

Evaluation of tooth loss among patients with diabetes mellitus using the National Database of Health Insurance Claims and Specific Health Checkups of Japan

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Background: Although diabetes mellitus is reported to be related to tooth loss, there is limited population-based evidence for this relationship. We investigated the actual situation of tooth loss by performing a population-based survey using information obtained from the National Database of Health Insurance Claims and Specific Health Checkups (NDB) in Japan. **Methods:** Medical, dental and pharmacy claims data generated between 1 April 2015 and 31 March 2016 were obtained and analysed. Patients with medical and pharmacy claims of diabetes mellitus were allocated to the diabetes mellitus group. Patients with medical claims of acute upper respiratory inflammation, but without claims of diabetes mellitus, were allocated to the control group. The number of claims involving tooth loss, treatment of periodontal disease and visits to medical and dental institutions were obtained from the NDB. Descriptive statistics were used to compare the nature of tooth loss between patients with diabetes mellitus and the control group. **Results:** There were 5,248,405 patients in the control group and 1,570,082 patients in the diabetes mellitus group. Patients in the diabetes mellitus group showed a higher level of tooth loss than patients in the control group, among both sexes. Patients with diabetes mellitus tended to lose their posterior teeth at an earlier age than patients in the control group. Moreover, patients in the diabetes mellitus group showed greater tooth loss, regardless of whether or not periodontal disease was treated. **Conclusion:** Patients with diabetes mellitus show a higher level of tooth loss than those without diabetes mellitus, based on the results of a population-based survey.

Key words: National database, diabetes mellitus, tooth loss, population-based survey

INTRODUCTION

The relationship between diabetes mellitus and periodontal disease has been reported in recent studies^{1–4}. Periodontal disease increases the risk of complications among patients with diabetes mellitus^{5,6}, and diabetes mellitus aggravates periodontal disease^{7,8}. As several studies have reported that the main cause of tooth loss in patients aged >40 years is periodontal disease^{9,10}, it can be assumed that patients with diabetes mellitus will lose more teeth than those without diabetes mellitus. Taylor *et al.*⁴ showed that most previous studies reported more tooth loss among patients with diabetes mellitus. However, they also pointed out that these studies were not population-based and tended to include patients

with diabetes mellitus from only one institution or clinic. Therefore, there is limited population-based evidence of a relationship between diabetes mellitus and tooth loss.

In Japan, which has a universal health coverage system, the National Database of Health Insurance Claims and Specific Health Checkups (NDB) was created to store health insurance-related medical information¹¹. The NDB is one of the largest health-related databases in the world, with approximately 12,884 million claims from over one hundred million people issued between 1 April 2009 and 31 December 2016 (data as of 31 March 2017)¹². The database contains almost all the information pertaining to medical and dental treatment of patients in Japan, and information from this database has recently been

used for several epidemiological studies based on medical claims^{13–16}. However, there are few studies that have used medical and dental claims data simultaneously.

Therefore, the purpose of our study was to reveal the actual situation of tooth loss in a population-based survey using data obtained from the NDB in Japan.

METHODS

Data source

We conducted an observational study using data from the NDB. We obtained data on medical, dental and pharmacy claims, between 1 April 2015 and 31 December 2016, from the Japanese Ministry of Health, Labour and Welfare. This study assessed data for the period 1 April 2015 to 31 March 2016 and for patients aged 50–74 years. Data linkage was performed using ID1¹¹, which is a hash value generated from the insurer's ID. The NDB contains data on clinical and procedural characteristics, such as patient identification numbers, sex, age group, history of treatment and prescription date. As of 1 April 2015, over 90% of medical, dental and pharmacy claims were electronically issued¹⁷. Therefore, almost all claims were recorded in this database. However, tooth loss could only be recorded when patients visited dental clinics or hospitals listed in the NDB. Thus, tooth-loss data for patients who did not visit such dental clinics or hospitals could not be identified in the NDB. Therefore, in order to reveal the number of teeth lost, we selected patients who had both medical and dental claims between 1 April 2015 and 31 March 2016. Informed consent was not obtained because this study used anonymised claim data. This study was approved by the Ethics Committee of Tokyo Dental College (approval number 805) and conducted in full accordance with the World Medical Association Declaration of Helsinki.

