Advances in Health Sciences Research, volume 25
2nd Sriwijaya International Conference of Public Health (SICPH 2019)

Association Between Toothbrushing and Cardiovascular Disease Risk Factors: A Systematic Review

Sabrina Intan Zoraya
Public Health Faculty Postgraduate Program
Sriwijaya University
Palembang, Indonesia
sabrinaikm2019@gmail.com

Abdillah Adipatria Budi Azhar
Public Health Center Dental Polyclinic
Taman Bacaan Public Health Center
Palembang, Indonesia
AbdillahAzhar@gmail.com

***Abstract*— *Background:* Cardiovascular disease is still the leading cause of death globally. For a decade, interest has been growing in linking cardiovascular disease risk factors and oral hygiene. A method that is commonly applied to maintain oral hygiene is toothbrushing. The purpose of this review is to synthesize findings from studies reporting the association between toothbrushing and cardiovascular disease risk factors. *Methods*: We performed systematic search according to Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. We retrieved studies from PubMed Central, BioMed Central, and ScienceDirect using 'association' AND 'toothbrushing' AND 'cardiovascular disease' AND 'risk factor' keywords. After duplication removal, relevant studies were selected based on inclusion criteria. *Results*: The database search yielded 837 articles. Five eligible articles were from 4 cross-sectional studies and 1 retrospective cohort study conducted in Scotland, Iran, China, and Japan. The cardiovascular disease risk factors examined were behavioral risk factors such as physical activity, drinking, diet, and smoking status; blood pressure, total cholesterol, levels of low-density lipoprotein cholesterol, levels of high-density lipoprotein cholesterol; conditions such as hypertension, hyperuricemia, and dyslipidaemia; and obesity, chronic kidney disease, and diabetes mellitus. All studies revealed significant association between toothbrushing and cardiovascular disease risk factors. *Conclusions*: There was significant association between toothbrushing and cardiovascular disease risk factors. Low frequency of toothbrushing was found to be independent risk factor for diabetes mellitus in men and dyslipidaemia in women. Toothbrushing should be included in the prevention of the development of cardiovascular disease risk factors.**

Keywords: toothbrushing, cardiovascular disease, risk factor

I. INTRODUCTION

Cardiovascular disease is a disease involving the heart and blood vessels.[1] Cardiovascular disease includes coronary heart disease, stroke, hypertensive heart disease, cardiomyopathy and myocarditis, rheumatic heart disease, atrial fibrillation and flutter, aortic aneurysm, endocarditis, peripheral artery disease, and other cardiovascular and circulatory disease.[2]

Cardiovascular disease is still the leading cause of death globally. According to WHO, cardiovascular disease causes deaths of 17.9 million people in 2016. It contributes to 31% of all deaths worldwide.[3] Despite having a decreased cardiovascular disease incidence and mortality rate, developed countries still hold a high number of deaths caused by cardiovascular disease.[4] Cardiovascular disease, mainly coronary heart disease, causes 47% of all deaths in Europe, 40% in European Union, and 43,2% in United States of America.[5, 6] Eastern Europe and Central Asia are the countries with the highest per capita cardiovascular disease burden. Largest total burden of cardiovascular disease comes from the countries of East Asia and South Asia. This is due to their increased ageing population.[2] Meanwhile, South East Asia had an escalated total burden of cardiovascular disease of 25% from 2000 to 2016. Three leading causes of cardiovascular disease burden in South East Asia are coronary heart disease, stroke, and hypertensive heart disease.[7]

The risk factors of cardiovascular disease have been studied extensively. They comprise of several modifiable risk factors such as, physical inactivity, drinking, unhealthy diet and smoking.[3] Unhealthy diet causes too much saturated fat and cholesterol intake. This condition raises the level of low density lipoprotein-cholesterol (LDL-C). High level of LDL-C can promote atherosclerosis by forming arterial plaque. High density lipoprotein-cholesterol (HDL) can prevent the plaque formation. Adjusting LDL-C and HDL can be achieved by avoiding smoking and being physically active. Obesity increases blood pressure that can lead to hypertension.[8] Hypertension, hyperuricaemia, dyslipidaemia, chronic kidney disease, and diabetes mellitus are also risk factors for cardiovascular disease.[9-13] Therefore, preventing these risk factors can

prevent cardiovascular disease.

