

# ASSOCIATIONS BETWEEN FACTORIES' ENVIRONMENTAL FACTORS AND WORKERS' ORAL HEALTH STATUS

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## ABSTRACT:

**Background:** In Thailand, dental caries prevalence in adults is high (86.7%). Oral health services focused on children age groups while adults were relatively neglected. Four million adult workers were in a factory setting. Factory's environment might affect oral health status of their workers. This study aimed to assess associations between factories' environmental factors and workers' oral health status.

**Methods:** Seven factories in Kaengkhroi district of Saraburi province with not more than 200 workers were invited. Oral examinations were conducted to assess dental caries and oral hygiene status. Socio-demographic and behavior information were obtained by interview, using a standardized questionnaire. Data were analyzed using Chi-square, Kruskal-Wallis and Mann-Whitney-U tests, negative binomial and binary logistic regressions.

**Results:** Six factories participated in the study. Numbers of workers for each factory were between 28 and 35 workers. Dental caries and oral hygiene of workers differed between the six factories. Workers in factories where wash basins were available in toilets had 60% (IRR= 0.4 (0.2-0.9)) fewer decayed teeth (DT score) and 7 times (OR= 7.0 (2.2-22.8)) more likely to have good oral hygiene. Workers in medium size factories, those working in factory that provided additional health insurance were three times more likely to have good oral hygiene.

**Conclusion:** Environmental factors of factory namely wash basin in toilet, factory size and additional health insurance factories were associated with caries and oral hygiene of workers.

**Keywords:** Oral health, Oral hygiene, Caries, Environment factor, Workers, Thailand

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DOI:

Received: March 2016; Accepted: May 2016

## INTRODUCTION

Children are generally the main target group of oral health services, including in Thailand. Oral health of Thai children has been improved during the past decade and currently considered satisfactory comparing to other countries, for example, dental caries prevalence of 12 years-old Thais was 52.3%, mean DMFT score was 1.3 [1, 2]. In contrast with children age group, oral health program for adults has been of little interest. National oral health surveys of Thailand showed that dental caries status of Thai adults has not been improved or even getting

worse since 2002 to 2012, with caries prevalence of 85.6% to 86.7% and mean DMFT scores of 6.1 to 6.0 [1, 2].

A possible reason for a relative neglect on adult oral health might relate to difficulty in access target groups. About half (15.7 million) of the majority of Thai adults works in services and commerce, while the other half (14.9 million) are in agricultural sections [3]. Only 7.9 million are engaged in manufacturing business with around 4 million are factorial workers [4]. It is unpractical to approach or establish any oral health program for the majority who are in the first two occupational categories.

Important strategies to promote health involve changing environments where people live and work.

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Cite this article as:

Sukcharoenkosol H, Krisdapong S. Associations between factories' environmental factors and workers' oral health status. *J Health Res.* 2016; 30(6): 411-20. DOI:

This is because people's behaviors profoundly link with their social, cultural and environmental circumstances [5]. Creating health supportive environments are considered one of the five elements in Ottawa Charter[5]. Regarding oral health, evidence on the effects of oral behaviors, that is, tooth brushing and consuming sugary food, on oral status have been established [6, 7]. People who brush twice or more daily with fluoridated-toothpaste and those who consume less sugary foods are more likely to have lower dental caries [8, 9].

Nevertheless, satisfactory oral health behaviors were shown to relate with oral health environments. In schools with oral health policies and less-sweet food were provided, children consumed less cariogenic food and subsequently, had less dental caries compared to children in other schools where sweets were common [7, 10]. A study on traumatic dental injuries in Thailand found that students in schools with safe accident-relating environments such as dry floor, no obstructed objects, no concrete ground, had less traumatic dental injuries than students in schools with no supportive environments [11]. Moreover, provisions of oral health program could increase people's awareness and subsequently, lead to better oral behaviors, for example, a study found that those receiving oral examination and oral hygiene instruction had more dental visits and better concern on their oral health [12]. Children, whose mothers joined oral health education session during pregnancy, had less severe early childhood caries [13].

