Association between Toothbrushing and Cancer Risk

Akifumi Enomoto[1],*, Yuto Takada[1], Takeshi Shimoide[1], Atsushi-Doksa Lee[1], Yuko Kinoshita[1], Miku Kawaguchi[1], Yasuhiro Kakiuchi[2], Takahiro Tabuchi[3]

[1]Department of Oral and Maxillofacial Surgery, Kindai University Faculty of Medicine, Osaka, Japan,
[2]Department of Forensic Medicine, Kindai University Faculty of Medicine, Osaka, Japan,
[3]Department of Cancer Epidemiology, Cancer Control Center, Osaka International Cancer Institute, Osaka, Japan

*Corresponding author:
ID Akifumi Enomoto
Department of Oral and
Maxillofacial Surgery, Kindai
University Faculty of Medicine,
377-2 Ohno-Higashi, Osaka-
Sayama, Osaka 589-8511, Japan
Tel: +81-72-366-0221
E-mail:
enomotoa@med.kindai.ac.jp

Background: Most cancers are lifestyle-related and are thus preventable. Lifestyle habits can be improved by individual efforts; for example, because oral health is suggested to play a preventive role in cancer risk, toothbrushing is considered a critical and fundamental measure for controlling oral health. This study aimed to investigate the association between toothbrushing and cancer risk.

Methods: Cross-sectional data from the Japan COVID-19 and Society Internet Survey, a large-scale (n = 32,000) online survey conducted in 2022, were used. From September 12 to October 19, 2022, questionnaires were distributed to candidates selected by simple random sampling from a Japanese Internet research company's panelists to represent the Japanese population. The association between toothbrushing and cancer risk according to cancer prevalence was then analyzed.

Results: Among all 32,000 participants, 2,495 (7.8%) who had any cancer previously were analyzed. Multivariable logistic regression analysis revealed a significant association between toothbrushing habit and cancer risk.

Conclusion: The findings of this study suggest that daily toothbrushing is essential for maintaining oral health and preventing cancer.

Keywords: Life style, Neoplasms, Oral health, Risk factors, Toothbrushing

INTRODUCTION

Many cancers are lifestyle-related and are caused by lifestyle habits such as smoking, alcohol consumption, poor diet/nutrition, lack of exercise, and obesity, and variable environmental factors such as occupational exposure, air pollution, and ultraviolet light or other radiation exposure. The environmental factors depend on the country, region and time period, and are difficult for individuals to control. However, lifestyle habits can be improved by individual efforts. In Japan, the National Cancer Center Research Institute conducted research using Japanese subjects, listed five lifestyle habits (no smoking, consuming alcohol in moderation, eating a healthy diet, being physically activity, and maintaining a healthy body weight) as important factors for cancer prevention, and established an evidence-based cancer prevention program [1].

Several studies have previously shown that smoking is associated with many cancers, including lung cancer [2,3]. People who smoke have a 1.5-fold higher risk of developing certain types of cancer compared to non-smokers in Japan [1,4]. Regarding alcohol consumption, a study of Japanese men found that those who consumed ≥ 46 g and ≥ 69 g of alcohol per day had a respective 40% and 60% higher risk of developing cancer than those who consumed < 23 g of alcohol per day [5]. Diet, physical activity, and body weight control are suggested as important factors based on epidemiological evidence [6-9]. In Japan, the population-attributable fraction of cancer due to preventable factors is estimated to be about 55% for male and about 30% for female. Among these, smoking and alcohol consumption account for a large proportion of the preventable lifestyle habits.

The five lifestyle habits–smoking, excess alcohol consumption, poor diet/nutrition, lack of exercise, and obesity–are strongly associated with poor outcomes such as worsened systemic diseases (diabetes mellitus [DM], hyperlipidemia, hypertension, cardio-cerebrovascular disease). Indeed, certain diseases, such as DM and hypertension, are considered risk factors for cancer. However, oral health has also been reported to have a significant impact on general health outcomes. Maintaining oral health is very important for overall health and preventing the exacerbation of metabolic syndrome and systemic diseases [10]. According to a 2016 survey by the Japanese Ministry of Health, Labour and Welfare, the habit of toothbrushing is a critical and fundamental measure for oral disease prevention and oral health maintenance. Thus, good toothbrushing habit may affect cancer incidence.

