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

Toru Ichihashi,1,2 Ayae Goto,1 Enkhtuguldur Myagmar-Ochir,2 Yasuo Haruyama,3 Takashi Muto,2 Gen Kobashi1,2,3

Objective 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 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.

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 accounted for 6.9%, approximately ¥3 trillion (about US$273 billion). 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. In particular, periodontal diseases have been shown to be associated with an increased risk of non-communicable diseases such as diabetes and cardiovascular disease. 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. Thus, oral health is generally considered one of the most important indicators for well-being. 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,
Subjects who completed the follow-up survey between 2002 and 2014 FY

(n=2,691)

Subjects categorized by frequency of dental checkups

Irregular group
(n=1,017)

Subregular group
(n=877)

Regular group
(n=797)

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.12,15 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 χ² 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,
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%.

**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
Ichihashi T, et al. BMJ Open 2022;12:e063658. doi:10.1136/bmjopen-2022-063658

(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,
## 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.
### 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, JPY|     |       |      |          |                 |          |                     |          |
| 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| 1563.702|0.731| Ref.           |          |                     |          |
| Subregular             | 877 | 905.054| 1270.342|0.97| 0.90 to 1.06 | 0.537    | 0.97                | 0.89 to 1.05| 0.967 |
| Regular                | 797 | 907.259| 1487.887|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| 1169.612|0.765| Ref.           |          |                     |          |
| Subregular             | 536 | 650.923| 1018.878|0.91| 0.89 to 1.05 | 0.087    | 0.85                | 0.76 to 0.95| 0.005 |
| Regular                | 477 | 700.535| 1024.149|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 | 1159.672| 1876.128|0.004| Ref.           |          |                     |          |
| Subregular             | 341 | 1304.509| 1504.154|1.13| 0.99 to 1.28 | 0.066    | 1.08                | 0.95 to 1.22| 0.255 |
| Regular                | 320 | 1215.408| 1949.321|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.
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 in 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 36 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.
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.

Acknowledgements We thank the participants, target companies and relevant health insurance associations for their participation in this study and Mr. Hassett William for the English check. We would like to express our profound gratitude to the people of the Lion Foundation for Dental Health for their assistance this research.

Contributors TI was responsible for this study. TI and YH contributed to the study concept and design. TI and AG were involved in the acquisition of data. TI, EM-M and EMM were involved in the design, or conduct, or reporting, or dissemination plans of this research.

Funding This study was partially supported by a research grant (19-1-02) from the 8020 Promotion Foundation, Japan.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval Written informed consent was provided by participants to participate according to the Declaration of Helsinki, and ethical approval was given by the Ethical Review Committee of the Japanese Society for Oral Health (No. 27-7).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement No data are available.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/.

ORCID iD

Toru Ichihashi http://orcid.org/0000-0001-8235-6585

REFERENCES

1 Ministry of Health, Labour and Welfare. Survey on the trend of medical care expenditures, 2019. Available: https://www.mhlw.go.jp/topics/media/years/19/di/iryouhi_data.pdf [Accessed 28 Mar 2022].

2 Kino S, Bernabe E, Sabbath W. The role of healthcare system in dental check-ups in 27 European countries: multilevel analysis. J Public Health Dent 2017;77:24–51.

3 Morita T, Yamazaki Y, Mita A, et al. A cohort study on the association between periodontal disease and the development of metabolic syndrome. J Periodontol 2010;81:512–9.

4 Myllymäki V, Saxlin T, Knutttila M, et al. Association between periodontal condition and the development of type 2 diabetes mellitus-results from a 15-year follow-up study. J Clin Periodontol 2018;45:1276–86.

5 Kudo C, Shin WS, Sasaki N, et al. Effects of periodontal treatment on carotid intima-media thickness in patients with lifestyle-related diseases: Japanese prospective multicentre observational study. Odontontology 2018;106:316–27.

6 Kran M, Arpak N, Unsal E, et al. The effect of improved periodontal health on metabolic control in type 2 diabetes mellitus. J Clin Periodontol 2005;32:256–72.

