FACTORS RELATED TO TOOTH LOSS AMONG INDUSTRIAL WORKERS IN PHATHUM THANI, THAILAND

Jeerateep Jaidee[1] Supaporn Chatrchaiwiwatana[2] and Amornrat Ratanasiri[1]

[1]Faculty of Medicine, [2]Faculty of Dentistry, Khon Kaen University, Khon Kaen, Thailand

Abstract. Tooth loss is an important oral health problem among Thai people. The objectives of this study were to evaluate the prevalence of and factors associated with tooth loss among Thai industrial workers in order to apply preventive oral health programs to this population. The study consisted of 1,500 adults working in Nava Nakorn Industrial Estate, Pathum Thani Province, Thailand in 2014. Probability proportion to size cluster sampling was used and 16 clusters were included in the study. An oral health questionnaire was developed, evaluated for content validity by experts and then given to participants to fill out. The study population consisted of 621 males (41.4%) and 879 females (58.6%) aged between 19-25 years. The overall prevalence of tooth loss was 62.2% and the major reason for tooth loss was dental caries (60%). Results from multivariable logistic regression analysis show that factors associated with tooth loss were: having a history of scaling or tooth cleaning [adjusted odds ratio (AOR)= 2.47; 95% CI: 1.21-4.65], having dental caries with exposed pulp (AOR=4.12; 95% CI: 3.26-7.67), having tooth mobility due to periodontal disease (AOR=2.41; 95% CI: 2.71-5.22), having needed tooth restoration (AOR=1.75; 95% CI: 1.23-2.65), having a history of maxillofacial or a temporo-mandibular joint accident (AOR=2.13; 95% CI: 1.87-3.23), wearing dentures (AOR=2.58; 95% CI: 2.17-6.72), using dental care services during the previous year (AOR=2.21; 95% CI: 1.26-4.57), eating snacks and candy daily (AOR=2.14; 95% CI: 1.82-2.92), having toothache (AOR=2.64; 95% CI: 1.43-3.92), having dental caries (AOR=2.23; 95% CI: 1.62-3.27) and having a history of orthodontic treatment (AOR=3.61; 95% CI: 1.84-5.68). The Nagelkerke R squared for the model was 0.42. Our findings suggest several clinical, socio-economic and lifestyle factors are associated with tooth loss among these Thai industrial workers. An appropriate preventive oral health program targeting this high-risk group taking these factors into consideration needs to be developed and implemented in this at risk population.

Keywords: tooth loss, prevalence, related factors, industrial Thai workers

Correspondence: Supaporn Chatrchaiwiwatana, Faculty of Dentistry, Khon Kaen University, Khon Kaen 40002, Thailand.
Tel: 66 (0) 43 202405; Fax: 66 (0) 43 202862
E-mail: csupa@kku.ac.th

INTRODUCTION

Tooth loss is an important oral health problem in Thailand (Dental Health Division, 2012), occurring primarily due to two most common oral diseases: dental

caries and periodontitis (Chatrchaiwiwatana, 2007; Akhter *et al*, 2008; Atieh, 2008; Jafarian and Etebarian, 2013; Åstrøm *et al*, 2014; Ribeiro *et al*, 2015). Eighty point nine percent of Thai adults aged 35-44 years are estimated to have tooth loss (Dental Health Division, 2012), the major cause being caries exposing tooth pulp. We also saw this in our previous study among Thai industrial employees (Chartchaiwiwatana *et al*, 2012). Poor oral health, decayed teeth, filled teeth, and periodontal disease are associated with a higher risk of tooth loss (Chatrchaiwiwatana, 2007; Saheeb and Sede, 2013). Some characteristics such as socioeconomic status and lack of health insurance have long been reported to be associated with tooth loss (Chatrchaiwiwatana, 2007; Nguyen *et al*, 2010; Zhang *et al*, 2011; Batista *et al*, 2012; Chatrchaiwiwatana *et al*, 2012; Gaio *et al*, 2012; Khalifa *et al*, 2012; Mai *et al*, 2013; Piuvezam and de Lima, 2013; Singh *et al*, 2014; Steele *et al*, 2015; Laguzzi *et al*, 2016). Oral health behaviors such as regular tooth brushing and regular dental checkups reduce the risk of tooth loss (Cunha-Cruz *et al*, 2004; Vysniauskaité *et al*, 2005; Mundt *et al*, 2007; Batista *et al*, 2012). Tobacco smoking and sweets consumption increase the risk of tooth loss (Chatrchaiwiwatana, 2007; Atieh, 2008; Aggnur *et al*, 2014). Lack of knowledge and poor attitudes about oral health care are associated significantly with dental caries and periodontitis leading to tooth loss (Tanaka *et al*, 2008).