For a decade, interest has been growing in linking cardiovascular disease risk factors and oral hygiene. Poor oral hygiene is a major risk factor for periodontal disease. Periodontal disease is a disease affecting tissues around the tooth such as gums and alveolar bone. A study reported that periodontal disease can elevate the level of blood lipids.[14] Poor oral hygiene is also a risk for dental caries. Several studies reported the association between dental caries and obesity.[15, 16] These findings underline the importance of maintaining oral hygiene to prevent cardiovascular disease risk factors. A method that is commonly applied to maintain oral hygiene is toothbrushing. The association between toothbrushing and cardiovascular disease risk factors has been reported in several studies. The purpose of this review is to synthesize findings from these studies.

II. METHODS

We performed systematic search according to Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. We retrieved articles from PubMed Central, BioMed Central, and ScienceDirect using 'association' AND 'toothbrushing' AND 'cardiovascular disease' AND 'risk factor' keywords. Duplicate articles were removed.

Articles were screened by reviewing the abstract and full articles based on these inclusion criteria: 1) population was from developed or developing country; 2) exposure of interest was toothbrushing; 3) outcome was related to cardiovascular disease risk factors, 4) type of studies was epidemiological observational study including analytical cross-sectional, case control, and prospective and retrospective studies.

Every remaining article was assessed by Joanna Briggs Institute (JBI) critical appraisal checklist for eligibility. Five eligible articles were prepared for data extraction referring to JBI guideline. The data extraction details are title, author, year of publication, journal, study design, setting, participant, participant recruitment procedure, exposure of interest, outcome, outcome measurement, method of data analysis, and study result. The data were synthesized into narrative and tabular summary.

III. RESULTS

The database search yielded 837 articles. We gained 309 articles from PubMed Central, 50 articles from BioMed Central, and 359 articles from ScienceDirect. We removed 21 duplicate articles and excluded 806 irrelevant articles. Ten remaining articles were then screened manually from their titles and abstracts. A total of 5 articles were excluded. One article was excluded because the exposure of interest was index of oral hygiene instead of toothbrushing. Other 4 articles were excluded because the outcome was not related to cardiovascular disease risk factors. The title and abstract screening generated 5 articles that were set up for eligibility assessment with Joanna Briggs Institute (JBI) critical appraisal checklist. The PRISMA flow diagram of this process is shown in Fig. 1. The 5 eligible articles were from 4 cross-sectional studies and 1 retrospective cohort study conducted in Scotland, Iran, China, and Japan. The cardiovascular disease risk factors examined were behavioral risk factors such as physical activity, drinking, diet, and smoking status; blood pressure, total cholesterol, levels of low-density lipoprotein cholesterol (LDL-C), levels of high-density lipoprotein cholesterol (HDL-C); conditions such as hypertension, hyperuricemia, and dyslipidaemia; and obesity, chronic kidney disease, and diabetes mellitus. These studies are summarized in Table I.

Synthesized Findings

Association between Toothbrushing and Physical Activity

A study assessed physical activity using questionnaire about participants' activity four weeks before the interview or during a particular week. The domains of activity questioned were leisure time sports, walking, and domestic physical work. It was reported that less physical activity was associated with toothbrushing frequency less than twice a day ($p<0,001$).[17] In addition, physical activity was assessed by calculating walk time and sleep time based on the answers from self-administered questionnaire. Walk time differed significantly ($p<0,001$) between 'at least once a day' (40,4±39,3 minutes) and 'after

TABLE I

SUMMARY OF ARTICLES APPRAISED

Reference	Source	Study Design	Sample Size	Cardiovascular Risk Factors Assessed
[17]	Oliveira et al. (Scotland)	Cross-sectional	11869 adults	Physical activity, smoking, obesity, hypertension, and diabetes mellitus.
[18]	Kuwabara et al. (Japan)	Cross-sectional	85866 adults	Walk time, sleep time, drinking, smoking, hypertension, hyperuricaemia, chronic kidney disease, dyslipidaemia, and diabetes mellitus.
[19]	Liu et al. (China)	Cross-sectional	4500 adults	diet, smoking, drinking, physical activity.
[20]	Kelishadi et al. (Iran)	Cross-sectional	5258 students (10-18 years old)	Obesity, levels of cholesterol, and blood pressure.
[21]	Kuwabara et al. (Japan)	Retrospective cohort	13070 adults	Hypertension, hyperuricaemia, dyslipidaemia, and diabetes mellitus.

