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Original Article

Cross-sectional associations between oral diseases and work productivity loss among regular employees in Japan

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Abstract: The association between oral diseases and work productivity loss remains unclear. This study examined whether dental caries, tooth loss, and poor periodontal status were associated with absenteeism and presenteeism. This cross-sectional study used two independent datasets: 184 employees at a medical university and 435 employees from among the registrants of an online research company. Absenteeism and presenteeism, according to the World Health Organization Health and Work Performance Questionnaire, were dependent variables. The independent variables were the number of decayed and filled teeth (DFT), missing teeth (MT), and self-reported periodontal status. Multivariable linear regression models were developed to estimate unstandardised coefficients with 95% confidence intervals (CIs) for absenteeism and presenteeism. After adjusting for covariates, among the 435 employees enrolled from among the registrants of an online research company, poor periodontal status was significantly associated with a 7.8% (95%CI = −14.5, −1.0) decline in presenteeism but not absenteeism. DFT and MT were not significantly associated with either absenteeism or presenteeism in both populations. Given that periodontal status was potentially associated with a 7.8% decline in work performance, occupational specialists, managers, and dental health professionals should be aware of the impact on work productivity.

Key words: Absenteeism, Presenteeism, Oral health, Work performance, Work productivity

Introduction

Health problems lead to work productivity loss[1, 2]. Work-related health problems potentially account for 4–6% of gross domestic product loss[3]. Productivity loss among workers includes absenteeism and presenteeism. Absenteeism is defined as work hours lost owing to disease, and presenteeism is defined broadly as a decline in work performance[4, 5]. In particular, costs from presenteeism can be larger than costs from absenteeism[2].

Oral diseases, such as dental caries and periodontal disease, have important implications for work productivity[6, 7]. Dental treatment requires relatively long visits to clinics that can lead to work absence. Dental caries often induces acute pain, which could decrease productivity. Periodontal

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disease also causes pain and discomfort. Tooth loss, which is a consequence of both dental caries and periodontal disease, is linked to a decline in the ability to eat, sleep, and communicate. Oral diseases affect communication skills and satisfaction with personal appearances and these can impair work performance.

Several studies have estimated the loss of work hours due to oral diseases[8–16]. Among the four US studies[8–11], the latest study using the National Health Interview Survey estimated that, in 2008, 320.8 million work or school hours were lost due to dental care[8]. In Canada, between 2007 and 2009, an average of 3.5 hours loss per participant, which amounted to 40.36 million hours, was attributed to dental problems and treatment[12]. An Australian study reported an annual average of 0.23 occasions of missed work and 0.15 occasions of reduced activity owing to dental problems in 2010[13]. Two Brazilian studies indicated that dental pain in the last 6 months might have correlated to missed work among approximately 15% of the entire cohort of workers[14, 15]. A study in Spain indicated that 2.8% of the worker participants reported short-term work absences due to oral diseases whereas 4.1% reported difficulties in working in the past 12 months[16]. Worldwide, the total cost of productivity loss in 2015 was estimated at $187.61 billion[17]. However, earlier studies reported only the impact of oral diseases and treatments on work hour loss, whereas studies on presenteeism seem to be scarce. Only one study reported an association between oral diseases and presenteeism[18]. Zaitsu *et al.* indicated that only periodontal disease was associated with a two-fold risk of presenteeism in the preceding year. This study has two limitations. First, presenteeism was assessed using a questionnaire of which potential answer was a dichotomised category (yes or no). Presenteeism is generally measured based on a self-rating score[19]. Thus, it is evident that the degree of decline in work performance due to periodontal disease has not been ascertained yet. Moreover, potential confounders, such as socioeconomic status and work-related variables, were not sufficiently considered. Therefore, we aimed to examine whether dental caries, tooth loss, and poor periodontal status were cross-sectionally associated with absenteeism and presenteeism, according to the World Health Organization Health and Work Performance Questionnaire (WHO-HPQ), among regular employees in Japan with consideration of potential confounders, such as socioeconomic status and work-related variables.

Subjects and Methods

Ethical considerations

All experiments adhered to the principles of the Declaration of Helsinki and the Ethical Guidelines for Medical and Health Research Involving Human Subjects of the Japan Ministry of Health, Labour, and Welfare. The study protocol was reviewed and approved by the Asahikawa Medical University Research Ethics Committee (No. 18273). All participants provided informed consent before responding to the questionnaire.

