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Association between the interval of worksite dental check-ups and dental and medical expenditures: a single-site, 12-year follow-up study in Japan

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ABSTRACT

Objectives The purpose of this study was to identify the effective intervals of worksite dental check-ups to reduce cumulative dental expenditures (CDEs) and cumulative medical expenditures (CMEs), based on 12 years of follow-up dental check-ups.

Setting, design and participants A longitudinal study was conducted between 2002 and 2014 fiscal years. A total of 2691 full-time employees (2099 males and 592 females) aged 20–59 years in a manufacturing company in Japan were recruited.

Primary and secondary outcome measures Based on the follow-up of 12-year dental check-ups, the interval of dental check-ups visits was classified into the following categories: 'Once per year' as the regular group, 'At least once per 2 years' as the subregular group and others as the irregular group. CDEs and CMEs per capita were examined by the three groups of dental check-ups interval after adjustment for sex, age, occupation and total CMEs at baseline. For sensitivity analysis, decayed teeth, missing teeth and Community Periodontal Index were added as adjustment factors.

Results Compared with the irregular group, the pooled CDEs (including dental check-ups fee) per capita in the subregular group (OR 0.91, 95% CI 0.85 to 0.98) and regular group (OR 0.87, 95% CI 0.81 to 0.93) were significantly lower overall. The younger adults in the subregular group and younger-aged and middle-aged adults in the regular group had significantly lower CDEs. Sensitivity analysis confirmed these findings.

Conclusions Our findings suggest that regular and subregular worksite dental check-ups were related to reduction of CDEs. It is important to promote a yearly interval between dental check-ups.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The main strength of this study is the 12-year longitudinal, long-term follow-up of dental health check-ups, which provided better data to analyse cumulative dental expenditures (CDEs) and cumulative medical expenditures (CMEs) of workplace participants.
⇒ The paper points out that pooled costs over a 12-year period used as the CDEs and CMEs per capita, avoids year-to-year variation in participants' dental and medical expenditures.
⇒ By dividing the frequency of dental health check-ups into regular (once a year), subregular (at least once every 2 years) and irregular (other) groups show a better interpretation of check-up intervals and CDEs.
⇒ The limitations of this study are the data which was obtained from a single company and confounding factors did not include education, income or general health status.
⇒ Lack of detailed data on CMEs for lifestyle-related diseases did not allow clarification of the association between the frequency of dental check-ups and CMEs.

INTRODUCTION

Total medical expenditures have been increasing year by year due to the rapidly ageing population in recent years in Japan. In 2019, they reached ¥43.6 trillion of which dental expenditures (DEs) accounted for 6.9%, approximately ¥3 trillion (about US$273 billion).[1] To control DEs, prevention, early detection and treatment of dental caries and periodontal diseases are important. Dental check-ups help to identify and prevent oral problems and their risk factors.[2] In particular, periodontal diseases have been shown to be associated with an increased risk of non-communicable diseases such as diabetes and cardiovascular disease.[3–7] Previous studies also reported that diabetes, cardiovascular diseases and some cancers are related to lifestyle habits such as frequency of toothbrushing and use of oral hygiene products.[8–10] Thus, oral health is generally considered one of the most important indicators for well-being.[11] These studies reported that it is important to establish favourable health behaviour into adulthood by providing health management and health guidance through dental check-ups and to focus on the prevention of periodontal diseases. In addition,

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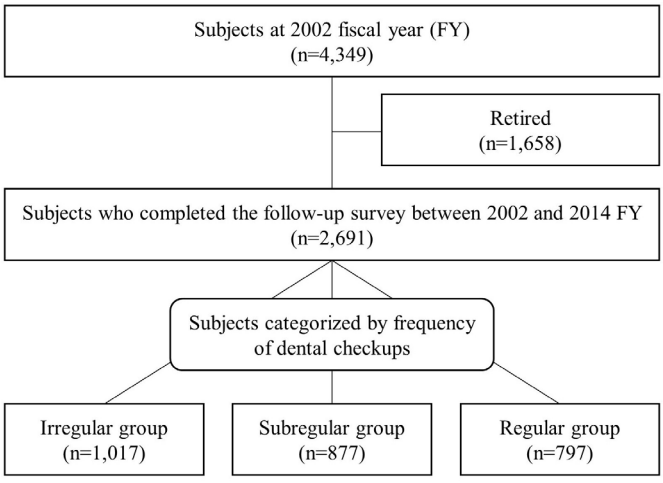