Studies on adults showed that those having coverage dental insurance tended to have more number of teeth [14]. Receiving free dental checkup, industrial workers in Finland had less dental problems, required less dental treatment and treatment times [15]. A preventive program in the United Kingdom provided for workers could improve workers' oral hygiene practices and lead to better gingival health [16]. Moreover, a study in Japan showed that providing disclosing agents for dental plaque, toothbrush and dental floss together with pamphlets on tooth brushing method and oral health care to workers in workplace could improve their periodontal health and lead to lower dental caries [17]. Negative effects of workplace environments on workers' oral health were also reported, for example, workers who worked longer in a stone mine factory had more tooth attrition, which was due to factorial acidic environment [18].

This study is a part of a longitudinal project on

workplace oral health promotion aiming to creating oral health-supportive environments in factories. Although the minority of Thai adults are engaged in factory setting as above mentioned, practicality in approaching this target group make it an opportunity to improve Thai adults' oral health. However, before starting the longitudinal project, we are interested whether current factory environments would affect oral health of workers. We hypothesized that workers in factories with oral health-supportive environments would have better oral health than those without oral health-supportive environments. As socio-demographic factors such as age, sex, educational levels were also affected oral health [19-23], potential effects of such individual factor would be taken into account. Therefore, the objective of this study was to assess the associations between factories' oral health-supportive environments and workers' oral health status after controlling for workers' socio-demographic backgrounds.

## METHODS

This study was conducted, during July to August 2013, in the Kaengkhoi district of Saraburi which is an industrial province located at the center part of Thailand. There are 269 factories in Kaengkhoi district, categorized into 22 large, 26 medium and 221 small factories. Size of factory was defined according to the Thai Ministry of Industry based on capital amount and labor intensity. Small size refers to factories with less than 50 workers or cost of investment less than 50 million baths. Medium size are factories having 50-200 workers or investment cost of 50-200 million baths while large size are those having more than 200 workers or investment cost of more than 200 million baths [24]. Inclusion and exclusion criteria for factories related to the size of factory. Medium and small-size factories were included while large-size factories were excluded from the study. Thus, seven factories were invited to participate. No inclusion and exclusion criteria were applied for workers. Instead, all workers in participated factories were asked to join the study. The required sample size of workers was calculated for each factory using a power of 90.0% and a significance level of 0.05. Minimum sample size for each factory ranged from 25 to 29 (Table 1).

Data were collected from workers and managers through oral examinations and interviews. Oral examinations conducted by one dentist under natural daylight were to assess dental caries and oral

hygiene status using criteria of World Health Organization [25] and Oral Hygiene Index Simplified (OHI-S) index respectively [26]. OHI-S index comprises of DI (debris index) and CI (calculus index). Six teeth were examined for debris and calculus deposits, one surface for each tooth; that is buccal surface of right and left upper first molars, labial surface of right upper incisor and left lower incisor, lingual surface of right and left lower first molars. DI and CI scores range from 0-3: 0 = no debris/ calculus present, 1= debris/ calculus covering not more than one third of tooth surface or presence of extrinsic stains without other debris regardless of surface area covered, 2= debris/ calculus covering from one third up to two thirds of tooth surface, = debris/ calculus covering more than two thirds of tooth surface. Summing up all 6 surface scores and dividing by 6 results in DI and CI scores (maximum score =3). Thereafter, a sum of DI and CI scores is OHI-S score (maximum score = 6) [26].

Intra-examiner reliability was tested during a pilot study showing almost perfect agreement with Kappa statistics of 0.85 [25]. In addition to oral examination, interviewed questionnaire was used to collect data on socio-demographic background (age, gender and educational level) and oral health behaviors (frequency of tooth brushing per day, frequent consumptions (yes/no) of processed snacks/fruits/sweet drinks/soft drinks frequency of taking snack breaks per day including processed snacks and fruits, frequency of having sweet drinks or soft drinks per day). Interviews were conducted by 4 interviewers who were dental nurses and well-trained for correct understanding in the questionnaire. Lastly, one dentist interviewed managers of participated factories by on information regarding factory's oral health policies and environments, that is the presence or absence of extra health insurance for workers (in additional to basic package insurance which is compulsory for all factories), snack shop in factory, wash basin in restrooms, after lunchtime tooth brushing activity supported by factory, provision of free toothbrush and prohibition of eating while working. Information obtained from managers were double-checked by direct observations and asking workers. Size and location (rural/urban) of factories were also recorded. This study was approved by the ethical committee, Faculty of Dentistry Chulalongkorn University, Approval No. HREC-DCU 2013-024.