every meal' (43,0±44,0 minutes) toothbrushing frequency group. Sleep time also differed significantly (p<0,039) between 'at least once a day' (6,5±3,9 hours) and 'after every meal' (6,6±4,4 hours) toothbrushing frequency group.[18] On the contrary, another study reported no significant association between physical activity and toothbrushing frequency.[19]

Association between Toothbrushing and Drinking

Two studies stated the toothbrushing association with drinking. Significant difference (p<0,001) of drinking habit was found between toothbrushing group 'after every meal' (39,6%) and 'at least once a day' (47,3%).[18] Another study reported that people who brushed their teeth rarely or never had higher prevalence of harmful alcohol use than people who brushed their teeth more often (p<0,05). Harmful alcohol use measurement was ≥25 gram/day for men and ≥15 gram/day for women.[19]

Association between Toothbrushing and Diet

Only one study reported the link between toothbrushing and diet. This study measured diet based on daily vegetable and fruits intake. Insufficient intake was defined as consumption of <400 gram/day of vegetables and fruits. Prevalence of insufficient intake of vegetables and fruits was significantly higher in people who rarely or never brushed their teeth (p<0,05). On the other hand, this study also reported that people who brushed their teeth more often had higher prevalence of consuming red meats than their counterparts who brushed their teeth less frequently (p<0,05).[19]