Regular group had a dental checkup once per year
Subregular group had a checkup at least once per two years
Irregular group did not have a dental checkup for more than two years

Figure 1 Flow diagram of study enrolment.

periodontal pockets and missing teeth were reported to be related to dental and medical cost[12–14]; thus, the implementation of dental check-ups in adulthood is expected to reduce medical expenditures (MEs).

The workplace is a key area to provide oral health education for adults.[15 16] Many previous studies have investigated the impact of worksite dental check-ups on better oral health and health behaviour.[17–22] These studies suggested that employees with annual dental check-ups had better periodontal status, and regular, long-term routine dental check-ups reduced tooth loss.[23–25] Periodontitis has an impact on excess MEs, and a previous study reported that severe periodontitis patients had about 20% higher DEs and inpatient MEs.[12 26] In addition, studies of the relationship between the number of dental check-ups and MEs reported that dental care costs were lower in groups with more frequent visits.[23 27 28] However, these studies were based on a comparison of visits during the study period and did not evaluate what intervals were effective.

We hypothesised that by quantifying the effective intervals of dental check-ups, we could clarify those who received dental check-ups and conduct an efficient health promotion programme and provide health guidance. The purpose of this study was to identify the intervals of worksite dental check-ups that reduced cumulative DEs (CDEs) and cumulative MEs (CMEs) based on worksite dental check-ups over a 12-year period in Japan.

MATERIALS AND METHOD

Study design and participants

This study was conducted using a longitudinal study design. The target companies were employees of 12 offices of a single manufacturing company headquartered in Tokyo, Japan, which first introduced worksite dental check-ups for all employees in the 2002 fiscal year (FY). Of the 4349 participants, 2691 (61.9%) completed the follow-up survey between 2002 FY and 2014 FY. Other participants dropped out because of retirement (n=1658). Furthermore, we examined the interval of visits between 2002 FY and 2014 FY to assess worksite dental check-up status, and subjects were further classified into the following categories: 'once per year' (n=797) as the regular group, 'at least once per 2 years' (n=877) as the subregular group, and others as the irregular group (n=1017) (figure 1).

Data collection

In Japan, most people are covered by public health insurance. The company's health insurance association records include DEs and MEs. DEs are the cost of dental treatment at a dentist's clinic or hospital's oral surgery department. MEs include outpatient and inpatient MEs and consist of general medical care costs, excluding dental care. Data on DEs and MEs of employees for each year between 2002 FY and 2014 FY that was held by the relevant health insurance association was consolidated for each individual by outsourcing, and anonymised by removing personal information.

Dental check-up contents and fee

Dental check-ups were performed at the worksite. A dentist examined the oral cavity (decayed teeth and missing teeth), and dental hygienists instructed participants how to brush their teeth according to their oral conditions, recommended dental visits for those who required treatment and performed an examination of periodontal status under the supervision of the dentist. Periodontal status was assessed using the Community Periodontal Index (CPI), which uses the following scores (code 0: healthy, code 1: bleeding, code 2: calculus present, code 3: shallow (4–5 mm) periodontal pocket, code 4: deep (≥ 6 mm) periodontal pocket). The worksite dental check-up did not include X-ray check or any treatment. The cost of dental check-up per visit per person was ¥2655 (about US$26), which was covered by the health insurance association and the company.

