Association between smoking habits and dental care utilization and cost using administrative claims database and specific medical check-up data

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Abstract
Background: This study aims to evaluate the association between smoking habits and dental care utilization and cost in individuals registered with the Japan Health Insurance Association, Osaka branch.

Methods: We used the administrative claims database and specific medical check-up data and included 226,359 participants, who visited dental institutions, underwent dental examinations, and underwent specific medical checkups, with smoking data from April 2016 to March 2017. We calculated propensity scores with age, gender, exercise, eating habits, alcohol intake, and sleep. We also compared dental care utilization with the total cost of each procedure.

Results: According to propensity score matching, 62,692 participants were selected for each group. Compared to non-smokers, smokers were younger, and a higher proportion were men. Smokers tended to skip breakfast, have dinner just before bed, and drink alcohol. After adjusting for potential confounding factors with propensity score matching, the mean annual dental cost among smokers was significantly higher than non-smokers. The prevalence of pulpitis, missing teeth, and apical periodontitis were higher among smokers than non-smokers, while inlay detachment, caries, and dentine hypersensitivity were higher among non-smokers.

Conclusion: This study suggests that smokers have higher dental cost consisted of progressive dental caries, missing teeth, and uncontrolled acute inflammation that necessitated the use of medications. It is suggested that smokers tend to visit the dentist after their symptoms become severe.

Keywords: Smoking habits, Dental care utilization, Dental cost, Administrative claims database

Introduction
According to the National Health and Nutrition Survey in 2017, the overall prevalence of smoking in Japan is 17.8% (29.0% among men and 8.1% among women) [1]. Tobacco smoking is still one of the leading causes of mortality and morbidity worldwide [2]. Smoking is not only the cause of lung cancer but also a risk factor for various dental diseases such as periodontal disease, oral cancer, caries, and tooth loss, as indicated by several epidemiologic studies [3–6].

Drilea et al. reported that smokers were less likely to visit dental clinics than non-smokers, when the data were adjusted for age, sex, race/ethnicity, poverty level, dental insurance, and dentate status [7]. As a result, they are more susceptible to oral problems such as
dentine hypersensitivity, toothache, and orofacial pain [8]. Another study showed that smokers were more likely to perceive that they had poorer oral health and tended to undergo dental checkups only when symptomatic [9]. Moreover, lower use of dental service among smokers increased the risk of several oral diseases including oral cancer [10]. The use of dental services after the appearance of symptoms is associated with higher dental costs. Studies of the healthcare costs among smokers have received attention from researchers. Ide et al. reported that smoking could be the cause of increased dental care utilization and cost through the deterioration of oral health [11]. Based on a cohort study in Finland, current smokers were more likely to use healthcare services and visit a dentist with increased healthcare costs than never-smokers [12]. Expenditure associated with smoking includes not only direct dental costs but also indirect costs such as loss of time spent on travel and treatment with lost work time [13]. Some factors were associated with dental care utilization, such as characteristics, health beliefs, financial resources, and access to health insurance [14].

In the Japanese medical insurance system, all Japanese residents enroll in an insurance group depending on the individual's age and occupation [15]. The healthcare system includes Employees’ Health Insurance, which covers employees of private companies and their families [16]. Those who work for small and medium-sized enterprises and their families are members of the National Health Insurance Association. Under the Japanese free access healthcare system, individuals can consult multiple medical institutions, including dental clinics and hospitals [17]. All insured people and their dependents over 40–74 years can undergo specific health checkups and receive health guidance every year. From 2008, health checkups to prevent metabolic syndrome have been conducted, according to the recommendations of the Health and Medical Service Law for the Aged [18]. They provide valuable information, such as smoking status, to prevent non-communicable diseases.

Little research has been conducted on dental care utilization and cost using the Japanese administrative claims database. This study aims to evaluate the association between smoking habits and dental care utilization and cost among participants registered with the Japan Health Insurance Association, Osaka branch.