The prevalence of and factors associated with tooth loss among Thai people in general have been previously reported, the prevalence and factors associated with tooth loss among Thai industrial employees have rarely been studied. The objectives of this study were to assess the prevalence of and factors associated with tooth loss among Thai industrial workers in Nava Nakorn Industrial Estate, Pathum Thani Province, Thailand. The reason for conducting this study is to obtain data for oral health promotion and intervention programs to reduce tooth loss among this population.

MATERIALS AND METHODS

Study population

We conducted a cross-sectional analytic study of 1,500 industrial workers randomly recruited from 214,700 workers in 108 factories in Nava Nakorn Industrial Estate, Pathum Thani Province, Thailand during 2014. Participants must have worked at the Nava Nakorn Industrial Estate for at least one year, and passed the probationary period and been hired as a permanent employee. Workers who were not Thai citizens, could not speak Thai, or lived outside the Nava Nakorn Industrial Estate were excluded. The probability proportion to size (PPS) cluster sampling method was used to determine the study population which included 16 factories, 1,500 participants.

The sample size was calculated using Epi Info version 4.0 with 95% reliability ($\alpha = 0.05$), the rate of this population utilizing dental care services in the previous year obtained from the literature (36%) with an acceptable difference and a relative error obtained from the literature (10%) (Jaidee *et al*, 2015).

This study protocol was approved by the ethics committee on human research, Khon Kaen University (HE571074).

Data collection, data management, and data analysis

We used structured questionnaire to determine the prevalence of and factors associated with tooth loss. The question-

Table 1
Socio-demographic characteristics of the study participants (*N*=1,500).

Socio-demographic characteristics	Number (%)
Sex	
Male	621 (41.4)
Female	879 (58.6)
Age (range; mean ± SD) in years	19-59; 31.75±7.57
Income (range; mean ± SD) in Thai baht	9,000-50,000; 15,524±5,490
Weight (range; mean ± SD) in kilograms	39-99; 58.31±10.83
Height (range; mean ± SD) in centimeters	143-190; 163.28±8.00
Place of origin in Thailand	
Northeast	759 (50.6)
Central	453 (31.6)
East	199 (13.8)
Others (South or West)	89 (5.9)
Education level	
Elementary school	85 (5.7)
High school	760 (50.7)
Diploma	429 (28.6)
Bachelor's degree or higher	226 (15.0)

naire was divided into three parts: 1) socio-demographic background; 2) oral health and lifestyle; 3) knowledge, attitudes, practices (KAP) regarding oral health. After developing the questionnaire, a panel of experts reviewed it to ensure good content validity. The revised questionnaire was then pretested and revised again before being used in the study.

Written informed consent was obtained from each participant prior to inclusion in the study. Each participant completed the questionnaire with assistance from a researcher as needed. The data were then entered into a database and rechecked for completeness and correctness before being included in the data analysis.

The data analysis was done using SPSS for Windows, version 22.0 (IBM, Armonk, NY). Descriptive statistics were calculated including percentages, means and standard deviations (SD). To assess crude associations between tooth loss and variables, bivariate analysis was conducted using independent *t*-test or chi-square test. Other non-parametric statistics were used based on the distribution of variables involved. Multivariable logistic regression analysis using tooth loss as an outcome was carried out to determine the association between tooth loss and several variables adjusting for potential confounding factors.

RESULTS

A total of 1,500 industrial workers were included in the study. Among these, 58.6% were females and 41.4% were males. Their ages ranged from 19 to 59 years, with a mean age of about 31 years. The mean monthly income was 15,524 Thai baht. Fifty point six percent of the participants were from northeastern Thailand and 31.6% were from central Thailand. Eighty-five percent of the par-

Table 2
Oral health conditions of the study participants (*N*=1,500).