The Japan COVID-19 and Society Internet Survey (JACSIS) was a large-scale online survey conducted in 2022 (n = 32,000) that evaluated the actual conditions of residents' health, daily activities, and social and economic situations, including COVID-19. The purpose of JACSIS was to provide information to aid in the planning and implementation of realistic measures for socioeconomic relief and the promotion of health in terms of "protecting and promoting health and social activities."

In the present study, the effect of toothbrushing habit on cancer risk was examined using JACSIS data.

MATERIALS AND METHODS

1. Study participants and setting

JACSIS surveyed a sample that matched the population distribution of Japan. The items evaluated were related to consultations and medical conditions for the treatment of various diseases. The data were used to clarify the general health status of the Japanese population. Cross-sectional analysis was conducted using JACSIS data obtained from September 12 to October 19, 2022. Questionnaires had been distributed to 41,626 candidates selected from among panelists of a Japanese Internet research company (Rakuten Insight Inc.) to represent the Japanese population in regard to age, sex, and prefecture of residence by simple random sampling. All participants provided web-based informed consent at registration. After excluding subjects who provided invalid responses, data from 32,000 respondents (age range, 17-82 years; sex, 49.1% male) were included for analysis.

2. Statistical analysis

The main outcome measure and index used in the present study was experience of cancer. If an individual chose the answer "I have experienced having cancer in my life" then that individual was assigned to the cancer experience group which was the primary outcome variable. Next, eleven explanatory variables were used: age, sex, smoking status, alcohol, body mass index (BMI), DM, living alone, homeowner, education level, income, and subsequent behavior. The survey asked the following questions regarding underlying behaviors.

For "How often do you brush your teeth?" the answer options were "I brush my teeth almost every day (6-7 times a week)," "I brush my teeth 1-5 times a week," and "I brush my teeth several times a month or never." The following potential confounding variables were assessed in the questionnaire as health and socioeconomic factors [10,11]: age, sex, smoking status, alcohol, DM, living alone, homeowner, education level, and income.

Among the 32,000 participants, 2,495 who had experienced cancer were extracted and identified. The outcome

index used in this study was the respondents' experience of cancer. Experience of cancer was used as the primary outcome variable for assigning the participants to the cancer-experienced group. Next, the explanatory variables were analyzed. Model 1 was an initial crude univariate model that examined the presence or absence of experience of cancer. Model 2 added other explanatory variables. The Mann-Whitney U test, Student's t-test, chi-square test, and Cochran-Armitage test were used to compare continuous and categorical variables between the cancer experience and no cancer experience groups. Data were analyzed using a combination of Microsoft Excel 2021 (Microsoft), Sigma-Plot (Systat Software Inc.), and EZR (Saitama Medical Center & Jichi Medical University) software packages. Results are reported as means±standard deviation unless otherwise indicated.

3. Ethics approval

The present study was approved by the Bioethics Review Committee of the authors' institution (approval No: 20084). All procedures were performed in accordance with the Ethical Guidelines for Medical and Health Research Involving Human Subjects of the Japanese Ministry of Health, Labour and Welfare, and the 1964 Helsinki Declaration and its later amendments.

RESULTS

In total, 2,495 (7.8%) of the 32,000 participants were identified as having experience of cancer. The participants' background characteristics are shown in Table 1. Table 1 also shows that among the entire cohort, 29,612 (92.4%) participants responded that they brushed their teeth almost every day, 1,459 (4.6%) brushed 1-5 times a week, and 929 (2.9%) brushed several times a month or never. As for the factors related to cancer risk, the individual factors were initially assessed by univariate analysis. Among those with experience of cancer, 1,943, 300, and 252 responded that they brushed their teeth almost every day, 1-5 times a week, and several times a month or never, respectively. By contrast, among those with no experience of cancer, 27,669, 1,159, and 677 responded that they brushed their teeth almost every day, 1-5 times a week, and several times a month or never, respectively. Univariate analysis with Model 1 showed a significant difference (p < 0.0001), suggesting that the habit of daily toothbrushing significantly affected the experience of cancer (Table 2).

