
Decay missing filled teeth (mean ± SD of teeth number)	6.79 ± (6.82)	9.51 ± (9.12)	<0.001[b]
Periodontal conditions (mean ± SD in sextant)			
Bleeding on probing	0.50 ± (0.97)	0.23 ± (0.70)	<0.001[b]
Calculus	0.55 ± (0.87)	0.08 ± (0.42)	<0.001[b]
Calculus with bleeding	3.36 ± (1.67)	2.65 ± (1.97)	<0.001[b]
Periodontal pocket 4-5 mm	0.97 ± (1.16)	1.53 ± (1.50)	<0.001[b]
Periodontal pocket ≥ 6 mm	0.15 ± (0.54)	0.51 ± (0.94)	<0.001[b]
Debris deposits (mean ± SD in sextant)			
Mild	1.90 ± (1.40)	1.82 ± (1.53)	0.035[b]
Moderate	1.43 ± (1.06)	1.46 ± (1.40)	0.001[b]
Severe	1.94 ± (1.54)	1.72 ± (1.77)	0.001[b]
Loss of clinical attachment level 6 mm 1 side or more			
No	181 (80.1%)	157 (41.4%)	<0.001[c]
Yes	45 (19.9%)	222 (58.6%)	
Loss of clinical attachment level 6 mm 2 sides or more			
No	160 (71.8%)	121 (32.9%)	<0.001[c]
Yes	66 (29.2%)	258 (68.1%)	
Tooth loss ≥ 1 teeth			
No	95 (42.0%)	114 (30.1%)	0.003[c]
Yes	131 (58.0%)	265 (69.9%)	

[a] Number of samples for some variables may not be 100%
[b] Test of difference between means (t-test), $p < 0.05$
[c] Test of difference between proportions (Chi-square test), $p < 0.05$

measurement of FPG might not be adequate in the present study. Under limited resources, the low-cost FPG is practically used to measure diabetes in rural hospitals of Thailand. However, it should be noted

Table 5. Adjusted odds ratio and 95% CI of variables associated with tooth loss in the final multivariable logistic regression model (Nagelkerke R Square = 24.9%)

Variable	Adjusted odds ratio	95% confidence limit		p-value
		Lower	Upper	
Age (years)	1.067	1.047	1.088	<0.001
Dental caries	1.149	1.071	1.232	<0.001
Diabetes mellitus				
Yes	1.729	1.092	2.738	0.020
No (reference)	1			
Type of toothpaste				
With fluoride	0.541	0.321	0.914	0.022
Without fluoride (reference)	1			
Loss of clinical attachment level 6 mm 2 sides or more				
Yes	2.436	1.575	3.767	<0.001
No (reference)	1			

that hemoglobin A1c is considered a more efficient measurement and should be increasingly used instead[46].

The present study may have some limitations due to a cross-sectional design, which by itself, the causal relationship between tooth loss and diabetes mellitus cannot be confirmed based on this type of study. However, the strengths of the present study include the fact that the authors were able to study tooth loss among high-risk Thai people who had diabetes mellitus as well as the present sample size was large enough to give sufficient statistical power of the study greater than 80%. The present results agree well with several prior studies around the world and can be established as baseline knowledge for future research both in Thailand and worldwide. However, in different countries, there may be some differences regarding the socioeconomic and health-related behaviors as well as ethnic disparities that might make risk factors for tooth loss differ based on varied conditions of the samples[47,48].

Conclusion

Conclusion can be drawn from the present study that diabetes mellitus was directly associated with tooth loss and several other factors including dental diseases, both dental caries and periodontitis. Older age was also related to increased tooth loss while use of fluoride toothpaste was a protective factor against tooth loss. Therefore, based on this knowledge, preventive oral health program and oral health promotion as well as early treatment of diabetes and oral diseases should be obtained to decrease occurrence, severity, and complications resulting from diabetes mellitus and tooth loss.

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Potential conflicts of interest

There is no conflict of interest regarding this study.

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ความสัมพันธ์ระหว่างโรคเบาหวานกับการสูญเสียฟันในผู้ใหญ่ในจังหวัดอุบลราชธานี ประเทศไทย

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ภูมิหลัง: *โรคเบาหวานมีความสัมพันธ์กับการเกิดโรคและภาวะแทรกซ้อนในช่องปากและทำให้เกิดการสูญเสียฟันตามมาได้ โดยพบว่าความชุกของโรคเบาหวานและการสูญเสียฟันในประเทศไทยเพิ่มสูงขึ้น*

วัตถุประสงค์: *เพื่อศึกษาความสัมพันธ์ระหว่างโรคเบาหวานกับการสูญเสียฟันในผู้ใหญ่เขตอำเภอนาจะหลวย จังหวัดอุบลราชธานี ประเทศไทย ในช่วงปี พ.ศ. 2553*

วัสดุและวิธีการ: *เป็นการศึกษาภาคตัดขวางเชิงวิเคราะห์ ประกอบด้วยอาสาสมัครจำนวน 605 ราย เพศชาย 130 ราย เพศหญิง 475 ราย อายุระหว่าง 20-86 ปี เป็นประชาชนทั่วไป 226 ราย และผู้ป่วยโรคเบาหวานจำนวน 379 ราย โดยอาสาสมัครได้รับการสัมภาษณ์และตรวจสุขภาพช่องปาก วิเคราะห์ผลการศึกษาโดยใช้สถิติเชิงพรรณาและวิเคราะห์หาความสัมพันธ์ในระดับสองตัวแปรและในระดับหลายตัวแปรโดยใช้สมการถดถอยพหุคูณลอจิสติก*

ผลการศึกษา: *ผลจากแบบจำลองสมการถดถอยพหุคูณลอจิสติก พบว่าการสูญเสียฟันตั้งแต่ 1 ซี่ขึ้นไป มีความสัมพันธ์กับอายุ โรคเบาหวาน โรคฟันผุ การสูญเสียระดับยึดของอวัยวะปริทันต์ทางคลินิกตั้งแต่ 6 มิลลิเมตร 2 ด้านขึ้นไป และการใช้ยาสีฟันที่มีส่วนผสมของฟลูออไรด์อย่างมีนัยสำคัญทางสถิติ โดยมีค่าอัตราส่วนความเสี่ยงที่ปรับแล้ว (ช่วงเชื่อมั่น 95%) เท่ากับ 1.067 (1.047, 1.088) 1.729 (1.092, 2.738) 1.149 (1.071, 1.232) 2.436 (1.575, 3.767) และ 0.541 (0.321, 0.914) ตามลำดับ*

สรุป: *การสูญเสียฟันมีความสัมพันธ์กับโรคเบาหวานอย่างมีนัยสำคัญทางสถิติในผู้ใหญ่คนไทย ดังนั้นการส่งเสริมป้องกันและดูแลรักษาทั้งโรคเบาหวาน และโรคในช่องปากตั้งแต่ระยะเริ่มต้นจะช่วยลดการเกิดโรค ตลอดจนลดความรุนแรงและภาวะแทรกซ้อนที่เกิดจากโรคเบาหวานและการสูญเสียฟันได้*