Oral health behaviors and conditions	Sex		Total No. (%)
	Male (*n*=621) No. (%)	Female (*n*=879) No. (%)	
Using dental care services during the previous year			
No	437 (29.1)	521 (34.8)	958 (63.9)
Yes	184 (12.3)	358 (23.8)	542 (36.1)
Types of dental services received in the previous year			
Scaling	563 (37.5)	883 (55.6)	1,446 (93.1)
Filling	101 (6.7)	214 (14.3)	315 (21.0)
Extraction	78 (5.2)	139 (9.3)	217 (14.5)
Surgical removal	34 (2.3)	56 (3.7)	90 (6.0)
Orthodontic	5 (0.3)	30 (2.0)	35 (2.3)
Root canal	11 (0.7)	22 (1.5)	33 (2.2)
Dentures	8 (0.5)	22 (1.5)	30 (2.0)
Dental checkup	10 (0.7)	8 (0.5)	18 (1.2)
Tooth whitening	7 (0.5)	6 (0.4)	13 (0.9)
Having dental caries			
No	256 (17.0)	369 (24.6)	625 (41.6)
Yes	355 (23.7)	520 (34.7)	875 (58.4)
Having periodontal disease			
No	558 (37.2)	784 (52.3)	1,342 (89.5)
Yes	63 (4.2)	95 (6.3)	158 (10.5)
Having tooth loss			
No	238 (15.9)	329 (21.9)	567 (37.8)
Yes	383 (25.5)	550 (36.7)	933 (62.2)
Reason for tooth loss			
Dental caries	216 (23.2)	305 (32.7)	521 (55.9)
Periodontal disease	77 (8.3)	60 (6.4)	209 (14.7)
Impacted, embedded tooth	40 (4.3)	72 (7.7)	112 (12.0)
Orthodontic treatment	29 (3.1)	85 (9.1)	114 (12.2)
Tooth accident	16 (1.7)	18 (1.9)	34 (3.6)

ticipants had lower than a bachelor degree education (Table 1).

Table 2 summarizes the oral health conditions and behaviors. Only 542 participants (36.1%) had received dental care in the previous year. Dental care received included scaling (93.1%), filling (21%), extractions (14.5%) and surgical removal (6%). Twenty point five percent of the workers had visited their dentists to get their teeth extracted and surgical removal but only 1.2% of employees did so for dental checkups. The proportions of workers having dental caries, periodontal disease, and tooth loss were 58.4%, 10.5% and 62.2%, respectively. Fifty-seven point five percent of participants brushed their teeth no more than twice a day, 42.5% brushed them more often. Thirty-three percent of participants ate snack, sugar and candy

Table 3
Factors associated with thooth loss on bivariate analysis among study subjects (*N*=1,500).

Variables	Tooth loss, *n* (%)		Crude odds ratio (95% CI)	*p*-value
	No (*n*=567)	Yes (*n*=933)		
Sex				0.08
Male	238 (41.9)	383 (41.0)	1.04 (0.8,1.3)	
Female	329 (58.1)	550 (59.0)		
Age (mean ± SD) in years	30.8 ± 7.3	32.2 ± 7.7	NA	0.001*
Income (mean ± SD) in Thai baht	15,461 ± 5,274	15,563 ± 5,620	NA	0.72
Places of origin in Thailnd			NA	0.28
Northeast	291 (51.3)	468 (50.2)		
Central	158 (27.9)	295 (31.6)		
North	78 (13.8)	121 (13.0)		
Others	40 (7.1)	49 (5.3)		
Education level			NA	0.26
Elementary school	26 (4.6)	59 (6.3)		
High school	278 (49.0)	482 (51.7)		
Diploma	174 (30.7)	255 (27.3)		
Bachelor's degree or higher	89 (15.7)	137 (4.7)		
Pay for rented room				0.008*
No	97 (17.1)	739 (79.2)	0.7 (0.6,0.9)	
Yes	470 (82.9)	194 (20.8)		
History of scaling or tooth cleaning				0.001*
No	29 (27.4)	858 (91.9)	3.5 (2.1,5.9)	
Yes	538 (72.6)	75 (8.1)		
History of tooth restoration				0.001*
No	476 (83.9)	709 (75.9)	2.45 (1.3,3.2)	
Yes	91 (16.1)	224 (24.1)		
History of tooth extraction				0.001*
No	517 (91.2)	766 (82.1)	3.3 (2.6,4.2)	
Yes	50 (8.8)	167 (17.9)		
In need of dental treatment				0.001*
No	201 (35.5)	344 (36.8)	1.5 (1.2,3.9)	
Yes	366 (64.5)	689 (63.2)		
Having dental caries exposing the pulp				0.001*
No	548 (96.6)	104 (11.2)	5.2 (3.3,8.2)	
Yes	19 (3.4)	829 (88.8)		
Having tooth mobility due to periodontal disease				0.001*
No	959 (99.2)	383 (71.9)	3.6 (1.9,5.1)	
Yes	8 (0.8)	150 (28.1)		
Having a history of a maxillofacial or TMJ injury				0.006*
No	564 (99.5)	22 (2.4)	2.6 (1.5,5.2)	
Yes	3 (0.5)	911 (97.6)		
Wearing dentures				0.001*
No	562 (99.1)	45 (4.8)	4.3 (2.2,7.4)	
Yes	5 (0.9)	888 (95.2)		