Definition of diabetes mellitus

Between 1 April 2015 and 31 March 2016, patients with claims for diabetes mellitus were identified on the basis of International Classification of Diseases (ICD)-10 codes (Appendix S1). Nishioka *et al.*¹⁸ reported that the accuracy of identifying patients with diabetes mellitus was higher when pharmacy claims were also considered. Therefore, pharmacy claims pertaining to 475 drugs were combined with medical claims to improve the accuracy of identifying patients with diabetes mellitus (Appendix S2). Patients with both medical and pharmacy claims related to diabetes

mellitus were defined as patients with diabetes mellitus in this study.

Definition of the control group

Although the NDB contains a large amount of patient data, it contains no information on the healthy population. Therefore, it is difficult to set a control group using this database. In this study, we identified a control group by selecting patients with upper respiratory inflammation. The rationale for selecting these patients was as follows: no studies have reported a relationship between tooth loss and upper respiratory inflammation; and upper respiratory inflammation is a reversible disease. On the basis of ICD-10 codes (Appendix S3), we identified patients with acute upper respiratory inflammation who did not have medical claims for diabetes mellitus. Thus, patients with medical claims of acute upper respiratory inflammation and no claims of diabetes mellitus were defined as the control group in this study.

Definition of tooth loss

The total number of dental claims for tooth extraction [billing codes: 310000110 (deciduous tooth), 310000210 (anterior tooth) and 310000310 (posterior tooth)] between 1 April 2015 and 31 March 2016 was defined as the total number of cases of tooth loss in this study. In addition, using the dental claims data, the total number of cases of anterior and posterior tooth extraction was also collected.

Definitions of periodontal disease treatment and annual number of visits to medical and dental institutions

Treatment of periodontal disease was defined using the billing codes 309004810, 309004970, 309005010, 309005110, 309005210, 309005310, 309005410, 309005510 and 309005670¹⁹. Details are shown in Appendix S4. As this study was based on claims data, the severity of periodontal disease was unknown. Therefore, we used the number of visits to medical and dental institutions to indicate periodontal disease severity. The annual number of visits to medical and dental institutions (calculated from the medical and dental claims made during the observation period) was defined as the number of days for which the patient received treatment.

Statistical analysis

Descriptive statistics were used to compare the tooth-loss characteristics between patients in the diabetes mellitus group and patients in the control group. All

categorical data were expressed as numbers and frequencies (%). Patient age was categorised into five groups with 5-year increments. The number of visits to medical and dental institutions was presented as mean (SD) and quartiles. Comparisons of the number of teeth lost were performed by dividing the patients in each study group into two further groups according to the number of visits to medical or dental institutions, and then into four subgroups by referencing the 25th, 50th and 75th percentiles as follows:

- Number of visits to medical institutions:
 - i Control group: subgroup 1, 1–6 visits; subgroup 2, 7–13 visits; subgroup 3, 14–23 visits; subgroup 4, ≥ 24 visits
 - ii Diabetes mellitus group: subgroup 1, 1–10 visits; subgroup 2, 11–16 visits; subgroup 3, 17–27 visits; subgroup 4, ≥ 28 visits.
- Number of visits to dental institutions:
 - i Control group: subgroup 1, 1–2 visits; subgroup 2, 3–5 visits; subgroup 3, 6–9 visits; subgroup 4, ≥ 10 visits
 - ii Diabetes mellitus group: subgroup 1, 1–2 visits; subgroup 2, 3–5 visits; subgroup 3, 6–10 visits; subgroup 4, ≥ 11 visits.

Overall tooth loss was presented as mean annual tooth loss (SD). With regard to tooth loss with or without treatment of periodontal disease, the mean annual tooth loss was described according to sex and age. Data were analysed using IBM SPSS Statistics for Windows, Version 25.0 (Released 2017; IBM Corp., Armonk, NY, USA).

RESULTS

Table 1 shows characteristics of the patients in the study. There were 5,248,405 patients with acute upper respiratory inflammation (control group) and 1,570,082 patients with diabetes mellitus. Most patients in the control group were female (61.3%), while most patients in the diabetes mellitus group were male (62.5%). Patients in the diabetes mellitus group were older than those in the control group. More patients in the control group had received treatment for periodontal disease (75.4% in the control group *vs.* 69.4% in the diabetes mellitus group). The mean annual number of visits to medical institutions and dental institutions was higher in the diabetes mellitus group than in the control group.