Data were analyzed using SPSS version 22

(IBM Corp., Armonk, NY, USA). DMFT and DT were calculated for dental caries and OHI-S scores for oral hygiene status. Oral hygiene status was categorized into good (OHI-S score = 0-1.2), fair (OHI-S score= 1.3-3.0) and poor (OHI-S score 3.1-6.0) [26]. Means DMFT and DT scores and percentage of workers with good oral hygiene were clinical outcomes of interest. The first step was to explore the difference between factories in relation to workers' clinical outcomes, workers' socio-demographic background as well as factory's environmental factors. Chi-square and Kruskal-Wallis tests were applied for comparing proportions and scores respectively. The second step was to assess associations of clinical outcomes as dependent variables with independent variables, that is, individual socio-demographic background and oral health behaviors. This is because such individual characteristics were potential confounders of the associations between factory's environments and clinical outcomes. Pearson correlation and t-test statistics were used to investigate associations of age with dental caries (DMFT and DT scores) and having good oral hygiene respectively. Mann-Whitney-U and Chi-square tests were used to investigate associations of individual socio-demographic background and oral health behaviors with dental caries (DMFT and DT scores) and having good oral hygiene. Finally, associations between main independent variables, namely, factory's environmental factors and dependent variables (clinical outcomes) were assessed using negative binomial (Incident rate ratio (IRR) and 95% CI were reported) for dental caries, and binary logistic regression models (Odd ratio (OR) and 95% CI were reported) for oral hygiene. Analyses on dental caries included only workers who had been working in their factories for at least 3 years. Individual socio-demographic background and oral health behaviors that were conceptually related to clinical outcomes and obtained *p-values* of less than 0.2 from previous analyses were entered into adjusted regression models.

## RESULTS

### Factories' characteristics

From all seven small to medium factories invited, six factories participated in the study. All the six factories were different in terms of their products as shown in Table 1. Three factories were considered small size factories, while the other three were medium size. Numbers of total workers in

**Table 1** Factory characteristics, environmental factors and clinical outcomes among the six participating factories

Factory	Factory and their workers' characteristics							Environmental factors						Clinical outcomes		
	Production	Total worker (n)	Required sample Size	Study sample N (%)	Males (%)	Workers' Mean age	Mean education (years)	Size	Location	Additional health insurance	Snack shop	Wash basin in toilet	Brushing activity + free toothbrush + no eating	Mean DMFT <sup>a</sup> (±SD)	Mean DT <sup>b</sup> (±SD)	Good oral hygiene (%)
A	Machinery construction products	100	26	35 (35.0)	77.1	39.9±10.7	8.3±3.5	small	urban	no	yes	yes	no	5.1±5.7	1.4 ± 1.8	54.3
B	Crackers products	87	25	30 (34.5)	26.7	34.7±9.8	7.2±1.7	small	rural	no	no	no	no	7.0±5.6	1.4± 2.0	50.0
C	Lead products	120	27	34 (28.3)	82.4	37.4±8.8	10.2±3.9	small	urban	yes	no	yes	yes	4.5±5.2	1.0± 1.7	73.5
D	General construction products	86	25	28 (32.6)	89.3	42.3±10.5	9.3±2.9	medium	urban	no	yes	yes	no	5.6±4.9	1.5± 2.7	85.7
E	Lime products	170	29	35 (20.6)	60.0	33.5±7.5	13.1±3.6	medium	rural	yes	no	yes	no	5.1±4.8	0.7± 2.1	94.3
F	Furfural and furfuryl alcohol products	140	28	29 (20.7)	65.5	44.5±10.0	12.1±3.9	medium	urban	no	yes	yes	no	5.6±5.6	0.6± 1.2	65.5
Total		703	160	191 (27.2)			10.1±3.9							5.4±5.3	1.1±2.0	70.7
<i>P-value</i>					<0.01 <sup>c</sup>	<0.01 <sup>d</sup>	<0.01 <sup>d</sup>							0.432 <sup>d</sup>	0.048 <sup>d</sup>	<0.01 <sup>c</sup>

<sup>a</sup> DMFT= number of decayed missing and filled teeth

<sup>b</sup> DT= number of decayed teeth

<sup>c</sup> Chi-square Test for gender and good oral hygiene among 6 factories

<sup>d</sup> Kruskal-Wallis Test for age, education year, DMFT and DT among 6 factories

each six factory was between 86 and 170, while numbers of those participating in study were between 28 and 35 workers (20.6-35.0% of total workers) which were higher than calculated minimum sample size. Majority of workers (60-89%) were male for 5 factories while the other factory (Factory B) had male workers for 26.7%. Workers' mean ages ranged from 33.5 to 44.5 and education years from 7.2 to 13.1. Among the six factories, proportions of male workers as well as workers' mean ages and education years statistically significantly differed ( $p < 0.001$ ), Table 1.