Table 3 (Continued).

Variables	Tooth loss		Crude odds ratio (95% CI)	*p*-value
	No (*n*=567)	Yes (*n*=933)		
Belief that tooth loss is due to aging				0.046*
No	399 (70.3)	610 (65.4)	0.6 (0.3,0.9)	
Yes	168 (29.7)	323 (34.6)		
Knows large dental caries can progress to tooth loss				0.05
No	120 (21.2)	699 (74.9)	1.8 (1.3,2.2)	
Yes	447 (78.8)	234 (25.1)		
Used welfare dental treatment				0.05
No	428 (75.5)	761 (81.5)	2.26 (1.2,4.6)	
Yes	139 (24.5)	172 (18.5)		
Received dental care services in the previous year				0.001*
No	200 (30.7)	758 (89.2)	2.26 (1.5,4.6)	
Yes	450 (69.3)	92 (10.8)		
Have a knowledge regarding availability of dental welfare				0.03*
No	110 (19.4)	791 (84.8)	1.34 (1.0,2.7)	
Yes	457 (80.6)	142 (15.2)		
Tooth brushing less than twice daily				0.04*
No	139 (17.7)	498 (68.4)	1.8 (1.1,2.7)	
Yes	643 (82.3)	220 (31.6)		
Eats candy, sugar or snacks daily				0.001*
No	798 (94.2)	204 (31.3)	2.48 (2.1,3.4)	
Yes	49 (5.8)	449 (68.7)		
Has dental caries				0.001*
No	497 (85.8)	128 (13.9)	2.8 (1.5,5.3)	
Yes	82 (14.2)	793 (86.1)		
Has toothache				0.001*
No	387 (68.3)	147 (15.8)	2.3 (1.8,4.9)	
Yes	18 (31.7)	786 (84.2)		
History of receiving orthodontic treatment				0.001*
No	554 (97.7)	859 (92.0)	4.3 (2.0,6.7)	
Yes	13 (2.3)	74 (8.0)		

*Test of difference between proportions (chi-square test) $p<0.05$; NA, not available.

daily (data not shown). Fifty-five point nine percent lost their teeth due to dental caries and females (36.7%) lost more teeth compared to males (25.5%). More females (32.7%) lost their teeth due to dental caries compared to 23.2% of males while more males (8.3%) experienced tooth loss related to periodontal disease compared to females (6.4%). More females (7.7%) had their impacted or embedded removed while 4.3% of males did so. More females (9.1%) had their teeth extracted due to orthodontic treatment compared to males (3.1%). Females (23.8%) also visited dentists more frequently than males (12.3%).

Table 3 summarizes the results for bivariate analysis of selected variables

Table 4
Factors associated with tooth loss on multivariable logistic regression analysis (N = 1,500).

Factors	Adjusted odds ratio (95% confidence limit)	p-value
Having a history of scaling or tooth cleaning	2.47 (1.21-4.65)	0.001
Having dental caries with exposed pulp	4.12 (3.26-7.67)	0.001
Having tooth mobility due to periodontal disease	2.41 (2.71-5.22)	0.001
Having a history of tooth restoration	1.75 (1.23-2.65)	0.001
Having a history of maxillofacial or TMJ injury	2.13 (1.87-3.23)	0.006
Wears dentures	2.58 (2.17-6.72)	0.001
Received dental care regularly during the previous year	2.21 (1.26-4.57)	0.001
Eats snacks or candy daily	2.14 (1.82-2.92)	0.001
Has a toothache	2.64 (1.43-3.92)	0.001
Has dental caries	2.23 (1.62-3.27)	0.001
Has a history of orthodontic treatment	3.61 (1.84-5.68)	0.001