The mean annual tooth loss in the two groups, categorised according to sex and age, is presented in *Table 2*. Both male and female patients with diabetes mellitus showed more tooth loss than patients of the corresponding sex in the control group. In addition, more tooth loss and an increase in tooth loss with age was observed in male patients in both control and diabetes mellitus groups. In a comparison, among age

Table 1 Comparison of characteristics between patients in the diabetes mellitus group and patients in the control group (with acute upper respiratory inflammation)

Characteristic	Control group (<i>n</i> = 5,248,405)	Diabetes mellitus group (<i>n</i> = 1,570,082)
Sex		
Male	2,032,117 (38.70)	981,139 (62.50)
Female	3,216,288 (61.30)	588,943 (37.50)
Age (years)		
50–54	1,023,600 (19.50)	131,659 (8.40)
55–59	966,703 (18.40)	186,888 (11.90)
60–64	1,036,224 (19.70)	300,005 (19.10)
65–69	1,216,940 (23.20)	484,298 (30.80)
70–74	1,004,938 (19.10)	467,232 (29.80)
Treatment of periodontal disease		
No	1,291,933 (24.60)	480,338 (30.60)
Yes	3,956,472 (75.40)	1,089,744 (69.40)
Annual number of visits to medical institutions	20.9 ± 28.0	25.9 ± 30.0
25th percentile	7	11
50th percentile	14	17
75th percentile	24	28
Annual number of visits to dental institutions	7.6 ± 6.9	8.1 ± 7.2
25th percentile	3	3
50th percentile	6	6
75th percentile	10	11

groups, of tooth loss between patients with diabetes mellitus and patients in the control group, the highest tooth loss was noted in the youngest age group in both sexes (values were calculated as: mean tooth loss in the control group minus mean tooth loss in male patients with diabetes): male patients, 50–54 years: 0.078 teeth/year, 70–74 years: 0.037 teeth/year; female patients, 50–54 years: 0.092 teeth/year, 70–74 years: 0.053 teeth/year).

The mean annual anterior and posterior tooth loss in patients with diabetes mellitus and in control groups is shown in *Table 3*. Similarly to the findings presented in *Table 2*, both sexes of patients with diabetes mellitus showed more tooth loss, of both anterior and posterior teeth, than patients in the control group. Moreover, male patients showed greater tooth loss than female patients. In the control group, both male and female patients aged 70–74 years showed the highest loss of posterior teeth [male patients: 0.147 (0.409) teeth/year; female patients: 0.117 (0.363) teeth/year]. However, in the diabetes mellitus group, the highest loss of posterior teeth was found in both male and female patients aged 55–59 years [male patients: 0.175 (0.453) teeth/year; female patients: 0.154 (0.427) teeth/year].

Table 2 Mean annual tooth loss subdivided according to sex and age group in the diabetes mellitus group and the control group (patients with acute upper respiratory inflammation)

Variable	Male						Female					
	Control group			Diabetes mellitus group			Control group			Diabetes mellitus group		
	<i>n</i>	Mean	SD	<i>n</i>	Mean	SD	<i>n</i>	Mean	SD	<i>n</i>	Mean	SD
Age (years)												
50–54	411,763	0.135	0.429	91,067	0.213	0.560	611,837	0.104	0.370	40,592	0.196	0.538
55–59	374,315	0.164	0.473	124,131	0.237	0.578	592,388	0.125	0.407	62,757	0.211	0.552
60–64	392,645	0.187	0.503	193,375	0.245	0.586	643,579	0.142	0.434	106,630	0.217	0.551
65–69	464,435	0.203	0.524	299,250	0.250	0.590	752,505	0.157	0.454	185,048	0.222	0.557
70–74	388,959	0.215	0.538	273,316	0.252	0.584	615,979	0.173	0.477	193,916	0.226	0.557

Table 4 shows mean annual tooth loss in diabetes mellitus and control groups based on the number of visits to medical and dental institutions. With respect to the number of visits to medical institutions, the diabetes mellitus group showed more tooth loss than the control group in all subgroups. Although subgroup 1 showed the highest tooth loss in the control group, subgroup 2 showed the highest tooth loss in the diabetes mellitus group. With respect to the number of visits to dental institutions, the diabetes mellitus group showed more tooth loss than the control group in all subgroups. In addition, tooth loss increased with the number of visits to dental institutions in both diabetes mellitus and control groups.

The mean annual tooth loss after treatment of periodontal disease in the diabetes mellitus and control groups is presented in Table 5. The diabetes mellitus

group showed more tooth loss regardless of whether or not periodontal disease was treated.