**Methods**

**Data source**

A cross-sectional study was conducted using data from the administrative claims database and specific check-up data obtained from the Japan Health Insurance Association, Osaka branch. The population in the Japan Health Insurance Association covers almost 40 million people; it is the largest medical insurer in Japan. A member firm of the Osaka Branch is a small- or medium-sized business with several small offices; approximately 80% of the offices have fewer than nine employees. The study participants were collected from April 2016 to March 2017. The participants aged older than 20 years, individuals with specific check-up records, and at least one dentist visit were included. The exclusion criteria were as follows: individuals who had missing data in the questionnaire regarding specific check-up and those whose questionnaire about smoking had answers that differed from the doctor’s interview. A flow diagram of the study participants is shown in Fig. 1. Of the 1,621,252 individuals from the database of the Japan Health Insurance Association, Osaka branch, our final analytic sample consisted of 226,359 participants (from April 2016 to March 2017). Among them, 29.0% were smokers.

**Questionnaire and clinical parameters in specific medical checkup**

The smoking status was determined during the medical consultation. Moreover, we also took into consideration the participant’s answer about smoking status. The questionnaire included the question, “Currently, do you smoke habitually?” (Yes/No). Currently habitual smokers were “those who have smoked a total of 100 or more cigarettes, or 6 months or longer, and have smoked in the last month.” Information of medication (hypotensive, insulin or hypoglycemic, hyperlipidemia drugs) and medical history (stroke, heart disease, chronic renal failure or artificial dialysis, anemia and metabolic syndrome) were obtained from the personal questionnaire. Further, we included other items, such as the following questions: “Have you gained over 10 kg from your weight at age 20?” (Yes/No); “Are you in the habit of exercising to sweat lightly for over 30 min a time, 2 times weekly, for over a year?” (Yes/No); “In your daily life, do you walk or do an equivalent amount of physical activity more than one hour a day?” (Yes/No); “Is your walking speed faster than the speed of those of your age and sex?” (Yes/No); “Have you gained or lost over 3 kg from your weight in a year?” (Yes/No); “Is your eating speed faster than others?” (Fast/Normal/Slow); “Do you skip breakfast more than 3 times a week?” (Yes/No); “Do you have any snacks or sweet beverages after dinner more than 3 times a week?” (Yes/No); “Do you have an evening meal within 2 h before bedtime more than 3 times a week?” (Yes/No); “How often do you drink alcohol?” (Everyday/Sometimes/Rarely); and “Do you feel refreshed after a night’s sleep?” (Yes/No). Furthermore, the check-up variables included waist circumstance (WC), body mass index (BMI), systolic blood pressure (SBP), diastolic blood pressure (DBP), and systolic arterial pressure (SAP).
(DBP), total cholesterol, triglycerides, high-density lipoprotein cholesterol (HDL), low-density lipoprotein cholesterol (LDL), fasting blood glucose (FBG), HbA1c, glutamic-oxaloacetic transaminase (GOT), glutamic pyruvic transaminase (GPT), γ-glutamyl transpeptidase (γ-GTP), uric acid (UA), and estimated glomerular filtration rate (eGFR).

**Dental and medical utilization and cost**

The data were linked with the claims database file using participants’ ID numbers. We also calculated dental and medical care utilization using the total annual cost of each procedure from April 2016 to March 2017. The annual number of medical visits was calculated for each participant. We counted the number of all diagnosed diseases and procedure codes of each group and calculated the prevalence between smokers and non-smokers.

**Propensity score matching and statistical analysis**

We calculated propensity score, defined as the conditional probability of each participant having a smoking habit given several confounders, such as age, sex, exercise, physical activity, walking speed, eating habit (speed, breakfast, snacks, and evening meal), alcohol intake, and sleep using logistic regression (Table 1). Standardized differences were calculated to assess the balance of covariates between smokers and non-smokers. If the standardized differences were less than 10%, the covariates were considered balanced [19]. The propensity score of the smoking group and the non-smoking group were compared to create matched pairs (smokers and non-smokers as reference) within a 0.15 caliper. In this propensity score model, goodness of fit was secured (C-index was

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**Table 1** Variables in the propensity score model

| Variables                     |
|------------------------------|
| Sex                          |
| Age                          |
| Exercising                   |
| Walking/physical activity    |
| Walking speed                |
| Meat speed                   |
| Dinner just before going to bed |
| Snack after dinner           |
| Skip the breakfast           |
| Alcohol                      |
| Good sleep                   |
0.699). The Student’s t-tests and the Wilcoxon–Mann–Whitney test for continuous measures. A chi-squared test was used to analyze categorical variables. A chi-squared test was used to analyze categorical variables. The 2-sided significance level was set at \(P < 0.05\). All statistical analyses were performed using SPSS version 23 (IBM Corp. Armonk, NY, USA).