Association between Toothbrushing and Smoking

Smoking was reported to be associated with low frequency

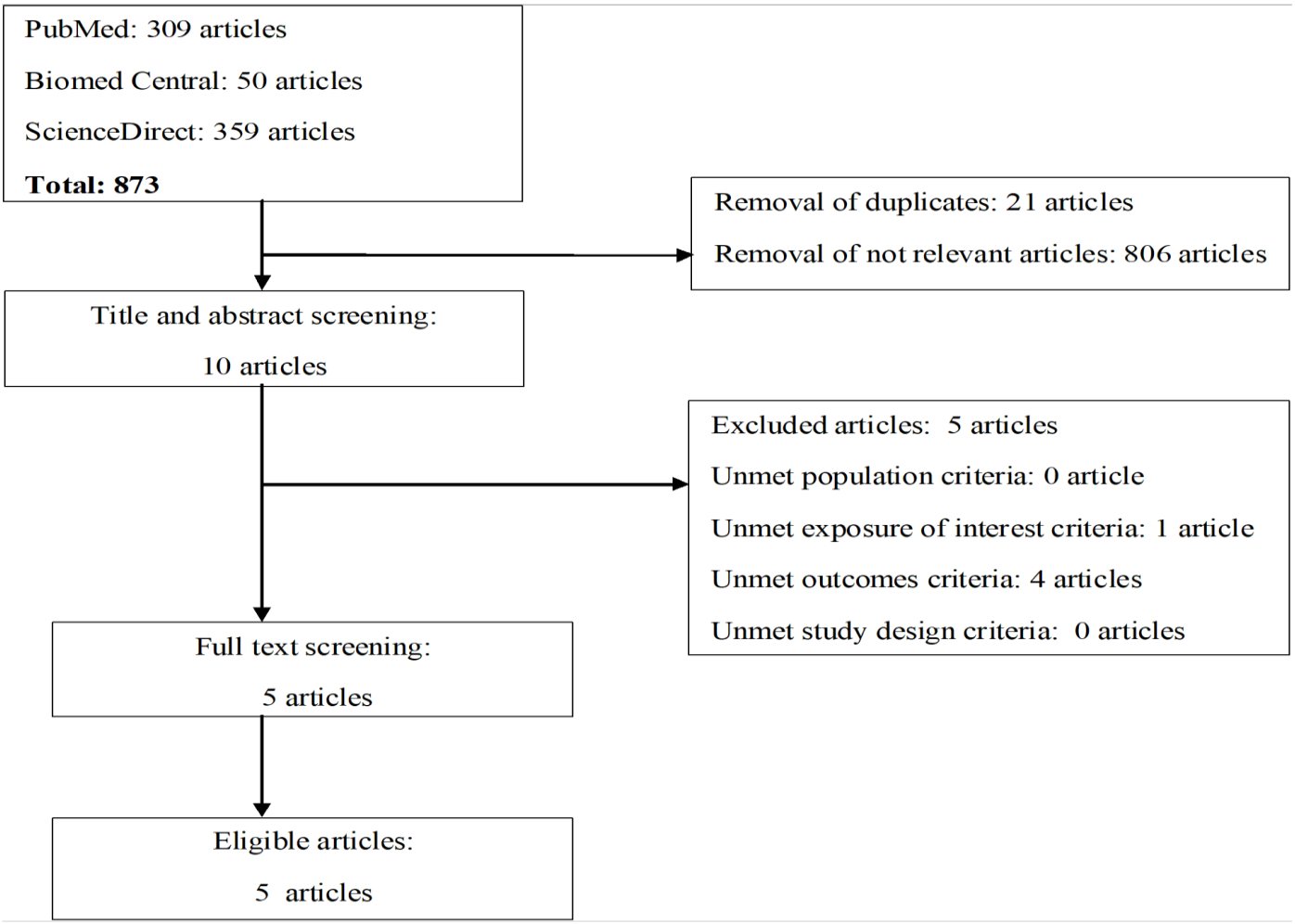

Fig. 1.
PRISMA Flow diagram of the selection process for systematic review based on the PRISMA guidelines

of toothbrushing. It was reported that toothbrushing frequency less than twice a day was significantly associated with high prevalence of smoking (p<0,001).[17] Another study also reported that higher prevalence of smoking was found in people who rarely or never brushed their teeth (p<0,05).[19] Significant difference of smoking history was found between toothbrushing group 'at least once a day' and 'less than once a day' (p<0,001), and 'after every meal' and 'at least once a day' (p<0,001).[18]

Association between Toothbrushing and Obesity

Obesity was indicated if the body mass index was ≥30. It was observed that participants who brushed their teeth less than twice a day had higher prevalence of obesity compared to those who brush their teeth more often (p<0,001).[17] Kelishadi et al. reported that both male and female students in Iran who rarely or never brushed their teeth had significantly higher prevalence of obesity compared to those who brushed their teeth once per day and more than once per day (p<0,001 in male students; p=0,02 in female students).[20]

Toothbrushing and Blood Pressure

Toothbrushing was found to be associated with blood pressure. A survey in Iranian students aged 10-18 years reported higher frequency of toothbrushing was associated with decreased frequency of elevated blood pressure in boys (p=0,03).[20]

Toothbrushing and Hypertension

Systolic blood pressure of ≥140mmHg and/or diastolic blood pressure of ≥90 mmHg indicated hypertension. A study reported that the prevalence of hypertension in participants who brushed their teeth less than once a day was higher (31,0%) compared to the prevalence of hypertension in participants who brushed their teeth after every meal (13,3%). Nevertheless, the difference was not significant (adjusted OR=0,89; p=0,579).[18] Meanwhile, Oliveira et al. reported that high prevalence of hypertension was found in participants who brushed their teeth less often than twice a day. The difference of hypertension prevalence among participant groups of toothbrushing frequency 'rarely/never', 'once a day, and 'twice a day' was significant (p<0,001).[17]

Association between Toothbrushing and Levels of Cholesterol

Kelishadi et al. found that both male and female participants with higher frequency of toothbrushing had lower mean levels of low-density lipoprotein cholesterol (p<0.0001).[20]

Association between Toothbrushing and Dyslipidaemia

A condition where low-density lipoprotein cholesterol level ≥140 mg/dL, high-density lipoprotein cholesterol level <40 mg/dL, or triglyceride level ≥150 mg/dL was called dyslipidaemia. The prevalence of dyslipidaemia in toothbrushing frequency group 'less than once a day' (60,3%) was significantly higher (p=0,023) compared to 'after every meal' group (29,0%).[18] Another study found that women with low toothbrushing frequency were more likely to have dyslipidaemia than women with high toothbrushing frequency (OR=1,18). Low toothbrushing frequency is an independent risk factor for dyslipidaemia in women.[21]