DISCUSSION

To our knowledge, this is the first study using information from the NDB to reveal the characteristics of tooth loss among patients with diabetes mellitus who visited medical and dental institutions in Japan. Some population-based surveys have investigated the relationship between diabetes mellitus and tooth loss in the USA^{20–23}. Greenblatt *et al.*²⁰ assessed 15,945 Hispanic participants aged 18–74 years and reported that uncontrolled diabetes mellitus was associated with nine or more missing teeth. Luo *et al.*²² evaluated 37,609 dentate adults aged ≥ 25 years and reported that patients with diabetes mellitus lost approximately

Table 3 Mean annual anterior and posterior tooth loss in the diabetes mellitus group and the control group (patients with acute upper respiratory inflammation)

Variable	Male				Female			
	Control group		Diabetes mellitus group		Control group		Diabetes mellitus group	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Anterior teeth								
Age (years)								
50–54	0.024	0.168	0.049	0.245	0.016	0.139	0.044	0.235
55–59	0.035	0.202	0.062	0.271	0.024	0.167	0.057	0.260
60–64	0.046	0.233	0.073	0.292	0.033	0.198	0.065	0.275
65–69	0.058	0.260	0.082	0.309	0.043	0.225	0.074	0.295
70–74	0.068	0.281	0.088	0.318	0.056	0.255	0.082	0.308
Posterior teeth								
Age (years)								
50–54	0.111	0.364	0.164	0.448	0.087	0.322	0.152	0.431
55–59	0.129	0.391	0.175	0.453	0.101	0.343	0.154	0.427
60–64	0.141	0.402	0.172	0.447	0.108	0.353	0.152	0.421
65–69	0.145	0.408	0.169	0.440	0.114	0.358	0.147	0.412
70–74	0.147	0.409	0.163	0.430	0.117	0.363	0.144	0.405

Table 4 Mean annual tooth loss in the diabetes mellitus group and the control group (patients with acute upper respiratory inflammation) according to number of visits to institutions

Variable	Control group			Diabetes mellitus group		
	<i>n</i>	Mean	SD	<i>n</i>	Mean	SD
Annual number of visits to medical institutions						
Subgroup 1	1,202,251	0.172	0.483	341,590	0.246	0.586
Subgroup 2	1,336,361	0.156	0.454	405,577	0.251	0.588
Subgroup 3	1,330,762	0.152	0.450	410,629	0.230	0.564
Subgroup 4	1,379,031	0.149	0.448	412,286	0.216	0.554
Annual numbers of visits to dental institutions						
Subgroup 1	1,149,442	0.028	0.173	465,319	0.063	0.261
Subgroup 2	1,445,096	0.071	0.280	365,130	0.144	0.407
Subgroup 3	1,172,363	0.156	0.423	375,668	0.275	0.576
Subgroup 4	1,481,504	0.340	0.671	363,965	0.505	0.836

Patients in control and diabetes mellitus groups were divided into two further groups according to the annual number of visits to medical and dental institutions, and these were stratified into four subgroups, by referencing the 25th, 50th and 75th percentiles:

Annual number of visits to medical institutions: control group. Subgroup 1: 1–6 visits; subgroup 2: 7–13 visits; subgroup 3: 14–23 visits; subgroup 4: ≥ 24

Annual number of visits to medical institutions: diabetes mellitus group. Subgroup 1: 1–10 visits; subgroup 2: 11–16 visits; subgroup 3: 17–27 visits; subgroup 4: ≥ 28 visits

Annual number of visits to dental institutions: control group. Subgroup 1: 1–2 visits; subgroup 2: 3–5 visits; subgroup 3: 6–9 visits; subgroup 4: ≥ 10 visits

Annual number of visits to dental institutions: diabetes mellitus group. Subgroup 1: 1–2 visits; subgroup 2: 3–5 visits; subgroup 3: 6–10 visits; subgroup 4: ≥ 11 visits.

twice as many teeth as those without diabetes mellitus. In the present study, 1,570,082 patients with diabetes mellitus were analysed; there are no other studies in which large numbers of patients have been used to analyse the relationship between diabetes mellitus and tooth loss.