7 Katagiri S, Nitta H, Nagasawa T, et al. Multi-center intervention study on glycohemoglobin (HbA1c) and serum, high-sensitivity CRP (hs-CRP) after local anti-infectious periodontal treatment in type 2 diabetic patients with periodontal disease. Diabetes Res Clin Pract 2009;83:308–15.

8 Kuwabara M, Motoki Y, Ichihara K, et al. Association between toothbrushing and risk factors for cardiovascular disease: a large-scale, cross-sectional Japanese study. BMJ Open 2016;6:e009870.

9 Farquhar DR, Divaris K, Mazul AL, et al. Poor oral health affects survival in head and neck cancer. Oral Oncol 2017;73:111–7.

10 Darnaud C, Thomas F, Pannier B, et al. Oral health and blood pressure: the IPC cohort. Am J Hypertens 2015;28:1257–61.

11 Hescot P. The new definition of oral health and relationship between oral health and quality of life. Chin J Dent Res 2017;20:189–92.

12 Iide R, Hashiyama T, Takahashi K. The effect of periodontal disease on medical and dental costs in a middle-aged Japanese population: a longitudinal worksite study. J Periodontol 2007;78:2120–6.

13 Kim YJ. Oral health of high-cost patients and evaluation of oral health measures as predictors for high-cost patients in South Korea: a population-based cross-sectional study. BMJ Open 2019;9:e032446.

14 Saito M, Shimazaki Y, Nonoyama T, et al. Associations of number of teeth with medical costs and hospitalization duration in an older Japanese population. Geriatr Gerontol Int 2019;19:335–41.

15 Fishwick MR, Ashley FP, Wilson RF. Can a workplace preventive programme affect periodontal health? Br Dent J 1998;184:290–3.

16 Schou L. Oral health promotion at worksites. Int Dent J 1989;39:122–8.

17 Westerman B. Appropriate dental care for employees at the workplace. Aust Dent J 1993;38:471–5.

18 Petersens PE. Evaluation of a dental preventive program for Danish chocolate workers. Community Dent Oral Epidemiol 1989;17:53–9.

19 Ahlberg J, Tuominen R, Murtomaa H. Dental knowledge, attitudes towards oral health care and utilization of dental services among male industrial workers with or without an employer-provided dental benefit scheme. Community Dent Oral Epidemiol 1996;24:380–4.

20 Lim LP, Davies W. Comparison of various modalities of “simple” periodontal therapy on oral cleanliness and bleeding. J Clin Periodontol 1996;23:595–600.

21 Lie T, Due NA, Abrahamsen B, et al. Periodontal health in a group of industrial employees. Community Dent Oral Epidemiol 1988;16:42–6.

22 Ahlberg J, Tuominen R, Murtomaa H. A 5-year retrospective analysis of employer-provided dental care for Finnish male industrial workers. Community Dent Oral Epidemiol 1997;25:419–22.

23 Oshikoji T, Shimazaki Y, Shinagawa T, et al. Relationship between receiving a workplace oral health examination including oral health instruction and oral health status in the Japanese adult population. J Occup Health 2011;53:222–9.

24 Renvert S, Persson RE, Persson GR. A history of frequent dental care reduces the risk of tooth loss but not periodontitis in older subjects. Swed Dent J 2011;35:69–75.
25 Åström AN, Ekback G, Ordell S, et al. Long-term routine dental attendance: influence on tooth loss and oral health-related quality of life in Swedish older adults. Community Dent Oral Epidemiol 2014;42:460–9.

26 Albert DA, Sadowsky D, Papapanou P, et al. An examination of periodontal treatment and per member per month (PMPM) medical costs in an insured population. BMC Health Serv Res 2006;6:103.

27 Ide R, Mizoue T, Tsukiyama Y, et al. Evaluation of oral health promotion in the workplace: the effects on dental care costs and frequency of dental visits. Community Dent Oral Epidemiol 2001;29:213–9.