Nagelkerke R squared = 42%; Model significant p=0.001; TMJ, temporomandibular joint.

associated with tooth loss. On bivariate analysis, factors associated with tooth loss were age, having the ability to pay for a rented room, having a history of scaling or tooth cleaning, having a history of tooth restoration, having a history of tooth extraction, needing dental treatment, having dental caries exposing the pulp, having tooth mobility due to periodontal disease, having a history of a maxillofacial or temporomandibular joint (TMJ) injury, wearing dentures, believing tooth loss depended on age, knowing large dental caries can progress to tooth loss, having used dental welfare, having used dental care services during the previous year, having a knowledge about the availability of dental welfare, tooth brushing, consuming candy and snacks daily, having dental caries, having had toothache and having had orthodontic treatment.

The results of multiple logistic regression analysis of factors related to tooth loss are presented in Table 4. After adjusting for confounding factors, having a history of scaling, having dental caries with exposed pulp, having tooth mobility due to periodontal disease, having tooth restoration, having a maxillofacial or TMJ accident, wearing dentures, having used dental care services during the previous year, eating snacks or candy daily, having a history of toothache, having dental caries and having orthodontic treatment were significantly related to tooth loss (p<0.05). The associations between those variables and tooth loss suggest those who went to see their dentists for scaling or tooth cleaning, having a filling (tooth restoration), having a denture replacement and those who had dental care services, or orthodontic treatments tended to lose more teeth than those who did not visit their dentists. Participants who had any of the followings also lost more teeth: dental caries, dental caries exposing the pulp, tooth mobility due to periodontal disease, toothache or a history of maxillofacial injury. Participants who reported eating snacks and candy daily also experienced more tooth loss.

DISCUSSION

The studied participants were better off than Thai adults in terms of income, education, occupation, and a number of social demographic characteristics, healthy lifestyles and habits; therefore they were expected to have better oral health. However, the proportions of participants in our study with dental caries, periodontal disease and tooth loss were only slightly lower than among adult Thais of working age (Dental Health Division, 2012).

Result of our study that dental caries was a major cause of tooth loss is in agreement with a number of studies (Chartchaiwiwatana *et al*, 2012; Saheeb and Sede, 2013; Jafarian and Etebarian, 2013). But this finding is different from a previous study among rural northeast Thai adults whereby most people were unable to get access to dental care and periodontal disease was a major cause of tooth loss (Chatrchaiwiwatana, 2007). Findings among other populations also showed that periodontal disease was a comparable cause of tooth loss (Akhter *et al*, 2008; Atieh, 2008; Jafarian and Etebarian, 2013; Ribeiro *et al*, 2015).

The findings that females experienced greater number of teeth lost due to caries although they visited dentists more frequently have been reported in previous studies but the reason for the difference was unclear (Lin *et al,* 2001; Susin *et al,* 2005). The industrial workers in our study were allowed to consume sweets or candies during working hours, therefore promoting dental caries while there is no established oral health promotion or prevention program to reduce caries. Such working environment could increase the prevalence of dental caries among the workers. Our finding that sweets consumption was associated with tooth loss is in agreement with previous studies (Atieh, 2008; Aggnur *et al*, 2014). Eating sweets and poor oral hygiene have been reported to be the main reasons for dental caries among Indian health care workers (Patil *et al*, 2012; Aggnur *et al*, 2014). Tooth brushing has been reported to reduce the chances of tooth loss (Vysniauskaité *et al*, 2005) but in our study we did not find this, nor have other studies among the Thai adults (Chatrchaiwiwatana, 2007; Chatrchaiwiwatana *et al*, 2012).

Previous studies found a number of variables were associated with tooth loss, such as age, gender, income, education, occupation, marital status, lack of health insurance and other socioeconomic factors (Chatrchaiwiwatana, 2007; Nguyen *et al*, 2010; Zhang *et al*, 2011; Chatrchaiwiwatana *et al*, 2012; Batista *et al*, 2012; Gaio *et al*, 2012; Sensorn *et al*, 2012; Jafarian and Etebarian, 2013; Piuvezam and de Lima, 2013; Mai *et al*, 2013; Singh *et al*, 2014; Ribeiro, *et al*, 2015; Steele *et al*, 2015; Laguzzi *et al*, 2016). However, in our study we did not find such associations. This may be due to different background characteristics and socioeconomic statuses in our subjects than previous studies.