### **Factories' environmental factors and clinical outcomes**

Two factories were located in rural area, while the others were in urban area. Two factories (C and E) provided health insurance, additionally to a basic package, to all their workers. Factories A, D and F had snack shops while the other three did not. Almost all factories, except Factory B, had wash basins in toilets so that workers could use the basins during brushing their teeth. In terms of tooth brushing activity after lunchtime, provision of free toothbrush and prohibition of eating while working, only Factory C had all these three oral health supportive factors while other factories did not have any of them (Table 1).

Regarding clinical oral health outcomes, mean DMFT scores of workers among the six factories did not statistically differ ( $p = 0.432$ ) although some differences were observed, for example, mean DMFT score was lowest (4.5) for Factory C and highest (7.0) for Factory B. (Table 1) However, statistically significant difference ( $p = 0.048$ ) was found for mean DT scores. Mean numbers of untreated decay teeth among the six factories ranged from 0.6 (Factory F) to 1.5 (Factory D). For oral hygiene status, percentages of workers with good oral hygiene were statistically significantly different ( $p < 0.001$ ). As high as 94% of workers in Factory E were categorized as having good oral hygiene, while about 50% of those working in factory B had good oral hygiene (Table 1).

### **Individual characteristics**

Socio-demographic and behavioral characteristics of sample were present in Table 2. Ages of sample ranged from 19 to 62 years with a mean  $38.5 \pm 10.2$  years. Most (67.0%) of the sample were male, most (62.8%) finished secondary school or higher. For oral health behaviors, the majority (86.9%) brushed their teeth at least two times per day. Percentage of

sample who frequently consumed processed snacks was slightly lower than those who did not, 45.5% and 54.5% respectively. Most of the sample (82.2%) frequently consumed fruits. In terms of taking snack breaks, 36.6% had snack breaks twice or more a day while 63.4% did not or had only once a day. There were also observed for consumptions of sweet drinks (47.1%) and soft drinks (47.6%). Nearly half (50.3%) drank sweet/soft drink twice or more a day, while the other half (49.7%) did not or drank once a day. (Table 2) In terms of oral health status, 80.6% of sample had dental caries experience. DMFT scores ranged from 0 to 22 with a mean  $5.4 \pm 5.3$ . Seventy-one percent of sample had good oral hygiene, while 28% had fair and 1% had poor oral hygiene.

Associations of individual characteristic and oral health status were shown in Table 2. Age was statistically significantly associated with all clinical outcomes. Older tended to have higher DMFT ( $r = +0.378$ ,  $p < 0.001$ ) and DT ( $r = +0.229$ ,  $p = 0.001$ ) scores, and poorer oral hygiene ( $p = 0.003$ ). Male workers were more likely to have lower DMFT scores than female workers ( $p = 0.014$ ), however significant difference between gender was not found for DT scores and oral hygiene status. All clinical outcomes were statistically significantly related to educational level, that is, workers who studied at secondary school level or higher tended to have lower DMFT scores ( $p = 0.044$ ), lower DT scores ( $p < 0.001$ ) and good oral hygiene ( $p = 0.035$ ) compare to their counterparts.

For oral health behaviors, statistically significant difference were observed for only tooth brushing frequency in relation to oral hygiene status ( $p = 0.035$ ). Workers who brushed their teeth at least two times per day were more likely to have good oral hygiene (73.5%) compared to those brushing once a day (52.0%). Others oral health behaviors were not significantly associated with clinical outcomes, however, some behavioral variables obtained *p-value* of less than 0.2, namely, brushing frequency ( $p = 0.145$ ), and frequent consumption of fruits ( $p = 0.134$ ) associated with DMFT scores; and frequent consumption of processed snacks with oral hygiene ( $p = 0.156$ ). Therefore, these variables would be included in further multivariate analyses (Table 2).