Statistical analyses

We pooled the follow-up 12 years for CDEs and CMEs. Dental check-up fees (dental CF) were expressed in Japanese yen (¥100≈US$1). Continuous variables were presented as mean and SD, and categorical variables were expressed as numbers and percentages. The χ^2 test was used for categorical variables. Student's t-test or analysis of variance was used for continuous variables. Mann-Whitney U test for two groups and the Kruskal-Wallis test for three groups were applied to compare the differences in CDEs and CMEs, as they did not exhibit a normal distribution. As the CDEs and CMEs included Poisson and gamma distributions, many frequencies of CDEs and CMEs were zero, and others were continuous; thus, the association of cumulative CDEs and CMEs were analysed using a generalised linear model (GLM) with a Tweedie distribution of log link adjusted for sex,

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Table 1 Characteristics of participants overall and by age group

	Overall (n=2691)		20–39 year (n=1528)		40–59 year (n=1163)		P value*
Sex, n, %							
Men	2099	78.0	1123	73.5	976	83.9	<0.001
Women	592	22.0	405	26.5	187	16.1	
Age, mean, SD, year	38.4	8.0	32.6	4.6	46.0	4.4	<0.001
Type of occupation, n, %							
Clerical	899	33.4	698	33.3	201	34.0	0.186
Sales	494	18.4	403	19.2	92	15.5	
Research	322	12.0	243	11.6	79	13.3	
Manufacturing	975	36.2	755	36.0	220	37.2	
Total Medical expenditures,† mean, SD	73 030	261 743	63 823	286 212	85 126	225 149	<0.001
Dental check-ups,‡ n, %	2586	96.1	1488	97.4	1098	94.4	<0.001
Dental check-ups, mean, SD, times	9.9	3.8	10.2	3.6	9.4	4.1	<0.001
Dental check-up fees, mean, SD, JPY	26 139	10 142	26 997	9487	25 011	10 844	<0.001
Decayed teeth,§ mean, SD	0.54	1.30	0.52	1.24	0.55	1.37	0.743
Missing teeth,§ mean, SD	3.52	2.61	2.92	2.01	4.33	3.08	<0.001
CPI, n, %							
Code 0 (healthy)	260	10.1	169	11.4	91	8.3	<0.001
Code 1 (bleeding)	20	0.8	17	1.1	3	0.3	
Code 2 (calculus)	1578	61.0	1004	67.5	574	52.3	
Code 3 (shallow pocket)	465	18.0	218	14.7	247	22.5	
Code 4 (deep pocket)	263	10.2	80	5.4	183	16.7	

¥100≈US$1.
*Using the $\chi 2$ test and Student's t-test or Mann-Whitney test.
†Included in dental and general (outpatient and inpatient) medical expenditures in 2002 (baseline).
‡Attended at least one of the 13 dental check-ups between 2002 and 2014.
§Participants who did not attend any dental check-ups between 2002 and 2014 were excluded.
CPI, Community Periodontal Index.

age, type of occupation and total MEs at baseline. Sensitivity analysis was conducted by excluding those who had not yet participated in the dental check-up using GLM adjusted for initial dental examination results (decayed teeth, missing teeth and CPI at time of the individual's first dental check-up) to analyse the association among dental check-ups and CDEs and CMEs. All statistical analyses were carried out using IBM SPSS Statistics V.27 (IBM Japan) at a significance level of less than 5%.

Patient and public involvement

No patients or the public were involved.

RESULTS

Table 1 shows the characteristics of the subjects in the baseline by overall, 20–39 years and 40–59 years age groups in 2002. A total of 2691 (2099 males and 592 females, mean age: 38.4 and SD: 8.0 years) patients were recruited, and of them 2586 (96.1%) patients attended a dental check-up at least once in the study period. Total cost of dental and medical care was ¥73 030±¥261 743 . Average participation rate in dental check-ups was 9.9±3.8 times, and the per capita fee of dental check-ups was ¥26 139±¥10 142. The baseline dental check-up results were decayed teeth (0.54±1.30), missing teeth (3.52±2.61) and CPI Code 0 (10.1%), code 1 (0.8%), code 2 (61.0%), code 3 (18.0%) and code 4 (10.2%).

Table 2 shows the cumulative dental check-up fees, CDEs and CMEs by frequency of dental check-ups over 12 years. Age, type of occupation, dental CF, CDEs, CDEs and dental CF, and CMEs showed significant differences among dental check-up groups. By age group, there were significant differences in age, dental CF, CDEs, CDEs and dental CF, and CMEs.