The identified variables were then entered into the multivariate logistic regression using Model 2 (Table 3). Frequency of toothbrushing was a significant factor regarding the

Table 1. Summary of the characteristics of all participants (n = 32,000)

Characteristic	Value
Cancer experience	
Experience (+)	2,495 (7.8)
Experience (−)	29,505 (92.2)
Frequency of toothbrushing	
Almost every day	29,612 (92.5)
1-5 times a week	1,459 (4.6)
Several times a month/never	929 (2.9)
Age (yr)	47.6 ± 17.1
17-19	253 (0.8)
20-29	5,265 (16.5)
30-39	7,188 (22.5)
40-49	5,348 (16.7)
50-59	4,670 (14.6)
60-69	4,646 (14.5)
70-79	4,244 (13.3)
≥ 80	386 (1.2)
Sex	
Male	15,724 (49.1)
Female	16,276 (50.9)
Smoking	
Never	18,630 (58.2)
Current/former	13,370 (41.8)
Alcohol	
Habit (−)	12,964 (40.5)
Habit (current/former) (+)	19,036 (59.5)
Body mass index (kg/m^2)	22.1 ± 3.7
< 20.0	9,502 (29.7)
20.0-25.0	16,815 (52.5)
25.1-30.0	4,610 (14.4)
> 30.0	1,015 (3.2)
Diabetes mellitus	
No	29,115 (91.0)
Yes	2,885 (9.0)
Living alone	
Yes	6,565 (20.5)
No (more than two)	25,435 (79.5)
Homeowner	
Yes	21,343 (66.7)
No	10,657 (33.3)
Education level	
Below high school	569 (1.8)
High school	8,143 (25.4)
Technical college	6,904 (21.6)
University or above	16,110 (50.3)
Missing	274 (0.9)
Income (million JPY)	
< 2	2,658 (8.3)
2-4	6,183 (19.3)
4-6	6,225 (19.5)
6-8	4,374 (13.7)
8-10	2,931 (9.2)
> 10	3,257 (10.2)
Missing	6,372 (19.9)

Values are presented as number (%) or mean±standard deviation.

Table 2. Evaluation of variables related to cancer experience and toothbrushing frequency

Characteristic	Cancer experience (+) (n = 2,495)	Cancer experience (–) (n = 29,505)	p-value
Frequency of toothbrushing			< 0.0001[a]
Almost every day	1,943 (6.6)	27,669 (93.4)	
1-5 times a week	300 (20.6)	1,159 (79.4)	
Several times a month/never	252 (27.1)	677 (72.9)	
Age (yr)	61 (17-81)	45 (16-82)	< 0.0001[a]
Sex			< 0.0001[a]
Male	1,347 (8.6)	14,377 (91.4)	
Female	1,148 (7.1)	15,128 (92.9)	
Smoking			< 0.0001[a]
Never	1,090 (5.9)	17,540 (94.1)	
Current/former	1,405 (10.5)	11,965 (89.5)	
Alcohol			< 0.0001[a]
Habit (–)	865 (6.7)	12,099 (93.3)	
Habit (+)	1,630 (8.6)	17,406 (91.4)	
Body mass index (kg/m^2)	22.3 ± 4.0	22.1 ± 3.7	0.0018[b]
Diabetes mellitus			< 0.0001[a]
No	1,686 (5.8)	27,429 (94.2)	
Yes	809 (28.0)	2,076 (72.0)	
Living alone			0.09
Yes	545 (8.3)	6,020 (91.7)	
No (more than two)	1,950 (7.7)	23,485 (92.3)	
Education level			0.2473
Below high school	55 (9.7)	514 (90.3)	
High school	674 (8.3)	7,469 (91.7)	
Technical college	525 (7.6)	6,379 (92.4)	
University or above	1,194 (7.4)	14,916 (92.6)	
Missing	47 (17.2)	227 (82.8)	
Income (million JPY)			0.5179
< 2	258 (9.7)	2,400 (90.3)	
2-4	628 (10.2)	5,555 (89.8)	
4-6	494 (7.9)	5,731 (92.1)	
6-8	283 (6.5)	4,091 (93.5)	
8-10	171 (5.8)	2,760 (94.2)	
> 10	195 (6.0)	3,062 (94.0)	
Missing	466 (7.3)	5,906 (92.7)	

Values are presented as number (%), mean (range), or mean±standard deviation.
[a]p < 0.001, [b]p < 0.01.

experience of cancer. Compared with those who brushed their teeth almost every day, those who brushed 1-5 times a week and those who brushed several times a month or never showed odds ratios about 4- and 7-fold higher for cancer risk, respectively. Additionally, statistical analysis results showed that health-related factors such as age, sex, smoking status, alcohol, BMI, and DM were significantly related to the experience of cancer, while socioeconomic factors such as living alone, homeowner, education level, and income were not significantly related.