### **Factories' environmental factors associated with oral health outcomes**

Since there are differences between the six participating factories in terms of some oral health

**Table 2** Individual characteristics: socio-demographic and behavioral factors associated with DMFT and DT scores and having good oral hygiene

Workers' characteristics	Range (Mean±SD)	% of sample (N=191)	DMFT <sup>a</sup> score		DT <sup>b</sup> score		Good oral hygiene	
			Mean±SD	P-value <sup>c</sup>	Mean±SD	P-value <sup>c</sup>	%	P-value <sup>d</sup>
<b>Socio-demographic factors</b>								
Age	19-62(38.5±10.2)		r=+0.378	<0.001 <sup>e</sup>	r=+0.229	0.001 <sup>e</sup>		0.003 <sup>f</sup>
<b>Gender</b>								
Female		33.0	6.7±5.6	0.014	0.8±1.7	0.180	79.4	0.090
Male		67.0	4.8±5.1		1.2±2.1		66.4	
<b>Education</b>								
Primary school		37.2	6.6±5.9	0.044	1.7±2.5	<0.001	52.1	<0.001
Secondary school or higher		62.8	4.8±4.8		0.7±1.4		81.7	
<b>Behavioral factors</b>								
<b>Frequency of tooth brushing</b>								
Once a day		13.1	7.3±6.5	0.145	1.8±3.4	0.417	52.0	0.035
At least two times per day		86.9	5.2±5.1		1.0±1.6		73.5	
<b>Frequently consumed processed snacks</b>								
No		54.5	5.6±5.5	0.732	0.9±1.4	0.777	66.3	0.156
Yes		45.5	5.2±5.1		1.3±2.4		75.9	
<b>Frequently consumed fruits</b>								
No		17.8	4.2±5.0	0.134	0.9±1.3	0.680	61.8	0.218
Yes		82.2	5.7±5.3		1.1±2.1		72.6	
<b>Frequency of snack breaks</b>								
No or once a day		63.4	5.4±5.3	0.727	1.1±1.9	0.783	67.8	0.322
Twice or more a day		36.6	5.5±5.4		1.1±2.1		75.7	
<b>Frequently consumed sweet drink</b>								
No		52.9	5.4±5.4	0.502	1.2±2.0	0.265	72.3	0.636
Yes		47.1	5.5±5.2		1.0±1.9		68.9	
<b>Frequently consumed soft drink</b>								
No		52.4	5.4±5.4	0.717	1.0±1.8	0.371	73.0	0.525
Yes		47.6	5.5±5.2		1.2±2.1		68.1	
<b>Frequency of drinking sweet/soft drinks</b>								
No or once a day		49.7	5.9±5.3	0.274	1.0±1.9	0.907	73.7	0.427
Twice or more a day		50.3	5.0±5.3		1.1±2.1		67.7	

<sup>a</sup> DMFT= number of decayed missing and filled teeth

<sup>b</sup> DT= number of decayed teeth

<sup>c</sup> Mann-Whitney Test

<sup>d</sup> Chi-square Test

<sup>e</sup> Pearson correlation, *r*= Pearson correlation coefficient

<sup>f</sup> T-test

outcomes of workers, that is, mean DT scores and percentages of workers with good oral hygiene, while differences between factories' characteristics and environmental factors were also detected as presented in Table 1, we further explored whether such the differences in oral health outcomes were associated with factory's characteristics. Table 3 shows crude and adjusted negative binomial and binary logistic regression models for associations of DT scores and having good oral hygiene respectively, with factory's characteristics. Previous analyses on workers' characteristics associated with oral health outcomes also found that age, gender and education years of workers among the six factories significantly differed (Table 1). Analyses on individual characteristics associated with clinical outcomes (Table 2) revealed that socio-demographic characteristics generally significantly associated

with clinical outcomes. Therefore, socio-demographic factors were entered into adjusted models. In addition, oral behaviors that conceptually related to certain oral health outcomes and obtained *p*-value of less than 0.2 on univariate analyses were also included in adjusted model.