**Results**

**Demographic and clinical characteristics of participants**

Table 2 shows the characteristics of smokers and non-smokers before and after propensity score matching. Compared to non-smokers, smokers were younger, and a higher proportion were men. The prevalence of anemia was higher in non-smokers (5.5% in smokers versus 10.0% in non-smokers). The results also indicate the differences in lifestyle between smokers and non-smokers. Smokers tend to skip breakfast, have dinner just before bed, and drink alcohol. Metabolic syndrome participants were 15.8% in smokers and 12.7% in non-smokers. According to propensity score matching, 62,692 participants were selected for each group. The two groups became well-balanced after propensity score matching according to standardized differences (bold letter). Clinical parameters and applicable metabolic syndrome are shown in Table 3. Smokers had a larger WC, triglyceride, γ-GTP and eGFR, and lower levels of total cholesterol and HDL. Standardized differences were higher than 0.1 in SBP, DBP, total cholesterol, triglyceride, HDL, and eGFR. However, the rate of metabolic syndrome was well-balanced between the two groups.

**Table 2** Characteristics of study participants from check-up questionnaire before and after matching

|                               | Before matching | After matching |
|-------------------------------|----------------|---------------|
|                               | Smoker | Non-smoker | S.d  | Smoker | Non-smoker | S.d  |
| Total participants            | 65,719 | 160,640    |      | 62,692 | 62,692    |      |
| Male (n, %)                   | 52,933 | 80.5       | 93,326 | 58.1   | 0.50      | 49,906 | 79.6  | 49,280 | 78.6   | 0.02    |
| Age (mean, SD)                | 49.4   | 9.3        | 50.8  | 9.8    | 0.14      | 49.6   | 9.3   | 49.8   | 9.7    | 0.02    |
| Medication (n, %)             |        |            |       |        |           |       |       |       |       |        |
| Hypotensive drug              | 8,254  | 12.6       | 23,209 | 14.4   | 0.05      | 8,003  | 12.8  | 9,374  | 15.0   | 0.06    |
| Hypoglycemic drug             | 2,941  | 4.5        | 6,446  | 4.0    | 0.02      | 2,887  | 4.6   | 2,615  | 4.2    | 0.02    |
| Hypolipidemic drug            | 4,200  | 6.4        | 14,153 | 8.8    | 0.09      | 4,101  | 6.5   | 5,192  | 8.3    | 0.07    |
| Medical history (n, %)        |        |            |       |        |           |       |       |       |       |        |
| Stroke                        | 533    | 0.8        | 1,871  | 1.2    | 0.04      | 516    | 0.8   | 762    | 1.2    | 0.04    |
| Heart disease                 | 1,449  | 2.2        | 4,499  | 2.8    | 0.04      | 1,391  | 2.2   | 1,894  | 3.0    | 0.05    |
| Kidney failure                | 170    | 0.3        | 584    | 0.4    | 0.02      | 164    | 0.3   | 226    | 0.4    | 0.02    |
| Anemia                        | 3,628  | 5.5        | 16,018 | 10.0   | 0.17      | 3,538  | 5.6   | 4,077  | 6.5    | 0.04    |
| Metabolic Syndrome            | 10,404 | 15.8       | 20,412 | 12.7   | 0.09      | 9,938  | 15.9  | 9,749  | 15.6   | 0.01    |
| Questionnaire (n, %)          |        |            |       |        |           |       |       |       |       |        |
| Body weight increase (from 20 years old) | 27,975 | 42.6        | 59,974 | 37.3   | 0.11      | 26,555 | 42.4  | 27,409 | 43.7   | 0.03 |
| Exercising                    | 13,271 | 20.2       | 38,258 | 23.8   | 0.09      | 12,970 | 20.7  | 13,360 | 21.3   | 0.01 |
| Walking/physical activity     | 23,895 | 36.4       | 60,929 | 37.9   | 0.03      | 22,891 | 36.5  | 23,100 | 36.8   | 0.01 |
| Walking speed (fast)          | 31,648 | 48.2       | 79,509 | 49.5   | 0.03      | 30,321 | 48.4  | 30,507 | 48.7   | 0.01 |
| Body weight gain and loss (in a year) | 20,974 | 31.9        | 44,620 | 27.8   | 0.09      | 19,820 | 31.6  | 19,263 | 30.7   | 0.02 |
| Meat speed (fast)             | 24,047 | 36.6       | 55,292 | 34.4   | 0.05      | 22,827 | 36.4  | 22,901 | 36.5   | 0.00 |
| Dinner just before going to bed | 30,471 | 46.4        | 53,773 | 33.5   | 0.27      | 28,199 | 45.0  | 27,422 | 43.7   | 0.03 |
| Snack after dinner            | 12,308 | 18.7       | 32,984 | 20.5   | 0.05      | 11,818 | 18.9  | 12,075 | 19.3   | 0.01 |
| Skip the breakfast            | 23,516 | 35.8       | 25,316 | 15.8   | 0.47      | 20,489 | 32.7  | 19,120 | 30.5   | 0.05 |
| Alcohol (every day)           | 27,899 | 42.5       | 45,841 | 28.5   | 0.30      | 25,914 | 41.3  | 24,832 | 39.6   | 0.03 |
| Good sleep                    | 35,783 | 54.4       | 91,508 | 57.0   | 0.05      | 34,399 | 54.9  | 34,834 | 55.6   | 0.01 |