Tobacco smoking has been reported to be significantly associated with periodontal disease and tooth loss (Chatrchaiwiwatana, 2003; Chatrchaiwiwatana, 2007; Mundt *et al*, 2007). However, in our study we did not find an association between tooth loss and tobacco smoking. This might be due to differences in workplace environment; our participants were not allowed to smoke cigarettes during working hours. The finding that tobacco smoking may be a less important cause of tooth loss due to dental caries was also reported previously (Mai *et al*, 2013). However, another study (Halboub *et al*, 2013) reported a

significant association between tobacco smoking and dental caries.

Our finding that tooth loss was associated with an oral prosthetic is in agreement with previous studies (Khalifa *et al*, 2012; Gonda *et al*, 2013). However, the cross-sectional nature of our study makes it impossible to determine whether tooth loss or wearing dentures came first. It was common for people to wear dentures after they lost teeth. But a previous study found wearing removable dentures is associated with a significantly greater risk for periodontal disease progression leading to tooth loss (Hirotomi *et al*, 2010), which was also seen in a study of Indian industrial workers (Patil *et al*, 2012). Previous studies (Zhang *et al*, 2011; Reddy *et al*, 2012) have found the need for prosthodontics increases with increasing age; therefore younger people who wear dentures or who need dentures to be replaced are at greater risk for further tooth loss.

In our study, having a history of previous dental visit was not associated with a lower risk of tooth loss, which is in agreement with several previous studies (Khalifa *et al*, 2012; Åstrøm *et al*, 2014; Ribeiro *et al*, 2015; Laguzzi *et al*, 2016). However, other studies found the opposite that having previous dental checkups or dental visits was associated with a lower risk of tooth loss (Cunha-Cruz *et al*, 2004; Mundt *et al*, 2007; Batista *et al*, 2012). A previous study among Indian industrial employees (Patil *et al*, 2012) found tooth loss was associated with dental visits and suggested the need for improved availability of dental facilities for industrial workers. In this study, the workers visited their dentists for dental services or to have their teeth extracted but not for dental checkups, which suggests that they were at high risk of missing more teeth in the future. The finding that the workers who had dental caries decided to remove their teeth rather than keeping them (*ie*, by having root canal treatment following by post and core) suggests that they lack of both time and money to keep their teeth. Recent research evidence among the Thai industrial workers confirms that tooth loss due to dental caries was related to lack of time to visit a dentist, have a negative attitude towards dental treatment, inability to afford the high cast of dental treatment, lack of knowledge regarding dental caries prevention, root canal treatment and the harmful effects of losing teeth (and therefore choosing to get an extraction upon having dental caries exposing the pulp) and lack of oral health promotion programs provided by either the government or private sectors (Chatrchaiwiwatana *et al*, 2012).

The slow onset of symptoms with dental caries and periodontal disease make it difficult for people to be aware they have oral disease until it is at the late stage. Early stages of dental caries and periodontal disease could be missed in our interview, which could result in an underestimation of the true prevalence of dental caries and periodontitis in this study. Tooth loss is easier to quantitate and be aware of. Therefore, self-reported tooth loss can be used as a reliable indicator for evaluating oral health history (Douglass *et al*, 1991; Axelsson and Helgado´ttir, 1995; Ho *et al*, 1997; Ramos *et al*, 2013).

Some might think self-reported tooth loss as a method for determining clinical tooth loss for research might be considered a limitation, but previous studies (Douglass *et al*,1991; Axelsson and Helgado´ttir, 1995; Ho *et al*,1997; Ramos *et al*, 2013) have found self-reported tooth loss is a valid and reliable indicator for use in epidemiological studies. The cross sectional nature of our study prevents

determining cause and effect, but our findings are in agreement with previous studies whereby the cause and effect relationship between tooth loss and risk factors can be confirmed.

A strength of this study was it evaluated the prevalence of tooth loss and associated factors among Thai industrial employees. Our findings along with previous studies (Chatrchaiwiwatana *et al*, 2012; Jaidee *et al*, 2015) are beneficial for developing appropriate preventive oral health programs to reduce tooth loss among this population.