For dental caries analyses, using DT scores as outcome variable, crude model revealed a potential difference between factories with and without wash basins in toilets. Mean DT score of workers in factories where wash basins were available was 1.1, while that of factories without wash basins was 1.8. Although such difference did not yield statistical significance (IRR = 0.6(0.3-1.2), *p*-value = 0.056), *p*-value of less than 0.2 warranted further multivariate analysis. When age, gender and educational level were entered into adjusted model, the difference became statistically significant

**Table 3** Negative binomial and binary logistic regression models for associations of factory characteristics with dental caries and oral hygiene respectively, adjusted for individual characteristics

Factory characteristic	Dental caries analysis <sup>c</sup>				Good oral hygiene analysis <sup>d</sup>			
	% of sample (N=139)	DT <sup>a</sup> Mean±SD	Unadjusted IRR <sup>b</sup> (95%CI)	Adjusted IRR <sup>b</sup> (95%CI)	% of sample (N=191)	% good oral hygiene	Unadjusted OR(95%CI)	Adjusted OR(95%CI)
<b>Size</b>								
Small	58.9	1.3±1.9	1		51.8	59.6	1	1
Medium	41.1	1.0±2.3	0.8(0.5-1.2)	-	48.2	82.6	3.2(1.6-6.3) <sup>f</sup>	3.1(1.4-6.9) <sup>f</sup>
<b>Location</b>								
Urban	73.0	1.1±1.9	1		66.0	69.0	1	
Rural	27.0	1.3±2.6	1.2(0.7-2.0)	-	34.0	73.8	1.3(0.6-2.5)	-
<b>Additional health insurance</b>								
No	71.8	1.3±2.1	1		63.9	63.1	1	1
Yes	28.2	1.0±2.1	0.7(0.5-1.2)	-	36.1	84.1	3.1(1.5-6.5) <sup>f</sup>	2.7(1.2-6.2) <sup>f</sup>
<b>Snack shop</b>								
No	46.0	1.2±2.2	1		51.8	73.7	1	
Yes	54.0	1.2±2.0	1.0(0.6-1.6)	-	48.2	67.4	0.7(0.4-1.4)	-
<b>Wash basin in toilet</b>								
No	17.8	1.8±2.6	1	1	15.7	50.0	1	1
Yes	82.2	1.1±2.0	0.6(0.3-1.2) <sup>e</sup>	0.4(0.2-0.9) <sup>f</sup>	84.3	74.5	2.9(1.3-6.5) <sup>f</sup>	7.0(2.2-22.8) <sup>f</sup>
<b>Brushing activity + free toothbrush + no eating</b>								
No	81.0	1.2±2.2	1		82.2	70.1	1	
Yes	19.0	1.0±1.8	0.8(0.5-1.4)	-	17.8	73.5	1.2(0.5-2.7)	-

<sup>a</sup> DT= number of decayed teeth

<sup>b</sup> IRR= incidence rate ratio

<sup>c</sup> Negative binomial regression, including workers with working time more than 2 years adjusting for age, gender and education

<sup>d</sup> Binary logistic regression, adjusting for age, gender, education and frequency of tooth brushing

<sup>e</sup> p value<0.2

<sup>f</sup> p value<0.05

( $p < 0.05$ ). DT scores of workers in factories with available wash basins in toilets were 60% (IRR= 0.4 (0.2-0.9)) less than those in factories without wash basins.

For oral hygiene analyses, crude models showed that workers in medium size factories, those in factory with additional health insurance and those in factories where wash basins were available in toilets were significantly more likely to have good oral hygiene compared to their counterparts. In adjusted models where age, gender, educational level and frequency of tooth brushing were controlled, size, a provision of additional health insurance and availability of wash basins in toilets remained statistically significantly associated with oral hygiene. Workers in medium size factories, those working in factory that provided additional health insurance were about three times more likely to have good oral hygiene compared to workers working in small size factories and where additional health insurance was not provided (OR = 3.1 (1.4-6.9), OR= 2.7 (1.2-6.2) respectively). Moreover,

workers in factories where wash basins were available were as high as 7 times (OR= 7.0 (2.2-22.8)) more likely to have good oral hygiene compare to those in factories without wash basins in toilets (Table 3).

## DISCUSSION

This study found that there were some differences in oral status between the six participating factories. After investigating into factory factors that might explain such the differences, we found that the presence or absence of wash basin in toilets significantly related to dental caries and oral hygiene. In addition, presence/absence of additional health insurance and size of factory significantly related to oral hygiene of workers. Thus, the existence or provision of health supportive environments ought to have some beneficial effects on workers' oral health. The presence of wash basins in toilet might facilitate workers' tooth brushing activity making their brushing time longer and brushing's better, which