S.d. Standardizes differences; SD Standard deviation
Dental diagnosis and dental procedure between smokers and non-smokers

Pulpitis, missing teeth, and apical periodontitis were more frequently diagnosed in smokers, while inlay detachment, dental decay, and hypersensitivity were more common in non-smokers (Table 5). As for dental procedures, smokers needed more frequent dental recalls and medication-assisted treatment to control acute inflammation (as shown in Table 6). However, the first consultation that included the Basic Periodontal Examination and scaling procedures were more frequently coded in non-smokers.

### Table 3 Clinical parameters and applicable of metabolic syndrome

| Clinical parameter (mean, SD) | Before matching | After matching |
|------------------------------|----------------|---------------|
| Total participants           | 65,719         | 62,692        |
| Smoker                       | 62,692         | 62,692        |
| Non-smoker                   | 160,640        | 160,640       |
| WC (cm)                      | 83.4           | 83.4          |
| BMI (kg/m2)                  | 23.3           | 23.3          |
| SBP (mmHg)                   | 121.7          | 121.6         |
| DBP (mmHg)                   | 75.4           | 75.3          |
| Total cholesterol (mg/dl)    | 62,692         | 62,692        |
| Triglyceride (mg/dl)         | 202.6          | 202.7         |
| HDL (mg/dl)                  | 134.7          | 134.3         |
| LDL (mg/dl)                  | 57.6           | 57.7          |
| FBG (mg/dl)                  | 24.7           | 24.6          |
| HbA1c (%)                    | 22.3           | 22.3          |
| GOT (U/L)                    | 5.6            | 5.6           |
| GPT (U/L)                    | 49.4           | 48.8          |
| γ-GTP (U/L)                  | 5.7            | 5.7           |
| UA (mg/dl)                   | 0.8            | 0.8           |
| CRE (mg/dl)                  | 0.4            | 0.4           |
| eGFR (ml/min/1.73m2)         | 81.0           | 80.8          |

**Table 4 Dental and medical utilization and cost between smokers and non-smokers**

|                      | Smoker | Non-smoker | P   |
|----------------------|--------|------------|-----|
| Annual dental cost (JPY) | 62,692 | 62,692 | <0.001 |
| Mean, SD             | 54,520 | 54,774 | 47,944 |
| Median, 1Q,3Q        | 38,750 | 19,210 | 71,000 |
| Number of dental institutions | 3.7 | 2.7 | 3.7 |
| Mean, SD             | 3     | 2.5     | 3    |
| Median, 1Q,3Q        | 3     | 2.5     | 2.5  |
| Annual medical cost (JPY) | 99,916 | 372,926 | 113,479 |
| Mean, SD             | 27,010 | 5,580 | 80,720 |
| Median, 1Q,3Q        | 3     | 1.9     | 5    |
| Number of medical institutions | 5.6 | 6.1 | 6.0 |
| Mean, SD             | 3     | 1.9     | 2.10 |
| Median, 1Q,3Q        | 3     | 1.9     | 2.10 |