Table 3 shows the relationship among CDEs, added dental check-up fees and CMEs. CDEs and dental CF were significantly lower in the subregular group (adjusted OR (aOR)=0.91, p=0.008) and the regular group (aOR=0.87, p<0.001) than the irregular group. In younger adults, CDEs and dental CF was significantly lower in the subregular group (aOR=0.86, p=0.002) and regular group

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Table 2 Comparison of each variable by frequency of dental check-ups

	Frequency of dental check-up						
	Irregular		Subregular		Regular		P value*
	Mean	SD	Mean	SD	Mean	SD	
Overall	n=1017		n=877		n=797		
Sex, men, n, %	806	79.3	668	76.2	625	78.4	0.256
Age, year	39.1	8.7	38.0	7.5	38.0	7.6	0.002
Type of occupation, n, %							
Clerical	243	23.9	312	35.6	344	43.2	<0.001
Sales	165	16.2	195	22.2	135	16.9	
Research	78	7.7	118	13.5	126	15.8	
Manufacturing	561	52.2	252	28.7	192	24.1	
Dental CF, JPY	15 719	9399	30 612	1839	34 515	0	<0.001
CDEs, JPY	236 663	202 118	207 742	198 987	197 527	185 427	<0.001
CDEs and dental CF, JPY	241 104	204 466	214 122	220 218	202 281	190 324	<0.001
CMEs, JPY	320 741	889 423	265 844	768 248	261 605	935 216	0.023
Younger adults	n=515		n=536		n=477		
Sex, men, n, %	386	75.0	383	71.5	354	74.2	0.400
Age, year	31.8	4.6	33.1	4.4	32.9	4.6	<0.001
Type of occupation, n, %							
Clerical	110	21.4	179	33.4	187	39.2	<0.001
Sales	72	14.0	124	23.1	92	19.3	
Research	44	8.5	90	16.8	84	17.6	
Manufacturing	289	56.1	143	26.7	114	23.9	
Dental CF, JPY	16 286	9101	30 597	1871	34 515	0	<0.001
CDEs, JPY	201 045	173 377	178 318	189 497	177 780	157 341	0.013
CDEs and dental CF, JPY	206 925	179 251	183 111	191 786	180 974	158 222	0.014
CMEs, JPY	231 638	676 227	174 732	601 841	184 406	484 966	0.017
Middle-aged adults	n=502		n=341		n=320		
Sex, men, n, %	420	83.7	285	83.6	271	84.7	0.908
Age, year	46.6	4.4	45.7	4.4	45.5	4.3	<0.001
Type of occupation, n, %							
Clerical	133	26.5	133	39.0	157	49.1	<0.001
Sales	93	18.5	71	20.8	43	13.4	
Research	34	6.8	28	8.2	42	13.1	
Manufacturing	242	48.2	109	32.0	78	24.4	
Dental CF, JPY	15 131	9670	30 637	1791	34 515	0	<0.001
CDEs, JPY	273 204	222 180	253 992	204 947	226 962	217 723	<0.001
CDEs and dental CF, JPY	276 167	222 222	262 868	251 340	234 041	226 587	<0.001
CMEs, JPY	412 151	1 057 625	409 058	957 620	376 680	1 345 110	0.043

¥100≈US$1. Dental CF, CDEs and CMEs were used for a pooled 12-year period. Younger adults: 20–39 years, middle-aged adults: 40–59 years. Regular: once per year, subregular: at least once per 2 years, irregular: others
*Using the $\chi 2$ test, analysis of variance and Kruskal-Wallis test.
CDEs, cumulative dental expenditures; CF, check-up fee; CMEs, cumulative medical expenditures.

(aOR=0.86, p=0.003) than in the irregular group. In CMEs, the subregular group (aOR=0.85, p=0.003) was significantly lower than the irregular group. In middle-aged adults, CDEs and dental CF was significantly lower in the regular group (aOR=0.88, p=0.023) than the irregular group.