In conclusion, our findings show the study participants are at increased risk of dental caries and tooth loss. The factors associated with tooth loss were: having a history of scaling or tooth cleaning, having dental caries exposing the pulp, having tooth mobility due to periodontal disease, having a history of tooth restoration, having a history of a maxillofacial or TMJ injury, wearing dentures, using dental care services in the previous year, eating snacks or candy daily, having a toothache, having dental caries and having a history of orthodontic treatment. Although these participants went to see their dentists, they still lost teeth. To improve tooth retention among study participants, appropriate preventive oral health programs or interventions need to be developed that are more effective in terms of cost and time. Preventive oral health programs are needed for the study population, which is increased risk for tooth loss.

ACKNOWLEDGEMENTS

The research team thanks the ISAN Substance Abuse Network and the Department of Community Medicine, Khon Kaen University for their database and research facilities.

REFERENCES

Aggnur M, Garg S, Veeresha K, Gambhir R. Oral health status, treatment needs and knowledge, attitude and practice of health care workers of Ambala, India - A cross-sectional study. *Ann Med Health Sci Res* 2014; 4: 676-81.

Akhter R, Hassan NM, Aida J, Zaman KU, Morita M. Risk indicators for tooth loss due to caries and periodontal disease in recipients of free dental treatment in an adult population in Bangladesh. *Oral Health Prev Dent* 2008; 6: 199-207.

Åstrøm AN, Ekback G, Ordell S, Nasir E. Long-term routine dental attendance: influence on tooth loss and oral health-related quality of life in Swedish older adults. *Community Dent Oral Epidemiol* 2014; 42: 460-9.

Atieh MA. Tooth loss among Saudi adolescents: social and behavioural risk factors. *Int Dent J* 2008; 58: 103-8.

Axelsson G, Helgadó´ttir S. Comparison of oral health data from self-administered questionnaire and clinical examination. *Community Dent Oral Epidemiol* 1995; 23: 365-8.

Batista MJ, Rihs LB, Sousa Mda L. Risk indicators for tooth loss in adult workers. *Braz Oral Res* 2012; 26: 390-6.

Chatrchaiwiwatana S. Tobacco smoking as a risk indicator of periodontitis. *KDJ* 2003; 6: 69-78.

Chatrchaiwiwatana S. Factors affecting tooth loss among rural Khon Kaen adults. Analysis of two data sets. *Public Health* 2007; 121: 106-12.

Chatrchaiwiwatana S, Ratanasiri A, Jaidee J, Soontorn S. Factors related to tooth loss due to dental caries among workers in an industrial estates in Thailand. *J Med Assoc Thai* 2012; 95 (suppl 11): S1-6.

Cunha-Cruz J, Nadanovsky P, Faerstein E, Lopes CS. Routine dental visits are associated with tooth retention in Brazilian adults: the Pró-Saúde study. *J Public Health Dent* 2004; 64: 216-22.

Dental Health Division. The seventh national oral health survey of Thailand report. Nonthaburi: Ministry of Public Health, Thailand, 2012.

Douglass CW, Berlin J, Tennstedt S. The validity of self-reported oral health status in the elderly. *J Public Health Dent* 1991; 51: 220-2.

Gaio EJ, Haas AN, Carrard VC, Oppermann RV, Albandar J, Susin C. Oral health status in elders from South Brazil: a population-based study. *Gerodontology* 2012; 29: 214-23.

Gonda T, MacEntee MI, Kiyak HA, Persson GR, Persson RE, Wyatt C. Predictors of multiple tooth loss among socioculturally diverse elderly subjects. *Int J Prosthodont* 2013; 26: 127-34.

Halboub E, Dhaifullah E, Yasin R. Determinants of dental health status and dental health behavior among Sana'a University students, Yemen. *J Investig Clin Dent* 2013; 4: 257-64.

Hirotomi T, Yoshihara A, Ogawa H, Miyazaki H. Tooth-related risk factors for periodontal disease in community-dwelling elderly people. *J Clin Periodontol* 2010; 37: 494-500.

Ho AW, Grossi SG, Dunford RG, Genco RJ. Reliability of a self-reported health questionnaire in a periodontal diseases study. *J Periodont Res* 1997; 32: 646-50.

Jafarian M, Etebarian A. Reasons for extraction of permanent teeth in general dental practices in Tehran, Iran. *Med Princ Pract* 2013; 22: 239-44.