Association between Toothbrushing and Hyperuricaemia

The concentration of serum uric acid >7,0 mg/dL denoted hyperuricaemia. Prevalence of hyperuricaemia was higher in 'less than once a day' toothbrushing practice group (27,2%) compared to 'every after meal' group (8,6%), but the difference was not significant (adjusted OR=0,87; p=0,446).[18]

Association between Toothbrushing and Chronic Kidney Disease

Only one study reported association between toothbrushing and chronic kidney disease. Higher prevalence of chronic kidney disease was found in participants who brushed their teeth less than once a day (8,3%) compared to that of participants who brushed their teeth after every meal (3,8%), but the difference was also not significant (adjusted OR=1,35; p=0,642).[18]

Association between Toothbrushing and Diabetes Mellitus

Diabetes mellitus was assessed based on doctor's diagnosis in one study. Other study measured diabetes mellitus by examining concentration glycated hemoglobin (HbA1c). HbA1c concentration ≥6,5% indicated diabetes mellitus. High prevalence of diabetes mellitus was found in participants who brushed their teeth less often than twice a day (p<0,001).[17] The prevalence of diabetes mellitus in participants who brushed their teeth less than once a day (17,4%) was found significantly higher (p=0,002) compared to the prevalence of diabetes mellitus in participants who brushed their teeth after every meal (3,1%).[18] Another study found that men with low toothbrushing frequency were more likely to have diabetes mellitus than men with high toothbrushing frequency (OR=1,43). Low toothbrushing frequency is an independent risk factor for diabetes mellitus in men.[21]

IV. DISCUSSION

This systematic review identifies that toothbrushing is significantly associated with cardiovascular disease risk factors such as blood pressure, levels of cholesterol, dyslipidaemia, diabetes mellitus, and obesity; and behavioral risk factors such as physical activity, drinking, diet, and smoking.

Low frequency of toothbrushing renders bacterial film deposition on the tooth surface. This bacterial film is composed of matrix and colonies of bacteria. There are two types of bacterial film, supragingival and subgingival bacterial film. Supragingival bacterial film is situated above the gum line,

while subgingival bacterial film is below gum line. The supragingival and subgingival bacterial film are further differed based on their amount of matrix, bacteria species, and metabolism. The supragingival bacterial film contains more matrix than the supragingival bacterial film. The supragingival bacterial film contains mostly Gram-positive, aerobic, and non-motile bacteria. The subgingival bacterial film is adhered mostly by Gram-negative, anaerobic, and motile bacteria. Supragingival bacteria primarily metabolize carbohydrate, while subgingival bacteria predominantly metabolize protein.[22] The supragingival and subgingival bacterial films are associated with dental caries. The dental caries is an infectious disease resulting from the demineralization of the tooth structure. The demineralization is developed due to the acid produced by the metabolism of the bacteria.[23] The subgingival bacterial film is also associated with periodontal disease. The subgingival bacteria induce host response in generating defensive mechanism via inflammation. This condition progresses to the defect of the tissues surrounding teeth, such as gums, periodontal ligament, and cementum. The chronic inflammation will result in bone loss.[24, 25]

The inflammation that occurs in dental caries and periodontal disease is connected to cardiovascular disease risk factors.[14] The inflammation enhances blood vessel permeability. It also change endothelial cells' cytoskeletal element that will interfere the endothelial functions leading to elevated blood pressure.[26] In this review, one study found decreased frequency of elevated blood pressure in boys with higher frequency of toothbrushing.[20] However, studies included in this review were contradictive in reporting the association between toothbrushing and hypertension. Some studies have reported that there is a connection between periodontal disease and hypertension. Nevertheless, long-term interventional studies are needed to confirm the link between them.[26]