Data sources and participants

This cross-sectional study included two target populations of adults aged 20–64 years in Japan. The participants were recruited separately, from two independent populations. The first target population consisted of employees (mainly healthcare and office workers) at a medical university. The second target population consisted of registrants of an online research company (mainly administrative and managerial, professional and engineering, and clerical workers). Prior to the participant recruitment, we set two target populations to cover a broad range of job categories. The inclusion criteria were regular full-time employment and age 20–64 years. We conducted a self-administered questionnaire, in both of the target populations, to obtain data on demographic characteristics, work-related variables, socioeconomic status, and self-reported periodontal disease-related questions. In the medical university population, decayed, missing, and filled teeth (DMFT) was determined based on a clinical dental examination. On the other hand, among the participants enrolled from the online research company's registrant population, DMFT were estimated by using the intraoral photographs captured by the participants themselves.

In the medical university population, all 2,006 employees were invited to complete a self-administered questionnaire between 19 October and 20 December 2020. Among them, 910 employees responded, of which 568 were regular employees aged 20–64 years. Of the 568 employees, 41 did not consent to the use of their dental examination records. Between 7 December and 18 December 2020, we organised a dental examination to determine the number of DMFT, among 28 teeth (excluding wisdom teeth) for the remaining 527 regular employees. After they were sent reminders, 184 employees underwent the dental examination, which did not include any evaluation of the clinical periodontal status. Thus, 184 regular employees, from the med-

Supplemental Table 1. Percentages of undiagnosable teeth from intraoral photographs taken with mobile phones

Tooth number	17	16	15	14	13	12	11	21	22	23	24	25	26	27
Percentage of undiagnosable teeth	27.8%	4.8%	1.6%	1.8%	5.7%	1.6%	0.5%	0.7%	1.1%	3.9%	1.6%	2.1%	5.1%	28.0%
Tooth number	**47**	**46**	**45**	**44**	**43**	**42**	**41**	**31**	**32**	**33**	**34**	**35**	**36**	**37**
Percentage of undiagnosable teeth	10.1%	1.8%	0.5%	1.6%	3.2%	0.9%	0.2%	0.2%	0.9%	1.4%	1.8%	0.9%	1.8%	9.0%

ical university, were included in this study.

Similarly, the registrants of an online research company population were provided with a self-administered questionnaire between 20 November and 16 December 2020. Those aged 20–64 years, who noted themselves as being regular employees, and completed the questionnaire, were included in this study. In total, 3,852 participants completed the questionnaire. The participants were then asked to capture intraoral photographs with their mobile phones. Therefore, DMFT were estimated by using the intraoral photographs, and any clinical periodontal status could not be assessed. Of the 3,852 participants, after received reminders, 565 completed uploading their photographs between 3 December 2020 and 12 January 2021. Suitable photographs were obtained from 435 participants; therefore, 435 regular employees recruited from the online research company, were included in this study.

The reasons for refusal to participate of all of the individuals who declined to participate in this study are unknown.

Independent variable: Dental caries, tooth loss, and periodontal status

The number of decayed and filled teeth (DFT), and missing teeth (MT), among 28 teeth (excluding wisdom teeth) were used to assess dental caries and tooth loss, respectively[20].

In the medical university population, the dental examination for DMFT was conducted by a dentist who followed the standardised oral health survey methods of the World Health Organization (WHO) guidelines[20]. A dental mirror was used for visual inspection to assess DMFT.

In the registrants of an online research company population, we assessed DFT and MT based on intraoral photographs. The participants provided two intraoral photographs of the upper and lower jaws. The diagnoses of DMFT, using the intraoral photographs, were determined by two independent dental clinicians who followed the WHO guidelines[20]. For tooth status diagnosis, in order to not overestimate DFT and MT, tooth status was determined to be healthy if the tooth condition was unknown, or tooth presence, or absence, was unclear. Any differences in diagnoses between the two dental clinicians were resolved through discussion. Supplemental Table 1 shows percentages of each undiagnosable tooth. Molars had a higher percentage of undiagnosed than incisors and premolars.

In both target populations, poor periodontal status was assessed using a self-administered questionnaire. In order to screen for periodontal inflammation, we asked four questions regarding smoking status, gingival bleeding, exposed tooth root, and periodontal treatment experience[21]. The potential answer to each question was 'yes' or 'no'. According to the cut-off point, if at least three questions were applicable to participants, then they were determined as having poor periodontal status[21]. The cut-off point was defined based on a clinical attachment loss of 7 mm or more[21].

Dependent variable: Absolute absenteeism and absolute presenteeism according to the World Health Organization Health and Work Performance Questionnaire

We used the Japanese version of the short form of the World Health Organization Health and Work Performance Questionnaire (WHO-HPQ) to assess absenteeism and presenteeism[19, 22, 23]. Absolute absenteeism and absolute presenteeism were used as dependent variables. Absolute absenteeism is defined as the total hours lost per month using 4-week estimates, which indicates a plus score as the number of lost work hours and a minus score as the number of excessive work hours. The difference in absolute absenteeism is applied to work hours lost regardless of any reason. Absolute presenteeism indicates the percentage of work performance, which ranges from 0 (total lack of performance during the time on the job) to 100 (no lack of performance during the time on the job). The difference in absolute presenteeism is applied to differences in work performance regardless of any reason. We calculated absolute absenteeism and absolute presenteeism following the established procedure[19, 22, 23].