Table 4 shows a sensitivity analysis of CDEs, added dental check-up fees and CMEs, adjusted for sex, age,

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Table 3 Relationship among cumulative dental expenditures, added dental check-up fees and cumulative medical expenditures in a 12-year period

	N	Mean	SD	P value*	Crude OR	95% CI	P value†	Adjusted OR	95% CI	P value‡
Overall (n=2691)										
CDEs and dental CF, JPY										
Irregular	1017	241 103	204 466	<0.001	Ref.					
Subregular	877	214 122	220 218		0.89	0.83 to 0.95	<0.001	0.91	0.85 to 0.98	0.008
Regular	797	202 281	190 324		0.84	0.78 to 0.90	<0.001	0.87	0.81 to 0.93	<0.001
CMEs, JPY										
Irregular	1017	937 854	1 541 429	0.749	Ref.					
Subregular	877	905 053	1 270 342		0.97	0.89 to 1.05	0.398	0.96	0.89 to 1.04	0.335
Regular	797	907 259	1 487 887		0.97	0.89 to 1.05	0.443	0.96	0.88 to 1.04	0.280
Younger adults (n=1528)										
CDEs and dental CF, JPY										
Irregular	515	206 925	179 252	0.014	Ref.					
Subregular	536	183 111	191 786		0.89	0.81 to 0.97	0.010	0.86	0.78 to 0.95	0.002
Regular	477	180 974	158 222		0.88	0.79 to 0.96	0.007	0.86	0.78 to 0.95	0.003
CMEs, JPY										
Irregular	515	695 888	1 131 985	0.685	Ref.					
Subregular	536	650 923	1 018 878		0.94	0.84 to 1.04	0.232	0.85	0.76 to 0.94	0.003
Regular	477	700 535	1 024 149		1.01	0.90 to 1.13	0.907	0.94	0.84 to 1.05	0.237
Middle-aged adults (n=1163)										
CDEs and dental CF, JPY										
Irregular	502	276 167	222 223	<0.001	Ref.					
Subregular	341	262 868	251 340		0.95	0.86 to 1.06	0.352	0.98	0.88 to 1.09	0.682
Regular	320	234 041	226 587		0.85	0.76 to 0.94	0.003	0.88	0.79 to 0.98	0.023
CMEs, JPY										
Irregular	502	1 186 085	1 838 978	0.008	Ref.					
Subregular	341	1 304 509	1 504 154		1.10	0.97 to 1.24	0.126	1.08	0.96 to 1.22	0.196
Regular	320	1 215 408	1 949 321		1.03	0.90 to 1.16	0.703	0.96	0.85 to 1.09	0.542

¥100≈US$1. Dental CF, CDEs and CMEs were used for a pooled 12-year period. Younger adults: 20–39 years, middle-aged adults: 40–59 years, regular: once per year, subregular: at least once per 2 years, irregular: others.
*Using the Kruskal-Wallis test.
†cOR and 95% CI were calculated by generalised linear model with a Tweedie distribution of log link.
‡aOR and 95% CI were calculated by generalised linear model with a Tweedie distribution of log link after adjustment for sex, age, type of occupation and CMEs in 2002.
aOR, adjusted OR; CDEs, cumulative dental expenditures; CF, check-up fee; CMEs, cumulative medical expenditures; cOR, crude OR.

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Table 4 Sensitivity analysis of cumulative dental expenditures, added dental check-up fees and cumulative medical expenditures in a 12-year period