DISCUSSION

This epidemiological study was conducted to identify the relationship of frequency of toothbrushing and cancer risk in Japan. The results indicate that daily toothbrushing is important for preventing cancer, thereby highlighting the importance of oral health in relation to cancer risk. The outcome index used in the present study was the experience of any cancer. The participants with experience of cancer were assigned to the relevant cancer-experienced group, and this assignment was used as the primary outcome variable. Explanatory variables were added and analyzed along with health-related and socioeconomic factors.

Recent interest in the association of periodontal disease and cancer risk has led to the publication of several studies which provide evidence for this positive association in pancreatic, lung, and head and neck cancers [12]. The assessment of periodontal disease is relatively hard to quantify clinically, and the literature in this research area is still insufficient. Toothbrushing habit is a self-reported item that

Table 3. Multivariable logistic regression analysis of factors related to cancer experience

Characteristic	Odds ratio	95% confidence interval	p-value
Frequency of toothbrushing			
Almost every day			
1-5 times a week	3.90	3.34-4.55	< 0.0001[a]
Several times a month/never	6.10	5.11-7.29	< 0.0001[a]
Age (yr)	1.03	1.03-1.04	< 0.0001[a]
Sex			
Male			
Female	1.34	1.20-1.48	< 0.0001[a]
Smoking			
Never			
Current/former	1.36	1.23-1.50	< 0.0001[a]
Alcohol			
Habit (–)			
Habit (+)	1.18	1.08-1.30	0.0004[a]
Body mass index (kg/m^2)	0.97	0.96-0.98	< 0.0001[a]
Diabetes mellitus			
No			
Yes	4.16	3.75-4.62	< 0.0001[a]
Living alone			
Yes			
No (more than two)	0.92	0.82-1.04	0.193
Homeowner			
Yes			
No	0.90	0.80-1.01	0.072
Education level			
Below high school			
High school	0.94	0.69-1.28	0.677
Technical college	1.08	0.79-1.48	0.641
University or above	1.11	0.82-1.52	0.498
Missing	-	-	-
Income (million JPY)			
< 2			
2-4	1.14	0.96-1.34	0.133
4-6	1.11	0.93-1.33	0.241
6-8	1.02	0.84-1.24	0.861
8-10	0.95	0.76-1.19	0.642
> 10	0.89	0.71-1.10	0.287
Missing	-	-	-

[a]$p < 0.001$.

makes consistent evaluation easy. Although certain lifestyle habits are considered to be important for cancer prevention, there has been no discussion of toothbrushing as one of these lifestyle habits, even though it is the most fundamental measure of oral health. Therefore, in the present study, we included toothbrushing habit as a lifestyle habit.

The habit of toothbrushing is a fundamental measure for periodontal disease prevention and oral health maintenance. The mechanism by which periodontal disease causes cancer is not fully understood. However, periodontal disease is the precursor of an infectious disease process that, if left untreated, causes chronic, mild inflammation. Several studies have reported that these infections can promote inflammation, and persistent mild inflammation can lead to the development of cancer [13,14]. Inflammation has been identified as a key factor in enabling the biological capacity necessary for the development of malignancy [15]. Inflammatory processes generate free radicals and reactive intermediates that can cause intracellular DNA mutations or interfere with DNA repair mechanisms [16]. Additionally, the inflammatory cells themselves may further contribute to damage by producing these free radicals, as well as cytokines, chemokines, and metabolites of arachidonic acid. These products, in turn, show a strong affinity for more inflammatory cells, perpetuating a vicious cycle. Severe periodontal disease, which is caused by neglecting proper toothbrushing habit, can lead to poor oral health and, as a result, is often accompanied by tooth loss. Tooth loss may

reduce masticatory performance and lead to the avoidance of chewing tough foods like fruits and fibrous vegetables [17,18]. Since these foods are often more nutritious and rich in cancer-fighting agents such as antioxidants, diet/nutrition issues arise, and affect cancer risk as a result. Studies have shown that several fruits and vegetables are associated with a decreased risk of certain cancers [19,20].