28 Ichihashi T, Muto T. Effectiveness of worksite dental health promotion activities in terms of dental and medical expenses and number of visits for treatment. J Dent Hlth 2001;51:168–75.

29 National Institute for Health and Care Excellence. Dental checks: intervals between oral health reviews. Available: https://www.nice.org.uk/guidance/cg19 [Accessed 01 Sep 2021].

30 The Health Education Authority. The scientific basis of dental health education: a policy document. 4th ed, 1996.

31 Richards W, Ameen J. The impact of attendance patterns on oral health in a general dental practice. Br Dent J 2002;193:697–702.

32 Takeuchi K, Sato Y, Suma S, et al. Associations of oral health status and dental health service utilization with dental and medical expenditures. J Dent Hlth 2017;67:160–71.

33 Ichihashi T, Nishinoue N, Takada K, et al. Comparison of oral health status and health behaviors between participants and Non-participants of voluntary participation-based occupational oral health program. J Dent Health 2013;63:238–48.

34 Moeller JF, Chen H, Manski RJ. Investing in preventive dental care for the Medicare population: a preliminary analysis. Am J Public Health 2010;100:2262–70.

35 Jones M, Lee JY, Rozier RG. Oral health literacy among adult patients seeking dental care. J Am Dent Assoc 2007;138:199–208.

36 Ueno M, Takeuchi S, Oshiro A, et al. Relationship between oral health literacy and oral health behaviors and clinical status in Japanese adults. J Dent Sci 2013;8:170–6.

37 Silva-Junior MF, Rosário de Sousa MdAL, Batista MJ. Health literacy on oral health practice and condition in an adult and elderly population. Health Promot Int 2021;36:933–42.

38 Schuller AA, Willumsen T, Holst D. Are there differences in oral health and oral health behavior between individuals with high and low dental fear? Community Dent Oral Epidemiol 2003;31:116–21.

39 Milgrom P, Newton JT, Boyle C, et al. The effects of dental anxiety and irregular attendance on referral for dental treatment under sedation within the National health service in London. Community Dent Oral Epidemiol 2010;38:453–9.

40 Teusner D, Smith V, Gnanamanickam E, et al. Examining dental expenditure and dental insurance accounting for probability of incurring expenses. Community Dent Oral Epidemiol 2017;45:101–11.

41 Nazir MA, AlGHamdi L, AlKadi M, et al. The burden of diabetes, its oral complications and their prevention and management. Open Access Maced J Med Sci 2018;6:1545–53.

42 Joshipura KJ, Hung H-C, Rimm EB, et al. Periodontal disease, tooth loss, and incidence of ischemic stroke. Stroke 2003;34:47–52.

43 Wolf TG, Cagetti MG, Fisher J-M, et al. Non-communicable diseases and oral health: an overview. Front Oral Health 2021;2:725460.

44 Borgnakke WS, Ylöstalo PV, Taylor GW, et al. Effect of periodontal disease on diabetes: systematic review of epidemiologic observational evidence. J Periodontol 2013;841340013:S135–52.

45 Pradeep AR, Hadge P, Arjun Raju P, et al. Periodontitis as a risk factor for cerebrovascular accident: a case-control study in the Indian population. J Periodontal Res 2010;45:223–38.

46 Fagundes NFC, Almeida ACPSC, Vilhena KFB, et al. Periodontitis as a risk factor for stroke: a systematic review and meta-analysis. Vasc Health Risk Manag 2019;15:519–32.

47 Kim H-D, Sim S-J, Moon J-Y, et al. Association between periodontitis and hemorrhagic stroke among Koreans: a case-control study. J Periodontol 2010;81:658–65.

48 Harada E, Moriya S, Murata A, et al. Relationship between subjective assessment of oral health and medical expenses in community-dwelling elderly persons. Gerodontology 2012;29:e246–52.

49 Sato M, Iwasaki M, Yoshihara A, et al. Association between periodontitis and medical expenditure in older adults: a 33-month follow-up study. Genatr Gerontol Int 2016;16:856–64.