In this study, patients with diabetes mellitus showed more tooth loss than patients in the control group. As these tooth-loss data were based on dental claims for tooth extraction, comparisons between these results and previous studies are essential. Using data from the Japanese national survey of oral health, Kambara

*et al.*²⁴ reported that the mean annual tooth loss was lower than 0.1 teeth/year. In our control group, mean annual tooth loss was higher than 0.1 teeth/year. However, these results were obtained from the dental claims of patients who visited medical and dental institutions. When patients who did not visit dental institutions were assumed as having no tooth loss, the mean tooth loss was lower than 0.1 teeth/year (results not shown). Therefore, we assumed that patients with acute upper respiratory inflammation could be regarded as an appropriate control group for tooth loss in the NDB.

Table 5 Mean annual tooth loss in diabetes mellitus and control (patients with acute upper respiratory inflammation) groups according to whether or not periodontal disease was treated

Variable	Treatment of periodontal disease											
	No						Yes					
	Control group			Diabetes mellitus group			Control group			Diabetes mellitus group		
	<i>n</i>	Mean	SD	<i>n</i>	Mean	SD	<i>n</i>	Mean	SD	<i>n</i>	Mean	SD
Male												
Age (years)												
50–54	95,427	0.122	0.404	24,641	0.187	0.522	316,336	0.139	0.436	66,426	0.223	0.573
55–59	93,909	0.153	0.456	36,096	0.215	0.550	280,406	0.168	0.479	88,035	0.247	0.589
60–64	104,931	0.181	0.495	59,679	0.224	0.562	287,714	0.189	0.506	133,696	0.255	0.596
65–69	130,370	0.197	0.515	97,209	0.226	0.560	334,065	0.205	0.528	202,041	0.262	0.603
70–74	110,178	0.210	0.538	89,128	0.227	0.561	278,781	0.218	0.538	184,188	0.264	0.594
Female												
Age (years)												
50–54	132,438	0.100	0.359	11,040	0.174	0.510	479,399	0.105	0.373	29,552	0.204	0.548
55–59	134,977	0.123	0.401	18,100	0.194	0.532	457,411	0.126	0.409	44,657	0.218	0.560
60–64	152,453	0.145	0.437	31,281	0.199	0.531	491,126	0.141	0.433	75,349	0.225	0.559
65–69	184,042	0.162	0.462	55,161	0.208	0.541	568,463	0.156	0.451	129,887	0.227	0.563
70–74	153,208	0.176	0.485	58,003	0.210	0.535	462,771	0.172	0.474	135,913	0.233	0.565

We found the difference between the control group and patients with diabetes in number of teeth lost among age groups was highest in the youngest age group. The same trend was observed in a previous study. Kapp *et al.*²¹ reported a strong association between diabetes mellitus and tooth loss in patients aged under 65 years, with no significant association in patients aged ≥ 65 years. Thus, patients with diabetes mellitus might lose their teeth earlier than those without diabetes mellitus.

With respect to this hypothesis, the mean annual posterior tooth-loss data showed an interesting finding. In the control group, tooth loss plateaued in patients around 65–74 years of age. However, in the diabetes mellitus group, the highest posterior tooth loss was observed in patients aged 55–59 years, and the mean annual posterior tooth loss decreased with age. Yoshino *et al.*²⁵ reported that the mandibular first and second molars tended to be the first teeth that were lost in 3,872 participants aged 40 or 60 years. Therefore, patients with diabetes mellitus might lose their posterior teeth earlier than those without diabetes mellitus.

In this study, patients with diabetes mellitus showed greater tooth loss than those in the control group, regardless of the number of visits to medical and dental institutions. As disease severity could not be determined using claims data, we used the number of visits to medical and dental institutions as an indicator of severity. On the basis of data for the number of visits, patients in the diabetes mellitus group showed more tooth loss than patients in the control group, in all subgroups. This result indicates that patients with diabetes mellitus may lose teeth throughout their lives, in comparison with patients with acute upper respiratory inflammation.

In assessments based on the number of visits to dental institutions, the difference in the number of teeth lost between the diabetes mellitus and control groups was highest in the groups with patients who had the most frequent visits. As this study was based on claims, a larger number of visits to dental institutions implied more opportunities for dental extraction. Ravalid *et al.*²⁶ pointed out that patients with the most advanced periodontal disease and dental caries problems visited dental institutions most frequently. This may explain why the highest difference in tooth loss was observed among the patients who visited dental institutions most frequently in our study.