Covariates

The following factors were selected as covariates: age, sex (men and women) psychological distress (none [0–4] and present [≥5]) according to the Kessler Psychological Distress Scale (K6)[24, 25], smoking status (never, former, and current), a history of diabetes (yes and no), and mental dis-

orders (yes and no). Additionally, information on socioeconomic status, annual household income (less than 5 million yen, 5 to 7.9 million yen, 8 to 9.9 million yen, and over 10 million yen) and education (high school or lower, professional training college, junior college, and technical college, and university or higher) were included. To consider work characteristics, years of service with the current company, job type (administrative and managerial, professional and engineering, clerical, and others), occupational status (untitled and titled), and the effort-reward imbalance ratio[26, 27] were also included. Job type categories were determined based on the Japan Standard Occupational Classification, which roughly follows the International Standard Classification of Occupations and International Standard Industrial Classification, because of the diverse job types of the second target population. As the proportions of participants in some job categories were small; therefore, these jobs were classified in the 'others' category.

Statistical analysis

Linear regression analysis was employed to estimate unstandardised coefficients and 95% confidence intervals of the absolute absenteeism score and the absolute presenteeism score, respectively. We created the following three models: the age- and sex-adjusted model, the fully adjusted model, and the fully adjusted model simultaneously including dental caries, tooth loss, and periodontal status. The fully adjusted model included age, sex, psychological distress, smoking status, a history of diabetes, a history of mental disorders, annual household income, education, years of service with the current company, job type, occupational status, and the effort-reward imbalance ratio. When periodontal status was included as a dependent variable, smoking status was excluded since the screening questionnaire consisted of current smoking status. Based on the screening questionnaire, only one participant among the employees at the medical university was ascertained to have poor periodontal status; therefore, no analysis of poor periodontal status was conducted in this population.

The k-nearest neighbour imputation method was employed independently for each population using the R package VIM[28]. The k-nearest neighbour imputation method and the R-package VIM are widely accepted methods for imputing missing values[28]. Two-tailed P values of <0.05 were considered statistically significant and 95% confidence intervals (CIs) were applied. All analyses were conducted using R software (ver. 4.1.0; R Foundation for Statistical Computing) for macOS.

Results

This study included 184 regular employees at a medical university and 435 regular employees from among the registrants of an online research company. Table 1 shows characteristics, oral diseases, presenteeism and presenteeism of the participants. The median age (with 1st and 3rd quantile) in the first and second populations was 31 (26, 42) and 46 (37, 53) years, respectively. The percentage of women was 56.5% and 30.6% in the first and second populations, respectively. The mean absolute absenteeism (with standard deviation) in the first and second populations was −12.5 (66.6) and −9.5 (58.1) hours, respectively. The mean absolute presenteeism (standard deviation) in the first and second populations was 57.1 (17.7) and 63.0 (17.7) hours, respectively. The median numbers of DFT and MT in the first and second populations were 4 and 3, and 8 and 0, respectively. In the first population, only one participant was applicable to poor periodontal status, whereas, in the second population, 6.7% of participants had poor periodontal status. In both populations, >70% of the participants had a university degree or higher education. Most participants were in administrative and managerial, professional and engineering, or clerical jobs.

Table 2 shows the work hours lost and the percentage of work performance according to job types. Only administrative and managerial workers of the first target population had longer work hours than expected whereas the others had shorter than expected work hours. Administrative and managerial workers of the first target population and all job type workers of the second targeted population assessed their work performance as >60% whereas the remainder assessed their work performance as <60%.

Table 3 shows associations of dental caries, tooth loss, and poor periodontal status with absenteeism after imputation. In the first population, after adjusting the covariates, the unstandardised coefficients of DFT and MT for the absolute absenteeism were 0.0 (95% CI = −2.5, 2.6) and -1.3 (95% CI = −7.5, 4.8), respectively. In the second population, when oral health indicators were simultaneously included in the fully adjusted model, the unstandardised coefficients of DFT, MT, and poor periodontal status for the absolute absenteeism were 1.0 (95% CI = −0.2, 2.1), −0.3 (95% CI = −4.0, 3.5), and 12.8 (95% CI = −10.2, 35.9), respectively.