The release of inflammatory mediators is reported to elevate the level of blood lipids.[14] This condition is called hyperlipidaemia, a form of dyslipidaemia. In this review, we see that people who brushed their teeth less often had higher level of LDL-C and higher prevalence or incidence of dyslipidaemia compared to people who brushed their teeth more frequently.[18, 20] VanWormer et al. reported that there was significant association between toothbrushing and lipids.[27] Low toothbrushing frequency is found to be an independent risk factor for dyslipidaemia in women.[21]

The subgingival Gram-negative bacteria, *Porphyromonas gingivalis*, are linked to dyslipidaemia and diabetes mellitus.[28] A study suggested that dyslipidaemia could harm immune response to *Porphyromonas gingivalis*.[29] These bacteria are abundant in people with high HbA1c concentration, especially in people with uncontrolled diabetes mellitus.[30] Low toothbrushing frequency leads the bacteria to proliferate. Individuals with low toothbrushing frequency had high prevalence of diabetes mellitus.[17, 18] It was reported in a study in this review that low toothbrushing frequency is an independent risk factor for diabetes mellitus in men.[21]

Behavioral risk factors are also linked with toothbrushing. Association between toothbrushing and physical activity was reported in the studies included in this review. Less physical activity was found in people with low frequency of toothbrushing.[17, 18] This finding was reported in two studies, while another study did not find significant relationship between toothbrushing and physical activity.[19] Even so, there is a systematic review and meta-analysis that emphasized the relationship between periodontal disease and physical activity. Low prevalence of periodontal disease was related to frequent physical activity.[31]

Toothbrushing association with drinking was reported by two studies in this review. These studies showed that people with less frequent toothbrushing drank more alcohol than the ones with more frequent toothbrushing.[18, 19] It was reported in a study that drinking alcohol can increase the severity of periodontal disease.[32, 33]

Low frequency of toothbrushing was reported to be associated with diet. People with low toothbrushing frequency tended to consume insufficient vegetables and fruits. Meanwhile, their counterparts with higher toothbrushing frequency had higher red meat consumption compared to them.[19] Higher consumption of red meat was informed to increase risk of diabetes mellitus and cardiovascular disease.[34, 35] However, recent research stated that red meat should be included in a healthful dietary pattern because of its protein and nutrient content.[36, 37] There is a possibility that people with high toothbrushing frequency opted for high red meat diet because they already had high intake of vegetable and fruits regularly.

Low frequency of toothbrushing was also reported to be significantly associated with smoking in three studies in this review.[17-19] There is a study reporting the efficiency of toothbrushing between smokers and non-smokers.[38] It was found that smokers had shorter time of toothbrushing and poorer oral hygiene compared to non-smokers. In contrast to the aforementioned studies, this study stated that there was no association found between toothbrushing frequency and smoking. Nevertheless, this study used smaller samples compared to the three studies included in this review. Therefore, the result may not be representative for large population.

The association between toothbrushing and obesity was reported in two studies.[17, 20] Higher prevalence of obesity was found in people who rarely or never brushed their teeth. It was reported by Hayden et al. that dental caries was associated with obesity.[16] Consumption of foods with high carbohydrate and sugar gives a significant contribution for both dental caries and obesity. The development of dental caries can result from

the duration of consuming those foods in adjunct to low frequency of toothbrushing.[15]

While we believe that this review informs consistency of the association between toothbrushing and cardiovascular disease risk factors found among studies, there are several limitations of this review. First, we only took studies published in English into consideration. We might overlook important studies published in other language. Second, we performed search for free full-text articles. In this case, we might miss valuable articles that were non-open access. Third, studies included in this review are mostly cross-sectional and some studies are single-centered although the sample size was large. Fourth, we did not analyze the study findings statistically. This might reduce the strength of this review in stressing the association between toothbrushing and cardiovascular disease risk factors.

V. CONCLUSIONS

There was significant association between toothbrushing and cardiovascular disease risk factors such as blood pressure, levels of cholesterol, dyslipidaemia, diabetes mellitus, and obesity; and behavioral risk factors such as physical activity, drinking, diet, and smoking. Low frequency of toothbrushing was found to be independent risk factor for diabetes mellitus in men and dyslipidaemia in women. These synthesized findings highlight the importance of maintaining oral hygiene to prevent cardiovascular disease risk factors. Therefore, toothbrushing should be included in the prevention of the development of cardiovascular disease risk factors.