The Organization for Economic Co-operation and Development reported that the mean annual number of visits to medical and dental institutions was 12.8 and 3.2, respectively²⁷. However, our study showed more visits than this report. As the patients in our study were aged 50–74 years, it is reasonable to

assume that they would make more visits to medical and dental institutions than younger patients.

In the present study, patients in the diabetes mellitus group showed more tooth loss than patients in the control group, regardless of whether or not periodontal disease was treated. Treatment of periodontal disease is effective for preventing tooth loss²⁸. However, Kapp *et al.*²¹ reported that diabetes mellitus was independently associated with tooth loss, regardless of a recent dental visit. The results of our study strengthen the possibility of a tendency for tooth loss among patients with diabetes mellitus.

There are several limitations to our study. We did not use any statistical tests because of the large number of patients. In analysis of large amounts of data, finding associations with outcomes is difficult because of the higher risks of Type I errors as a result of the large numbers²⁹. Therefore, our results are limited to patients who visited medical and dental institutions and received treatment covered by health insurance in Japan.

In our study, data linkage was performed by ID1. However, Noda *et al.*³⁰ reported that ID1 tended to overestimate the number of patients with diabetes mellitus. Therefore, the number of patients with diabetes mellitus may have been overestimated by a maximum of 6% in our study. In addition, because of the nature of ID1, the number of teeth lost might be underestimated if the ID1 was changed during the observation period.

As for the control group, we used patients who had medical claims of acute upper respiratory inflammation without claims of diabetes mellitus. Ideally, a healthy population should have been used as a control group. Although the nature of medical and dental claims did not allow us to use a healthy population, as stated above, the proportion of tooth loss in our control group was reasonable in comparison with the proportions reported in past studies. However, Mojon³¹ pointed out that dental plaque, which can cause dental caries and periodontal disease, could be aspirated into the lungs, thereby causing respiratory infection. Therefore, this relationship may confound the results of our study.

In addition, the severity of the periodontal disease was unknown because the claims data did not record this information. However, it is reasonable to speculate that the number of visits by patients to medical and dental institutions was associated with the severity of the condition. Therefore, we assumed that disease severity was considered to a certain extent in our study.

The number of patients with diabetes mellitus in our study was fewer than reported in past studies using information from the NDB¹⁸. We assume that this difference was because we only considered those

patients who sought treatment at both medical and dental institutions as patients with diabetes mellitus.

Ideally, the reasons for tooth loss should be shown. However, there are several problems with obtaining such data from the NDB for epidemiological study. In order to identify the reason for tooth loss, we needed to match data of the name of a disease with that of a medical procedure. However, it was not possible to do so, and this matter needs to be addressed in future work in order to help reveal the relationship between diabetes mellitus and tooth loss from periodontal disease. It is reported that, in Japan, 55.0% of tooth loss among patients with diabetes mellitus is caused by periodontal disease³²; therefore, it is reasonable to assume that the patients with diabetes mellitus in our study also tended to lose their teeth as a result of periodontal disease.

Although a decision-making process for tooth extraction has been discussed³³, it is reasonable to assume that whether or not a tooth is indeed extracted depends on the judgement of a dentist. However, major oral diseases, such as periodontal disease and dental caries, will ultimately lead to tooth extraction. Therefore, we assume that the general oral condition of the patients was reflected to a certain extent in this study.

The number of existing teeth has been reported to be associated with tooth loss³⁴. However, in the NDB, information on sound teeth is not stored because this database is based on claims; therefore, the number of teeth without a diagnosis of oral disease could not be verified. Similarly, the factors associated with tooth loss, such as oral hygiene status, are not included in the NDB. Therefore, this confounder may affect the results of this study.

The patients analysed in our study were aged 50–74 years. The reason for selecting this age group was that the number of patients with diabetes mellitus is higher around the age of 50 years³⁵. In addition, in Japan, medical insurance needs to be renewed when patients reach 75 years of age³⁶; this would have made it difficult to analyse the data using ID1. Therefore, patients aged ≥ 75 years were not included in our study.

In conclusion, using a large-scale database in Japan, we revealed that patients with diabetes mellitus showed more tooth loss than patients without diabetes mellitus. Therefore, more active and effective treatment for dental diseases is needed for patients with diabetes mellitus.

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Conflict of interest

None declared.

SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Appendix S1. The bill codes of diabetes mellitus.

Appendix S2. The name of medicine for diabetes mellitus.

Appendix S3. The bill codes of acute upper respiratory inflammation.

Appendix S4. The name of medical practice.

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