Association between tooth brushing behavior and diabetes mellitus occurrence in Indonesia

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***Abstract*---**Diabetes mellitus (DM) is a disease that is characterized by hyperglycemia, a condition where blood glucose level is higher than normal. Recent researches have shown that tooth brushing frequency is a potential risk factor for DM. Indonesian Basic Health Research (Riskesdas) collected the data of tooth brushing behavior of Indonesian people in 2018 according to the time of the tooth brushing. The data showed that the majority of Indonesian people brushed their teeth every day, but only 2.8 % of them did it at the right time. This problem might have an association with DM occurrence in Indonesia. This study aimed to analyze the tooth brushing behavior and DM occurrence association in Indonesia using the Indonesian Basic Health Research 2018 data. This cross-sectional study used a total of 455,040 interviewed respondents aged 30-80 years old that had complete data of their daily tooth brushing behavior. Tooth brushing behavior was the main independent variable. Other independent variables were age, sex, sweet drinks consumption, sweet foods consumption, fatty foods consumption, fruits and vegetables consumption, physical activity, and obesity. The dependent variable was the occurrence of DM based on diagnosis by doctor. The proportion of DM occurrence based on diagnosis by doctor in 30-80 years old respondents was 2.92%. DM occurrence was significantly associated with age, sex, sweet drinks consumption, sweet foods consumption, fatty foods consumption, physical activity, and obesity ($p < 0.001$). Tooth brushing behavior and DM occurrence in Indonesia, based on diagnosis by doctor in 30-80 years old respondents, was not significantly associated. Besides performing

correct tooth brushing behavior, performing the correct method of the tooth brushing is also important to decrease DM occurrence.

***Keywords*---**diabetes mellitus, Indonesian basic health research, Riskesdas, tooth brushing.

Introduction

Diabetes mellitus (DM) is a disease that is characterized by hyperglycemia, a condition where blood glucose level is higher than normal (American Diabetes Association, 2014; Moini, 2019). As of 2014, there are ± 422,000,000 people living with diabetes worldwide. The number of people having DM is continually escalating. It is projected to rise to ± 21,257,000 in Indonesia by 2030 (WHO, 2020). Due to the large impact of DM on health and economic burden, preventive measures are strongly needed. Preventing DM can be managed through modification of its risk factors. Obesity, lack of physical activity, low consumption of vegetable and fruits, and high intake of fatty foods are known risk factors for DM (Galaviz et al., 2018; Kalin et al., 2017). At the same time, recent researches have shown that tooth brushing frequency is a potential risk factor for DM (Kuwabara et al., 2017; Zoraya and Azhar, 2020).

Kuwabara et al. reported on their cross-sectional study that high prevalence of DM was associated with low frequency of tooth brushing (Kuwabara et al., 2016). They proceeded with a retrospective cohort study which confirmed that low tooth brushing frequency was a risk factor for DM in male patients (Kuwabara et al., 2017). Other retrospective cohort study by Chang et al. explained that brushing teeth three times a day or more could reduce the risk of DM onset (Chang et al., 2020). Meta-analysis by Fu et al concluded that tooth brushing frequency less than two times a day would increase the risk of having DM (Fu et al., 2019).

Low tooth brushing frequency causes the biofilm to deposit on the tooth surface (Kay, 2016). The key pathogen accumulated on the biofilm, *Porphyromonas gingivalis*, renders the disturbance on host-bacteria homeostasis (Hajishengallis, 2013; Olsen et al., 2017). This disturbance will induce the periodontal tissue inflammation, which will involve the alveolar bone destruction and tooth mobility, if the biofilm keeps piling up (Newman et al., 2019; Stephens et al., 2018; Walsh and Darby, 2019).

The inflammation of the periodontal tissue will raise the level of cytokines, i.e. interleukin-1β (IL-1β), IL-6, tumor necrosis factor-α (TNF-α), and oxidative stress. Studies informed that people who suffer from periodontal disease had higher level of IL-1β, IL-6, TNF-α, and oxidative stress index compared to the ones with healthy periodontal tissue (Jacob et al., 2014; Keles et al., 2014; Singh et al., 2014; Vincent et al., 2018). Studies also informed that the rise of the cytokines level and oxidative stress will disrupt the insulin signaling pathway. It will decrease the tyrosine phosphorylation of insulin receptor substrate-1 (IRS-1) and inhibit the translocation of glucose transporter 4 (GLUT4) (Chen et al., 2015; Shi et al., 2019). The storing of the blood glucose will be impaired as the cells become

irresponsive to the insulin. This condition will lead to DM (Mahan Buttaro et al., 2017).