Jaidee J, Ratanasiri A, Chatrchaiwiwatana S, Soonthon S. Prevalence and factors associated with the utilization of dental care services among factory workers in Nava Nakorn Industrial Estate, Pathumthani Province, Thailand. *J Med Assoc Thai* 2015; 98 (suppl 6): S73-80.

Khalifa N, Allen PF, Abu-bakr NH, Abdel-Rahman ME. Factors associated with tooth loss and prosthodontic status among Sudanese adults. *J Oral Sci* 2012; 54: 303-12.

Laguzzi PN, Schuch HS, Medina LD, de Amores AR, Demarco FF, Lorenzo S. Tooth loss and associated factors in elders: results from a national survey in Uruguay. *J Public Health Dent* 2016; 76: 143-51.

Lin HC, Corbet EF, Lo EC, Zhang HG. Tooth loss, occluding pairs, and prosthetic status of Chinese adults. *J Dent Res* 2001; 80: 1491-5.

Mai X, Wactawski-Wende J, Hovey KM, *et al*. Associations between smoking and tooth loss according to the reason for tooth loss: the Buffalo OsteoPerio Study. *J Am Dent Assoc* 2013;144:252-65.

Mundt T, Schwahn C, Mack F, *et al*. Risk indicators for missing teeth in working-age Pomeranians--an evaluation of high-risk populations. *J Public Health Dent* 2007; 67: 243-9.

Nguyen TC, Witter DJ, Bronkhorst EM, Truong NB, Creugers NH. Oral health status of adults in Southern Vietnam - a cross-sectional epidemiological study. *BMC Oral Health* 2010; 10: 2.

Patil VV, Shigli K, Hebbal M, Agrawal N**.** Tooth loss, prosthetic status and treatment needs among industrial workers in Belgaum, Karnataka, India. *J Oral Sci* 2012; 54: 285-92.

Piuvezam G, de Lima KC. Factors associated with missing teeth in the Brazilian elderly institutionalised population. *Gerodontology* 2013; 30: 141-9.

Ramos RQ, Bastos JL, Peres MA. Diagnostic validity of self-reported oral health outcomes in population surveys: literature review. *Rev Bras Epidemiol* 2013; 16: 716-28.

Reddy NS, Reddy NA, Narendra R, Reddy SD. Epidemiological survey on edentulousness. *J Contemp Dent Prac* 2012; 13: 562-70.

Ribeiro LS, Dos Santos JN, Ramalho LM, Chaves S, Figueiredo AL, Cury PR. Risk indicators for tooth loss in Kiriri adult Indians: a cross-sectional study. *Int Dent J* 2015; 65: 316-21.

Saheeb BD, Sede MA. Reasons and pattern of tooth mortality in a Nigerian Urban teaching hospital. *Ann Afr Med* 2013; 12: 110-4.

Sensorn W, Chatrchaiwiwatana S, Bumrerraj

S. Relationship between diabetes mellitus and tooth loss in adults residing in Ubonratchathani province, Thailand. *J Med Assoc Thai* 2012; 95: 1593-605.

Singh A, Purohit BM, Masih N, Kahndelwal PK. Risk factors for oral diseases among workers with and without dental insurance in a national social security scheme in India. *Int Dent J* 2014; 64: 89-95.

Steele J, Shen J, Tsakos G, *et al*. The interplay between socioeconomic inequalities and clinical oral health. *J Dent Res* 2015; 94: 19-26.

Susin C, Oppermann RV, Haugejorden O, Albandar JM. Tooth loss and associated risk indicators in an adult urban population from south Brazil. *Acta Odontol Scand* 2005; 63: 85-93.

Tanaka K, Miyake Y, Sasaki S, *et al*. Beverage consumption and the prevalence of tooth loss in pregnant Japanese women: the Osaka Maternal and Child Health Study. *Fukuoka Igaku Zasshi* 2008; 99: 80-9.

Vysniauskaité S, Kammona N, Vehkalahti MM. Number of teeth in relation to oral health behaviour in dentate elderly patients in Lithuania. *Gerodontology* 2005; 22: 44-51.

Zhang Q, Witter DJ, Bronkhorst EM, Creugers NH. Dental and prosthodontic status of an over 40 year-old population in Shandong Province, China. *BMC Public Health* 2011; 11: 420.