REFERENCES

[1] L. Beale, *Human Disease and Health Promotion*. New Jersey: John Wiley & Sons, Inc., 2017.
[2] H. Thomas *et al.*, "Global Burden of CVD Global Atlas of Cardiovascular Disease 2000-2016: The Path to Prevention and Control.," *Global Heart*, vol. 13, no. 3, pp. 143-163, 2018.
[3] WHO. "Cardiovascular Diseases." https://www.who.int/health-topics/cardiovascular-diseases/ (accessed October, 2019).
[4] D. Lloyd-Jones *et al.*, "Heart disease and stroke statistics--2010 update: a report from the American Heart Association," *Circulation*, vol. 121, pp. 948-954, 2010.
[5] M. Nichols *et al.*, "European Cardiovascular Disease Statistics 2012," *European Heart Network*, 2012.
[6] American Heart Association. "Heart Disease and Stroke Statistics 2019 at a Glance." https://healthmetrics.heart.org/wp-content/uploads/2019/02/At-A-Glance-Heart-Disease-and-Stroke-Statistics-–-2019.pdf (accessed October, 2019).
[7] A. E. Moran, G. A. Roth, and J. Narula, "Global Atlas of Cardiovascular Diseases, 2000-2016," *Global Heart*, vol. 13, no. 3, pp. 207-211, 2018.
[8] K. M. Brown, D. Q. Thomas, and J. E. Kotecki, *Physical Activity and Health: An Interactive Approach*. Sudbury, Massachusetts: Jones and Bartlett Publishers., 2002.
[9] M. Kuwabara, "Hyperuricemia, Cardiovascular Disease, and Hypertension," *Pulse (Basel)*, vol. 3, no. 3-4, pp. 242-252, 2016.
[10] J. Wu *et al.*, "Asymptomatic hyperuricemia and coronary artery disease in elderly patients without comorbidities," *Oncotarget*, vol. 8, no. 46, 2017.
[11] M. Miller, "Dyslipidemia and cardiovascular risk: the importance of early prevention," *QJM*, vol. 102, no. 9, pp. 657-667, 2009.
[12] R. T. Gansevoort, R. Correa-Rotter, B. R. Hemmelgarn, T. H. Jafar, H. J. L. Heerspink, and J. F. Mann, "Chronic kidney disease and cardiovascular risk: epidemiology, mechanisms, and prevention," *Global Kidney Disease*, vol. 382, no. 9889, pp. 339-352, 2013.
[13] B. B. Dokken, "The Pathophysiology of Cardiovascular Disease and Diabetes: Beyond Blood Pressure and Lipids," *Diabetes Spectrum*, vol. 21, no. 3, pp. 160-165, 2008.
[14] R. W. Vieira, "Cardiovascular and periodontal diseases," *Rev Bras Cir Cardiovasc*, vol. 29, no. 1, pp. 7-9, 2014.
[15] K. Alswat, W. S. Mohamed, M. A. Wahab, and A. A. Aboelil, "The Association Between Body Mass Index and Dental Caries: Cross-Sectional Study," *J Clin Med Res*, vol. 8, no. 2, pp. 147-152, 2016.
[16] C. Hayden *et al.*, "Obesity and dental caries in children: a systematic review and meta-analysis," *Community Dent Oral Epidemiol*, vol. 41, no. 4, pp. 289-308, 2013.
[17] C. d. Oliveira, R. Watt, and M. Hamer, "Toothbrushing, inflammation, and risk of cardiovascular disease: results from Scottish Health Survey," *BMJ*, vol. 340, no. c2451, 2010.
[18] M. Kuwabara *et al.*, "Association between toothbrushing and risk factors for cardiovascular disease: a large-scale, cross-sectional Japanese study," *BMJ Open*, vol. 5, pp. 1-6, 2015.
[19] W. Liu, L. Su, X. Xie, X. Xiang, J. Huang, and P. Ji, "Association Between Toothbrushing and Behavioral Risk Factors of Non-communicable Diseases: A population Based Survey of 4500 adults in China," *Scientific Reports*, vol. 9, p. 8498, 2019.