Although previous studies have reported the association between tooth brushing frequency and diabetes mellitus occurrence, the time of the tooth brushing was not clearly specified. Indonesian Basic Health Research, which is conducted every 5 year, collected the data of tooth brushing behavior of Indonesian people in 2018 according to the time of the tooth brushing. The correct tooth brushing behavior was defined as tooth brushing that was done at the right time i.e. after eating in the morning and before going to bed at night. The majority of Indonesian people brushed their teeth every day, but only 2.8 % of them did it at the right time (Badan Litbang Kesehatan Kementerian Kesehatan RI, 2019). This problem might have an association with DM occurrence in Indonesia. Therefore, we aimed to analyze the tooth brushing behavior and DM occurrence association in Indonesia using the Indonesian Basic Health Research (Riskesdas) 2018 data. The result could be used as an insight for the dental care providers and health promoters in educating people about the importance of performing correct tooth brushing behavior.

Methods

The data were obtained from the National Institute of Health Research and Development, Ministry of Health, Republic of Indonesia, which can be accessed with specific terms and procedures via www.litbang.kemkes.go.id. Permission to use the data and to publish the research result were granted through letters no. IR.01.01/1/994/2021 and IR.03.01/4/392/2022, respectively. Ethical approval for this study was given by the Health Research Ethics Committee, Faculty of Public Health, Sriwijaya University through a certificate no. 363/UN9.1.10/KKE/2020.

Samples for the Indonesian Basic Health Research 2018 were taken based on the census block from the Indonesian Population Census 2010. From 30.000 census blocks and 300.000 chosen households, there were 29.824 (99.41%) census blocks and 282.654 (95.58%) households visited. Individual samples interviewed were 1.017.290 (93.20%) people across all age groups. The samples used in this cross-sectional study were a total of 455,040 interviewed respondents aged 30-80 years old that had complete data of their daily tooth brushing behavior.

Tooth brushing behavior was the main independent variable. Other independent variables were age, sex, sweet drinks consumption, sweet foods consumption, fatty foods consumption, fruits and vegetables consumption, physical activity, and obesity. The dependent variable was the occurrence of DM. Tooth brushing behavior was categorized as correct (brushing teeth after eating in the morning and before going to bed at night) or incorrect (not/seldom/not applicable brushing teeth after eating in the morning and before going to bed at night). Age was categorized as < 45 years old or ≥ 45 years old based on the median of the respondents age. Sex was categorized as male or female. Sweet drinks, sweet foods, and fatty foods consumption were categorized as seldom or frequent. Fruits and vegetable consumption and physical activity were categorized as adequate or inadequate. Obesity was categorized as yes or no based on the calculation of the

respondents' body mass index. Meanwhile, DM occurrence was categorized as yes or no based on diagnosis by doctor.

Univariate analysis was conducted to compute the frequency and the proportion of each variable. Bivariate analysis using the Chi-square test was conducted to analyze the association between each independent variable and dependent variable. Finally, multivariate analysis using Poisson regression was carried out to analyze the association between all independent variables and dependent variable.

Results

Table 1. Univariate analysis

Variable	n	%
DM occurrence		
No	442,011	97.08
Yes	13,029	2.92
Tooth brushing behavior		
Incorrect	439,574	97.02
Correct	15,466	2.98
Age		
≥ 45 years old	236,720	50.82
< 45 years old	218,320	49.18
Sex		
Male	213,475	49.18
Female	241,565	50.82
Sweet drinks consumption		
Frequent	407,209	89.69
Seldom	47,831	10.31
Sweet foods consumption		
Frequent	384,527	84.61
Seldom	70,513	15.39
Fatty foods consumption		
Frequent	381,049	86.74
Seldom	73,991	13.26
Fruits and vegetables consumption		
Inadequate	445,382	98.27
Adequate	9,658	1.73
Physical activity		
Inadequate	75,031	18.10
Adequate	380,009	81.90
Obesity		
No	340,432	74.54
Yes	114,608	25.46

Table 2. Bivariate analysis

Variables	DM Occurrence				p-value
	Yes		No		
	n	%	n	%	
Tooth brushing behavior					
Incorrect	12,514	2.90	427,060	97.10	0.006
Correct	515	3.47	14,951	96.53	
Age					
≥ 45 years old	11,242	4.95	225,478	95.05	< 0.001
< 45 years old	1,787	0.82	216,533	99.18	
Sex					
Male	4,983	2.36	208,492	97.64	< 0.001
Female	8,046	3.46	233,519	96.54	
Sweet drinks consumption					
Frequent	7,966	2.00	399,243	98.00	< 0.001
Seldom	5,063	10.94	42,768	89.06	
Sweet foods consumption					
Frequent	8,225	2.18	376,302	97.82	< 0.001
Seldom	4,804	7.00	65,709	93.00	
Fatty foods consumption					
Frequent	10,342	2.75	370,707	97.25	< 0.001
Seldom	2,687	4.00	71,304	96.00	
Fruits and vegetables consumption					
Inadequate	12,727	2.91	432,655	97.09	0.014
Adequate	302	3.55	9,356	96.45	
Physical activity					
Inadequate	3,860	5.06	71,171	94.94	< 0.001
Adequate	9,169	2.45	370,840	97.55	
Obesity					
No	9,046	2.70	331,386	97.30	< 0.001
Yes	3,983	3.57	110,625	96.43	