Student's t-tests Median (Interquartile range (IQR)), Wilcoxon-Mann–Whitney test
SD Standard deviation; 1Q 1st quartile; 3Q 3rd quartile;
Discussion
In the present study, we show a positive association between smoking habit and high dental cost. Smokers were more likely to incur dental care costs than non-smokers among the users of dental and medical checkup services. Warnakulasuriya et al. have shown that oral health risk such as oral cancer, periodontal disease, tooth loss, implant failure, and dental caries have a strong association with tobacco smoking [20]. The cost of smoking exceeds the cost of periodontal therapy [21]. However, we could not obtain information about daily tooth cleaning habits, such as the frequency of using dental floss or other types of teeth cleaning tools. The result of the present study is consistent with that of a report that current smokers were less likely to consult a dentist in the past year than those who never smoked [8].

Based on the Act on Ensuring Medical Care for the Elderly, the Specified Health Checkup was started in 2008. In 2016, the targeted population was 53.6 million individuals with basic insurance, aged 40 to 74 years old; the total average rate of those who received this checkup was 51.4%. Although the consultation rate increased over time, the financial situation of the insurer remained variable. More than 75% of insured individuals underwent specific checkups in the health insurance society, but less than 50% of insurers received checkups in the National Insurance Association [23]. Individuals who have not undergone routine medical checkups are included in the list.

The data of participants in this study were derived from the administrative claims database and specific checkups. The advantage of a real-world database, such as the medical claims database used in our study, is that it can provide diagnosis and treatment information even

| Dental diagnosis (n, %)                      | Smoker     | Non-smoker | P-value |
|---------------------------------------------|------------|------------|---------|
| Periodontitis                               | 47,182     | 47,881     | <0.001  |
| Caries                                      | 28,697     | 29,764     | <0.001  |
| Pulpitis                                    | 8,999      | 6,132      | <0.001  |
| Apical periodontits                         | 8,069      | 5,721      | <0.001  |
| Missing tooth                               | 7,433      | 4,605      | <0.001  |
| Caries treated teeth                        | 5,802      | 4,741      | <0.001  |
| Hypersensitivity                            | 5,132      | 5,849      | <0.001  |
| Dental caries                               | 5,153      | 5,541      | <0.001  |
| Acute chronic marginal periodontitis         | 4,580      | 3,464      | <0.001  |
| Incompatible denture                        | 3,865      | 2,783      | <0.001  |
| Acute purulent periodontitis                 | 3,826      | 2,844      | <0.001  |
| Acute apical periodontitis                   | 3,784      | 2,803      | <0.001  |
| Missing tooth, bridge                        | 3,435      | 2,304      | <0.001  |
| Inlay detachment                            | 2,266      | 3,424      | <0.001  |
| Temporomandibular disorders                 | 1,502      | 1,762      | <0.001  |
| All metal crown desorption                  | 1,302      | 1,367      | <0.001  |
| Bruxism                                     | 972        | 1,326      | <0.001  |
| Enamel early caries                          | 577        | 711        | <0.001  |
| Chronic marginal periodontitis               | 444        | 481        | <0.001  |
| Aphthous stomatitis                         | 307        | 429        | <0.001  |

Chi-squared test
if a participant switches to another medical institution [24]. Moreover, we have used a propensity score matching method to adjust for potential confounding variables, such as lifestyle between the two groups.

There are some limitations to this study. We could only consider the medical and dental service under health insurance due to the characteristics of the administrative claims database. Individuals who did not visit the dental clinic were not analyzed. Therefore, medical expenses may have been overestimated. Free dental treatments, such as whitening, orthodontic treatment, implants, and aesthetic dentistry, were not included in this analysis. According to a survey conducted by the Ministry of Health, Labour and Welfare, the implementation rate of specific checkups was 47.4% in all Japan Health Insurance Associations. Hence, the utilization of medical and dental services may have been overestimated considering the total population. The information regarding pharmacy claims was not included in this database. Thus, the cost of healthcare excluded medication costs. We could not distinguish between former smokers and non-smokers without data on the smoking period. Jeong reported that electronic cigarette vaping and conventional cigarette use had a significant association with periodontal disease rates [25]. However, we were unable to identify the type of cigarettes used in this study. Socioeconomic status is a well-known risk indicator for dental disease [26]. The study population comprised insured individuals who were enrolled in the Japan Health Insurance Association, Osaka branch. However, we could not evaluate the economic situation in each household. Adults 75 years or older with high medical and dental costs could not be included in this study, as they usually transfer to the medical care system for the elderly.