subsequently, led to low dental caries and better oral hygiene. Tooth brushing with fluoride toothpaste certainly has benefit in reducing dental caries [27]. A previous study also found that oral health care program aiming to improve quality of tooth brushing could successfully reduce participants' new dental caries lesions [17]. This study also found a positive significant association between tooth brushing frequency and oral hygiene, that is, workers who brushed their teeth more frequently tended to have good oral hygiene. When tooth brushing frequency was controlled, the presence of wash basin remained significantly associated with having good oral hygiene. This might reflect other aspects of tooth brushing activity such as brushing time or brushing quality as abovementioned that were facilitated by wash basin but not collected by this study. Although there is no previous study on relating issue, a similar study could be discussed. Malikaew, et al. [11] found that schools with dry floor, no obstructed objects and no concrete ground, prevalence of traumatic dental injuries among students was lower than that of schools with wet floor, having obstructed objects and having concrete ground. This confirms the role of safety and health supportive environments on oral health.

In addition to the presence of wash basin in toilet, this study found that provision of additional health insurance by factory to their workers significantly related to workers' good oral hygiene. Having a more extensive health insurance might lead to better dental attendance pattern, and subsequently, good oral health practice and oral hygiene. Previous studies also showed that people with dental insurance coverage had better oral health in terms of more number of teeth, requiring less dental treatment and treatment times [14, 15]. Other studies also found that people who received oral screening, oral health education as well as oral hygiene aids had lower dental caries, better oral hygiene practices and better periodontal health [13, 16, 17]. Thus, this study's finding confirms with previous studies that providing access or opportunity to get access to oral health service might be beneficial to people's oral health.

Effects of socio-demographic and socioeconomic status on oral health were confirmed by the present study as we found that age, sex and education level were, in general, significantly associated with dental caries and oral hygiene. These findings agree with the existing knowledge, for example, previous studies showed that low educated workers had more

numbers of tooth loss and more likely to have periodontal disease [14, 21-23]. Significant association between size of factory and workers' oral hygiene as found in the present study might reflect the effect of socioeconomic status on oral health.

An important limitation of this study relates to small sample size, which was due to the fact that this study was a part of a longitudinal oral health promotion project and not designed to test the associations of oral health with covariates. Therefore, our small sample size could not warrant formal statistical comparisons. Statistically significant associations were not found even though some were expected. For example, dental caries noticeably differed between workers who brushed their teeth once (DMFT =  $7.3 \pm 6.5$ , DT =  $1.8 \pm 3.4$ ) and those brushing twice/more a day (DMFT =  $5.2 \pm 5.1$ , DT =  $1.0 \pm 1.6$ ) which was consistent with the existing evidence on the effectiveness of tooth brushing with fluoride toothpaste on caries prevention [6]. However, such the differences did not obtain statistical significance as expected. In addition to findings at individual level, tooth brushing supportive factory's policy should also contribute to better oral health of workers as Morishita, et al [17] found that workers who received oral health promotion package including free toothbrush and education pamphlets had lower DMFT score. However, in our study, there was only one factory (factory C) with tooth brushing supportive policy that is, providing free toothbrush and urged their workers to brush their teeth as a regulation of lead products factory. Due to a small sample, the presence of such supportive policy did not statistically significantly related to oral health of workers. Similarly, associations of dental caries with individual behaviors on sugary food consumption and with factory factors on the presence of snack shop were not statistically significant in the present study. These findings are inconsistent with existing evidence on the crucial role of sugary food on dental caries development [28]. A previous study also showed that dental caries was lower in schools with a diet policy where healthier and less sweet food was provided for children [7, 10]. Non-significance of our study's results might be due to our small sample size.

In spite of the study's unavoidable weakness on small sample size, our findings do provide useful information regarding the potential effects of workplace environments on workers' oral health. By

arranging or providing oral health supportive environment, beneficial effects on workers' oral health could be expected. Prevention program might be added in the further studies. Further studies on larger sample size as well as longitudinal studies are required for better understanding the effects of workplace environments on oral health of workers.

In conclusion, caries and oral hygiene in each factory was significant different. That was because of environmental factor of factory such as factories with wash basin in toilet, factory size and additional health insurance factories. This study shown that DT of workers in factories with wash basin in toilet was likely lowers than that no wash basin. While workers in medium factories, additional health insurance factories and factories with wash basin in toilet had likely significantly more number of good oral hygiene workers. Therefore improve environmental factor of factory might be help workers get better oral health.

#### ACKNOWLEDGEMENT

This research received a thesis grant from the Graduate School, Chulalongkorn University.

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