In the present study, smoking, alcohol, BMI, and DM were health and lifestyle factors related to cancer risk, similar to those reported in previous studies [1,2,5,21,22]. Regarding cancer prevention through changes in lifestyle habits, people in Japan who perform all five lifestyle habits (not smoking, consuming alcohol in moderation, eating a healthy diet, being physically activity, and maintaining a healthy body weight) had about a 40% lower risk of developing cancer compared with those who performed none or only one of these lifestyle habits [23]. It has been suggested that the population-attributable fraction of cancer due to smoking and alcohol consumption as preventable lifestyle habits is considerable [23]. Daily toothbrushing, which effectively prevents oral diseases, such as dental caries and periodontal disease, greatly contributes to oral health management. Promoting toothbrushing and oral health maintenance among the public is expected to critically contribute to the reduction of cancer in Japan in the future, although the population-attributable fraction of cancer due to preventable factors has not been estimated and remains unknown. Previous studies have demonstrated an association between toothbrushing frequency and gastric and upper aerodigestive tract cancer risk in Japan, and it has been reported that people who brush their teeth multiple times a day are less likely to get cancer [24,25]. Although we did not use daily toothbrushing frequency as data in the present study, we obtained similar results that support these conclusions. Indeed, the odds ratio for toothbrushing in the present study was higher than that for smoking and alcohol. Thus, in addition to practicing the five healthy habits proposed, we believe that cancer risk can be further reduced by establishing a daily toothbrushing habit. Good oral hygiene is related to eating a healthy diet, use of vitamin supplements, and regular physical activity. Thus, individuals with good dental behavior tend to have a healthy lifestyle. This suggests that people with better oral hygiene habits could have a lower incidence of cancer [25,26]. As mentioned, the population-attributable fraction of cancer due to maintaining oral health through tooth brushing remains unclear. Therefore, it is necessary to accumulate epidemiological research data on Japanese people at regular intervals of approximately 5-10 years, and include environmental exposure factors that change over time in these longitudinal studies. Furthermore, it is necessary to clarify the population-attributable fraction of cancer due to toothbrushing

as a cancer-preventing lifestyle habit along with the other interrelated risk factors. This understanding is essential for implementing evidence-based cancer prevention strategies at the national level.

The present study has some limitations. First, owing to the cross-sectional study design, the temporality between variables is not guaranteed. It is difficult to elucidate the causal relationship between toothbrushing habit and cancer occurrence. Second, although the participants were recruited to represent the Japanese population in terms of age, sex, and prefecture of residence, the respondents to web-based surveys who provide self-reported information might not accurately represent the Japanese population. The present survey was developed to cover broad, general topics rather than focus on dental health-related issues, which led to some difficulties. In addition, cancer deaths were not included in this survey. Therefore, the data might be underestimated.

Toothbrushing is a simple and easy habit that can be practiced from childhood without any risk or heavy burden. The present study's findings suggest that the habit of daily toothbrushing may prevent cancer. The key concept underlying the integrated common risk approach is that, compared with disease-specific approaches, the promotion of general health by controlling a small number of risk factors might have a major impact on the disease severity at a lower cost and at a greater level of efficacy [27]. Daily toothbrushing was found to be effective for preventing cancer. In addition, the results suggested that the habit of daily toothbrushing is very important to maintain oral health and lower cancer risk. These findings could provide meaningful insights regarding future collaboration between medical and dental professionals in Japan.

NOTES

- **ORCID**
  Akifumi Enomoto, https://orcid.org/0000-0001-5804-8283
  Yuto Takada, https://orcid.org/0009-0009-2293-350X
  Takeshi Shimoide, https://orcid.org/0000-0001-6250-0412
  Atsushi-Doksa Lee, https://orcid.org/0000-0002-4347-8106
  Yuko Kinoshita, https://orcid.org/0009-0004-0206-7871
  Miku Kawaguchi, https://orcid.org/0009-0001-6865-0574
  Yasuhiro Kakiuchi, https://orcid.org/0000-0002-3078-2897
  Takahiro Tabuchi, https://orcid.org/0000-0002-1050-3125

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