	N	Mean	SD	P value*	Crude OR	95% CI	P value†	Adjusted OR	95% CI	P value‡
Overall (n=2586)										
CDEs and dental CF, JYP										
Irregular	912	240 461	203 601	<0.001	Ref.					
Subregular	877	214 122	220 218		0.89	0.83 to 0.96	0.001	0.93	0.87 to 0.99	0.046
Regular	797	202 281	190 324		0.84	0.78 to 0.91	<0.001	0.89	0.83 to 0.96	0.003
CMEs, JPY										
Irregular	912	929 481	1 563 702	0.731	Ref.					
Subregular	877	905 054	1 270 342		0.97	0.90 to 1.06	0.537	0.97	0.89 to 1.05	0.967
Regular	797	907 259	1 487 887		0.98	0.90 to 1.07	0.585	0.99	0.91 to 1.08	0.989
Younger adults (n=1488)										
CDEs and dental CF, JPY										
Irregular	475	205 917	176 061	0.014	Ref.					
Subregular	536	183 111	191 786		0.89	0.81 to 0.98	0.016	0.88	0.80 to 0.97	0.009
Regular	477	180 974	158 222		0.88	0.80 to 0.97	0.010	0.87	0.79 to 0.96	0.006
CMEs, JPY										
Irregular	475	717 706	1 169 612	0.765	Ref.					
Subregular	536	650 923	1 018 878		0.91	0.89 to 1.05	0.087	0.85	0.76 to 0.95	0.005
Regular	477	700 535	1 024 149		0.98	0.81 to 1.01	0.677	0.95	0.85 to 1.06	0.365
Middle-aged adults (n=1098)										
CDEs and dental CF, JPY										
Irregular	437	278 009	224 058	<0.001	Ref.					
Subregular	341	262 868	251 340		0.95	0.86 to 1.05	0.352	1.00	0.90 to 1.11	0.983
Regular	320	234 041	226 587		0.84	0.75 to 0.94	0.002	0.92	0.82 to 1.02	0.122
CMEs, JPY										
Irregular	437	1 159 672	1 876 128	0.004	Ref.					
Subregular	341	1 304 509	1 504 154		1.13	0.99 to 1.28	0.066	1.08	0.95 to 1.22	0.255
Regular	320	1 215 408	1 949 321		1.05	0.92 to 1.19	0.476	1.00	0.88 to 1.13	0.953

¥100≈US$1. Dental CF, CDEs and CMEs were used for a pooled 12-year period. Younger adults: 20–39 years, middle-aged adults: 40–59 years, regular: once per year, subregular: at least once per 2 years, irregular: others

*Using Kruskal-Wallis test.

†cOR and 95% CI were calculated by generalised linear model with a Tweedie distribution of log link.

‡aOR and 95% CI were calculated by generalised linear model with a Tweedie distribution of log link after adjustment for sex, age, type of occupation, decayed teeth, missing teeth, CPI and total MEs in 2002.

aOR, adjusted OR; CDEs, cumulative dental expenditures; CF, check-up fee; CMEs, cumulative medical expenditures; cOR, crude OR; CPI, Community Periodontal Index.

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type of occupation, decayed teeth, missing teeth, CPI and total MEs in 2002. CDEs and dental CF were significantly higher in the subregular group (aOR=0.93, p=0.046) and the regular group (aOR=0.89, p=0.003) than the irregular group. In younger adults, CDEs and dental CF were significantly higher in the irregular group than the subregular group (aOR=0.88, p=0.009) and the regular group (aOR=0.87, p=0.006). Furthermore, CMEs were significantly lower in the subregular group (aOR=0.85, p=0.005) than in the irregular group. In middle-aged adults, CDEs and dental CF tended to be lower in the regular group than in the irregular group and the subregular group, but the differences were not significant.

DISCUSSION

In this longitudinal study, we found that a higher frequency of dental check-ups among a 12 year period was associated with CDEs (including dental CF). The same results were obtained for young adults. The middle-aged group showed lower CDEs only in the regular dental check-up group. The sensitivity analysis also confirmed these results. To the best of our knowledge, this is first report of a long-term study to show that the frequency of dental check-ups, even including dental check-up fees, had an impact on the reduction of CDEs.

All 2691 participants were followed for 12 years. Compared with the irregular group, the dental check-up interval for the regular and subregular groups was most effective for controlling the excess DEs adjusted for age and sex, type of occupation and MEs at baseline or adjusted for the addition of initial dental examination results (D, M or CPI) in the sensitivity analysis. These results are consistent with previous studies, which found lower CDEs in frequent dental check-up groups than in infrequent groups.[23 27 28] In terms of preventive dental visit intervals, the National Institute for Health and Care Excellence recommends that a preventive dental visit interval of 24 months should be the longest interval for those 18 years and older based on individual risk.[29] Moreover, the Scientific Basis of Dental Health Education policy document and other reports advocate at least one visit per year to promote oral health.[25 30 31] Previous studies reported the importance of oral health motivation and dental health guidance from a younger age in order to maintain lifelong oral health.[32] In this study, from a long-term perspective, we were able to clarify that regular dental check-ups (once a year) were effective in controlling CDEs. In addition, from the perspective of controlling CDEs, we were able to demonstrate the importance of encouraging young adults to have dental check-ups and to maintain their oral health continuously.