Chi-square test, $p < 0.05$

Table 3. Multivariate analysis

Variables	Crude PR (95% CI)	p-value	Adjusted PR (95% CI)	p-value
Tooth brushing behavior				
Incorrect	1		-	-
Correct	1.02 (0.90-1.16)	0.682	-	
Age				
≥ 45 years old	1	< 0.001	1	< 0.001
< 45 years old	0.18 (0.17-0.19)		0.18 (0.17-0.19)	
Sex		< 0.001		<

Male	1		1	0.001
Female	1.24 (1.18-1.31)		1.24 (1.18-1.31)	
Sweet drinks consumption				
Frequent	1	< 0.001	1	< 0.001
Seldom	3.76 (3.56-3.98)		3.77 (3.56-3.98)	
Sweet foods consumption				
Frequent	1	< 0.001	1	< 0.001
Seldom	1.64 (1.55-1.73)		1.64 (1.55-1.73)	
Fatty foods consumption				
Frequent	1	< 0.001	1	< 0.001
Seldom	0.88 (0.83-0.94)		0.88 (0.83-0.94)	
Fruits and vegetable consumption				
Inadequate	1	0.053	-	-
Adequate	1.16 (0.99-1.36)		-	
Physical activity				
Inadequate	1	< 0.001	1	< 0.001
Adequate	0.57 (0.54-0.60)		0.57 (0.54-0.60)	
Obesity				
No	1	< 0.001	1	< 0.001
Yes	1.24 (1.17-1.31)		1.24 (1.17-1.31)	

Poisson regression, $p < 0.05$

The proportion of DM occurrence based on diagnosis by doctor in 30-80 years old respondents was 2.92%. The tooth brushing behavior of most of the respondents (97.02%) was incorrect. There were more respondents aged ≥ 45 years old (50.82%) than < 45 years old (49.18%). Compared to male respondents, the proportion of female respondents was higher (50.82%). Most of the respondents frequently consumed sweet drinks (89.69%), sweet foods (84.61%), and fatty foods (86.74%). Most of the respondents had inadequate consumption of fruits and vegetables (98.27%). On the other hand, 81.90% of the respondents had adequate physical activity. Only 25.46% of the respondents had obesity. The result of the univariate analysis is displayed in Table 1.

The result of the bivariate analysis in Table 2 indicates that all of the independent variables have significant association with DM occurrence. At the same time, the result of the multivariate analysis shows that there is no statistically significant association between DM occurrence and tooth brushing behavior (adjusted PR (95% CI) = 1.02 (0.90-1.16), $p = 0.682$). The result of the multivariate analysis in Table 3 also shows that the association between DM occurrence and age, sex, sweet drinks consumption, sweet foods consumption, fatty foods consumption, physical activity, and obesity was statistically significant ($p < 0.001$).

Discussion

In this study, the association between tooth brushing behavior and DM occurrence was not statistically significant. This was different from the results reported in the previous studies associating tooth brushing frequency and diabetes mellitus (Chang et al., 2020; Fu et al., 2019; Kuwabara et al., 2016, 2017). It is presumed that, besides performing correct tooth brushing behavior, performing the correct method of the tooth brushing is also important to decrease DM occurrence. The correct method of tooth brushing can be introduced to patients by their dentists. Educating people about correct tooth brushing behavior and method has been a challenge for the dental care providers in Indonesia since most Indonesian people tend to be reluctant towards seeking health care (Widayanti et al., 2020). It is recommended that dental care providers collaborate with health promoters and influential people in social media to reach broader communities.

DM occurrence was less prevalent in the respondents aged < 45 years old (adjusted PR (95% CI) = 0.18 (0.17-0.18), p < 0.001). This is consistent with the previous studies in China and Saudi Arabia which use 51.5 and 40 years age cut-off (Al Mansour, 2020; Zou et al., 2017). Along with aging, the cells mitochondria produce more reactive oxygen species (ROS) (Chistiakov et al., 2014). Abundant ROS production, which cannot be tolerated by the antioxidant defense system, will cause the mitochondrial DNA (mtDNA) to mutate (Bhatti et al., 2017). The mutation of the mtDNA will impact the function of mitochondria. There will be less production of adenosine triphosphate (ATP). Less ATP can decrease the translocation of GLUT4 to the cell membrane which leads to the failure of the cell to respond to insulin (Hurrle and Hsu, 2017; Rains and Jain, 2011).