According to National Health and Nutrition Survey, smoking habits are declining among both men and women since 2016 (30.2% in men and 7.2% in women). Although smokers are at a higher risk of oral pain, smoking cessation significantly decreases the risk [27]. The adverse effects of smoking on oral health are often reduced by smoking cessation. As there exists a strong dose-dependent association between smoking and tooth loss, dentists play a crucial role in tobacco control [2].

In summary, this study suggests that smokers have higher dental costs, most often due to acute illness. Our findings support the call for public policies to promote non-smoking activities. Promoting regular dental visits is

| Table 6 Dental procedure between smokers and non-smokers |
|----------------------------------------------------------|
|                                                   | Smoker | Non-smoker | P-value  |
|----------------------------------------------------------|
| Dental procedure (n, %)                                  |        |            |         |
| Initial consultation                                    | 51,230 | 52,138     | 0.001  |
| Reexamination                                           | 50,082 | 47,968     | 0.001  |
| Professional mechanical tooth cleaning                 | 43,150 | 45,150     | 0.001  |
| Scaling                                                 | 42,810 | 45,458     | 0.001  |
| Basic periodontal examination                          | 40,986 | 44,338     | 0.001  |
| Dental hygiene practical guidance                       | 38,260 | 40,559     | 0.001  |
| Prescription                                            | 23,138 | 16,907     | 0.001  |
| Dispensing                                              | 22,417 | 15,987     | 0.001  |
| Drug information provision                              | 22,197 | 16,234     | 0.001  |
| Dental X-ray                                            | 19,166 | 16,678     | 0.001  |
| Photo diagnosis                                         | 19,148 | 16,666     | 0.001  |
| Electrical root canal length measurement test           | 15,116 | 11,417     | 0.001  |
| Crown preparation                                       | 14,194 | 11,219     | 0.001  |
| Inlay restoration                                       | 9,821  | 11,061     | 0.001  |
| Molar tooth extraction                                  | 9,109  | 6,050      | 0.001  |
| Inlay preparation                                       | 8,291  | 9,450      | 0.001  |
| Intracanal medication                                   | 7,549  | 5,924      | 0.001  |
| Periodontal inspection                                  | 7,037  | 7,915      | 0.001  |
| Replacement                                             | 4,521  | 5,680      | 0.001  |
| Regional dental care support hospital reexamination     | 912    | 1,086      | 0.001  |

Chi-squared test
one strategy to help people prevent and treat oral disease in early stages.

Conclusion
The annual dental cost was significantly higher among smokers than non-smokers. The disease codes in smokers consisted of progressive dental caries, missing teeth, and uncontrolled acute inflammation. It is suggested that smokers tend to visit the dentist after their symptoms become severe.

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Author contributions
KK, FO, HF, and TM contributed to the study conception and design. FO and YH were involved in data acquisition. KK, TD, KK, and MM performed data analysis and interpretation. The draft of the manuscript was written by KK and TM. All authors have read and approved the final manuscript.

Availability of data and materials
The data that support the findings of this study are available from the Japan Health Insurance Association. However, restrictions apply to the availability of these data, which were used under license for the current study, and hence, are not publicly available. Data are, however, available from the authors upon reasonable request and with permission of the Japan Health Insurance Association.

Declarations

Ethics approval and consent to participate
This study was conducted in accordance with the Declaration of Helsinki and the Ethical Guidelines for Medical and Health Research Involving Human Subjects of the Ministry of Health, Labour and Welfare, Japan. The study protocol was approved by the Ethics Committee of Osaka Dental University (No. 110957, July 29, 2019). The need for additional informed consent was waived by the committee, according to the guidelines.

Consent for publication
Not applicable.

Competing interests
The authors declare they have no conflicts of interest with respect to this research study and paper.

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