Japan's medical insurance is based on a 'universal health insurance system', which allows anyone to freely use medical facilities (including dental care) and receive advanced medical care when they become ill. Company employees are enrolled in a health insurance association, and the copayment rate for medical expenses is 30%. In addition, to maintain the physical and mental health of employees, employers are required to conduct periodic health check-ups (not including dental check-ups) once a year. Dental check-ups are conducted at the discretion of health insurance societies or companies. In this study, the subjects were employees of a company that first introduced worksite dental check-ups for all employees in 2002. The participation rate was 96.1%, which was suitable for a follow-up study of the relationship among worksite dental check-ups and CDEs and CMEs, with little bias due to lost to follow-up. Medical costs fluctuate from year to year for individuals, and this study used cumulative costs, which limited time-related bias.

Some factors that contribute to excess DEs include poor periodontal status and poor toothbrushing habits.[12 13] A longitudinal study that compared participants and non-participants in dental check-ups found that the non-participants had poorer oral health (decayed teeth, CPI, toothbrushing habits) than the participants.[33] These results suggest that non-participants may be at risk of further deterioration of their oral condition by missing the opportunity for dental check-ups. Thus, it is necessary to establish a system that allows all workers to receive dental check-ups within a certain period. Delayed detection of oral diseases may lead to increased DEs due to the severity of the disease, dentist expenses and higher-cost treatment.[12 14 34] In addition, inadequate health literacy has been associated with poor oral health behaviours and worse clinical conditions.[35–37] On the other hand, people with high levels of health literacy more frequently visit dental services.[36] There were some reports that dental fear was related to reasons for delaying or avoiding dental visits.[38 39] In the present dental check-up, dental hygienists instruct participants to brush their teeth according to their oral conditions and recommend dental visits for those that require treatment. Therefore, periodically undergoing dental check-ups leads to better health behaviours and encourages people to acquire correct knowledge and increase their health literacy through repeated dental health guidance.[40]

Recently, the relationship among dental caries and periodontal disease, the major causes of tooth loss, and general health has been clarified. In particular, the chronic inflammation of periodontal disease, a lifestyle-related disease, affects systemic inflammation and may affect general health. A previous study reported that routine periodontal assessment may prevent periodontal complications among patients with diabetes and another 12-year follow-up study showed that having fewer teeth at baseline significantly increased the risk of development of stroke.[41 42] In addition, association with various NCDs has been shown, including cardiac disease (CVD), diabetes, metabolic syndrome, chronic respiratory disease and stroke.[3–7 43–47] The occurrence and progression of periodontal disease may contribute to the increase of NCDs and healthcare costs, as well as DEs.[48 49] However, in the present long-term longitudinal study, there was no association between frequency of dental check-ups and CMEs.

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Possible causes included that the employees were relatively healthy employees and were relatively young in this study. Long-term studies in the community are needed to test this hypothesis.

This study had several limitations. First, as this study was based on the results of one company's employees, generalisation was limited and should be used with caution when interpreting the results. Second, the study design was not a randomised controlled trial (RCT) because the dental check-up programme was conducted in conjunction with general health check-ups in the company. Future studies using RCTs are necessary to evaluate the effectiveness of dental check-ups. Third, regarding social economic statuses (SES), data were only available for occupational categories, so we were not able to adjust for other factors such as education and income. However, since the type of occupation is a constant reflection of education and income, this study considered the impact of SES to be minimal. To clarify the relationship between dental check-ups and dental and medical expenditures, future analyses including the effects of SES, medical history, biochemical data and MEs for each disease related to dental disease are needed.

Despite these limitations, the strength of the current study was that it provided the first long-term report of effective intervals in worksite dental check-ups for good/better health and CDEs. In addition, this study suggests that implementation of worksite dental check-ups, including dental check-ups fee, had a long-term impact on control of CDEs.

In conclusion, the current findings indicate that there was a relationship between regular worksite dental check-ups and lower CDEs. It is important to promote a yearly interval between dental check-ups.

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