The prevalence of DM occurrence in the female respondents was higher than that of the male respondents (adjusted PR (95% CI) = 1.24 (1.18-1.31), p < 0.001). This result contradicts the result of the studies in Africa and Sweden (Hilawe et al., 2013; Nordström et al., 2016). Higher prevalence of DM occurrence among female respondents could be due to the role of female sexual hormone level. It is reported that menopausal women have low estrogen level. Low estrogen level will cause the deposition of fat which can induce the insulin resistance (Ko and Kim, 2020). The level of sex hormone binding globulin (SHBG) also decreases in menopausal women. This will in turn increase the testosterone level. Women with high testosterone level are more likely to have DM (Stefanska et al., 2015). Apart from hormonal factor, the chance of having DM is also influenced by psychological factor (Kautzky-Willer et al., 2016). Women are more susceptible with stress in daily life compared to men. Williams et al reported that stress can disrupt the glucose metabolism in women aged ≥ 25 years old (Williams et al., 2013).

The DM occurrence was more prevalent among the respondents who rarely consumed sweet drinks (adjusted PR (95% CI) = 3.77 (3.56-3.98), p < 0.001) and foods (adjusted PR (95% CI) = 1.64 (1.55-1.73), p < 0.001). Although the association between vegetables, fruits, and DM occurrence were not statistically significant, it can be seen from the result that the prevalence of DM occurrence was higher among the respondents who consumed fruits and vegetables adequately. People who had been diagnosed with DM tend to lower their

consumption of sweet drinks and foods, and increase their intake of fruits and vegetables. Consuming sweet drinks and foods with high glycemic index frequently can cause craving for more drinks and foods which will increase the deposition of fat in the liver and cause de novo lipogenesis (DNL) (Schwarz et al., 2017). Meanwhile, consuming fruits and vegetables adequately could increase insulin sensitivity (Bertoia et al., 2015; Wedick et al., 2012).

Among the respondents who rarely consumed fatty foods, DM occurrence was less prevalent (adjusted PR (95% CI) = 0.88 (0.83-0.94), $p < 0.001$). Although some studies reported that total fat intake was not associated with increased risk of DM, high consumption of fatty foods can lead to obesity which is one of the risk factors for DM (Rahati et al., 2014; Widiyanto, 2018).

Respondents with adequate physical activity had lower prevalence of DM occurrence (adjusted PR (95% CI) = 0.57 (0.54-0.60), $p < 0.001$). This result confirms a large population study in China (Wang et al., 2018). Those with inadequate physical activity might deal with several barriers that prevent them to do the physical activity. The barriers can arise from personal, social, and environmental aspects (Anjali and Sabharwal, 2018). Tight schedule, stress, and fatigue are barriers from the personal aspect (Anjali and Sabharwal, 2018; Stults-Kolehmainen and Sinha, 2014). From the social aspect, lack of family support can also be a barrier (Anjali and Sabharwal, 2018; Guthold et al., 2020). Uneasiness to be physically active outside home, unavailability of facility, and design of housings and buildings are barriers from the environmental aspect (Anjali and Sabharwal, 2018; Busthanul et al., 2020; Yeung and Johnston, 2020). In many areas in Indonesia, often times, facilities for the pedestrian are used by the street vendors (Busthanul et al., 2020). On the other hand, buildings are designed with stairs that are farther from the entrance causing people to choose elevator instead (Yeung and Johnston, 2020; Widiyanto 2022)).

The prevalence of DM occurrence was higher in respondents with obesity (adjusted PR (95% CI) = 1.24 (1.17-1.31), $p < 0.001$). Even though not every person with obesity will suffer from DM, obesity must be prevented. Preventing obesity can be obtained through low calorie diet and adequate physical activity (Fock and Khoo, 2013; Xiao and Yang, 2012). This study has some limitations. While using samples with national representation, this study cannot determine the causal relationship between the tooth brushing behavior and DM occurrence. This study cannot classify the types of DM and measure the respondents' age on the onset of DM. Further studies should measure the method and the duration of the tooth brushing aside from only measuring the tooth brushing behavior.

Conclusion

Tooth brushing behavior and DM occurrence in Indonesia, based on Indonesian Basic Health Research 2018 data of 30-80 years old respondents, was not significantly associated. Besides performing correct tooth brushing behavior, performing the correct method of the tooth brushing is also important to decrease DM occurrence. We recommend that dental care providers collaborate with health promoters and influential people in social media on educating people about correct tooth brushing behavior and method.

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