[20] R. Kelishadi *et al.*, "Tooth brushing and cardiometabolic risk factors in adolescents: Is there an association? The CASPIAN-III study," *Int J Prev Med*, vol. 4, no. 3, pp. 271-278, 2013.
[21] M. Kuwabara *et al.*, "Low frequency of toothbrushing practices is an independent risk factor for diabetes mellitus in male and dyslipidemia in female: A large-scale, 5-year cohort study in Japan," vol. 70 pp. 107–112, 2017.
[22] S. Reddy, *Essentials of Clinical Periodontology & Periodontics*, 5th ed. New Delhi: Jaypee Brothers Medical Publishers, 2018.
[23] H. O. Heymann, J. Edward J Swift, and A. V. Ritter, *Sturdevant's Art & Science of Operative Dentistry*. Missouri: Mosby Elsevier, 2014.
[24] J. Manakil, *Periodontal Diseases: A Clinician's Guide*. Intech, 2012.
[25] M. G. Newman, H. H. Takei, P. R. Klokkevold, and F. A. Carranza, *Carranza's clinical periodontology*. Missouri: Saunders Elsevier, 2014.
[26] X.-F. Leong, C. Y. Ng, B. Badiah, and S. Das, "Association between Hypertension and Periodontitis: Possible Mechanisms," *Scientific World Journal*, vol. 2014, 2014.
[27] J. J. VanWormer, A. Acharya, R. T. Greenlee, and F. J. Nieto, "Oral Hygiene and Cardiometabolic Disease Risk in the Survey of the Health of Wisconsin," *Community Dent Oral Epidemiol*, vol. 41, no. 4, pp. 374–384, 2013.
[28] N. Makiura *et al.*, "Relationship of Porphyromonas gingivalis with glycemic level in patients with type 2 diabetes following periodontal treatment," *Oral Microbiol Immunol*, vol. 23, no. 4, pp. 348-351, 2008.
[29] L. Lei, H. Li, F. Yan, and Y. Xiao, "Hyperlipidemia impaired innate immune response to periodontal pathogen porphyromonas gingivalis in apolipoprotein E knockout mice," *PLoS One*, vol. 8, no. 8, 2013.
[30] N. Aoyama *et al.*, "Increased Oral Porphyromonas gingivalis Prevalence in Cardiovascular Patients with Uncontrolled Diabetes Mellitus," *Int Heart J*, vol. 59, pp. 802-807, 2018.
[31] R. O. Ferreira *et al.*, "Physical Activity Reduces the Prevalence of Periodontal Disease: Systematic Review and Meta-Analysis," *Front Physiol*, vol. 10, 2019.
[32] M. Tezal, S. G. Grossi, A. W. Ho, and R. J. Genco, "The effect of alcohol consumption on periodontal disease," *J Periodontol*, vol. 72, no. 2, pp. 183-189, 2001.
[33] K. Suwama, A. Yoshihara, R. Watanabe, R. Stegaroiu, S. Shibata, and H. Miyazaki, "Relationship between alcohol consumption and periodontal tissue condition in community-dwelling elderly Japanese," *Gerodontology*, vol. 35, no. 3, pp. 170-176, 2018.
[34] R. Micha, S. K. Wallace, and D. Mozaffarian, "Red and processed meat consumption and risk of incident coronary heart disease, stroke, and diabetes mellitus: a systematic review and meta-analysis," *Circulation*, vol. 121, pp. 2271-2283, 2010.

[35] A. Pan *et al.*, "Red meat consumption and risk of type 2 diabetes: 3 cohorts of US adults and an updated meta-analysis," *Am J Clin Nutr*, vol. 94, pp. 1088-1096, 2011.
[36] S. H. McNeill, "Inclusion of red meat in healthful dietary patterns," *Meat Science*, vol. 98, no. 3, pp. 452-460, 2014.
[37] M. A. Binnie, K. Barlow, V. Johnson, and C. Harrison, "Red meats: Time for a paradigm shift in dietary advice," *Meat Science*, vol. 98, no. 3, pp. 445-451, 2014.
[38] I. D. M. MacGregor, "Toothbrushing efficiency in smokers and non-smokers," *j Clin Periodontol*, vol. 11, no. 5, pp. 313-320, 1984.