Table 4 shows associations of dental caries, tooth loss, and poor periodontal status with presenteeism after imputation. In the first population, after adjusting the covariates, the unstandardised coefficients of DFT and MT for the ab-

Table 1. Basic characteristics, oral diseases, presenteeism, and presenteeism of participants

Variable	Category		First target population (employees at a medical university) (n=184)		Second target population (employees from among registrants of an online research company) (n=435)	
Decayed and filled teeth (DFT)		Median, 1st and 3rd quantiles	4	1, 7	8	4, 12
Missing teeth (MT)		Median, 1st and 3rd quantiles	3	2, 3	0	0, 0
Poor periodontal status	None	N, %	178	96.7	406	93.3
	Having	N, %	1	0.5	29	6.7
	Missing	N, %	5	2.7	0	0.0
Age		Median, 1st and 3rd quantiles	31	26, 42	46	37, 53
Sex	Men	N, %	79	42.9	302	69.4
	Women	N, %	104	56.5	133	30.6
	Missing	N, %	1	0.5	0	0.0
Psychological distress	none [0–4]	N, %	118	64.1	273	62.8
	having [≥5]	N, %	64	34.8	157	36.1
	Missing	N, %	2	1.1	5	1.1
Smoking status	Never	N, %	150	81.5	249	57.2
	Former	N, %	26	14.1	100	23.0
	Current	N, %	6	3.3	86	19.8
	Missing	N, %	2	1.1	0	0.0
History of diabetes		Median, 1st and 3rd quantiles	3	1.6	13	3.0
History of mental disorders		Median, 1st and 3rd quantiles	3	1.6	53	12.2
Annual household income	less than 5 million yen	N, %	65	35.3	81	18.6
	5 to 7.9 million yen	N, %	40	21.7	130	29.9
	8 to 9.9 million yen	N, %	23	12.5	95	21.8
	over 10 million yen	N, %	37	20.1	114	26.2
	Missing	N, %	19	10.3	15	3.4
Education	High school or lower	N, %	6	3.3	42	9.7
	Professional training college, junior college, and technical college	N, %	42	22.8	53	12.2
	University or higher	N, %	136	73.9	339	77.9
	Missing	N, %	0	0.0	1	0.2
Years of service with the current company		Median, 1st and 3rd quantiles	5	2, 10	13	7, 23
	Missing	N, %	6	3.3	0	0.0
Job type	Administrative and managerial	N, %	31	16.8	91	20.9

Table 1. Continued

Variable	Category		First target population (employees at a medical university) (n=184)		Second target population (employees from among registrants of an online research company) (n=435)	
	Professional and engineering	N, %	139	75.5	110	25.3
	Clerical	N, %	0	0.0	145	33.3
	Others	N, %	14	7.6	89	20.5
Occupational status	Untitled	N, %	98	53.3	212	48.7
	Titled	N, %	85	46.2	215	49.4
	Missing	N, %	1	0.5	8	1.8
Effort-reward imbalance ratio		Mean, standard deviation	1.08	0.34	1.14	0.52
	Missing	N, %	4	2.2	0	0.0
Absolute absenteeism (working hour lost)		Mean, standard deviation	−12.5	66.6	−9.5	58.1
	Missing	N, %	8	4.3	0	0.0
Absolute presenteeism (percentage of work performance)		Mean, standard deviation	57.1	17.7	63.0	17.7
	Missing	N, %	2	1.1	0	0.0

Psychological distress was assessed using the Kessler Psychological Distress Scale (K6).

Poor periodontal status was detected using a screening questionnaire for employees.

Absolute absenteeism and absolute presenteeism were assessed using the World Health Organization Health and Work Performance Questionnaire.

Table 2. Work hours lost and percentages of work performance according to job types

Populations	Job type	Absolute absenteeism (work hours lost)		Absolute presenteeism (percentage of work performance)	
		Mean	Standard deviation	Mean	Standard deviation
First target population (employees at a medical university)	Administrative and managerial worker	2.7	47.6	63.2	14.5
	Professional and engineering worker	−15.2	72.2	55.6	18.0
	Clerical worker	-	-	-	-
	Others	−20.7	39.2	58.6	18.8
Second target population (employees from among registrants of an online research company)	Administrative and managerial worker	−11.6	52.2	64.4	19.6
	Professional and engineering worker	−18.1	57.2	63.0	16.6
	Clerical worker	−1.9	54.8	62.2	16.7
	Others	−9.2	68.4	62.8	18.8

Absolute absenteeism indicates a plus score as the number of lost work hours and a minus score as the number of excessive work hours.

Table 3. Associations of dental caries, tooth loss, and poor periodontal status with absenteeism after imputation

First target population (employees at a medical university) (n=184)

		Age- and sex-adjusted model		Fully adjusted model		Fully adjusted model simultaneously including dental caries, tooth loss, and poor periodontal status	
Dependent variable	**Independent variable**	Unstandardised coefficient	95% confidence interval	Unstandardised coefficient	95% confidence interval	Unstandardised coefficient	95% confidence interval
Absolute absenteeism (work hours lost)	Decayed and filled teeth (DFT)	0.6	−1.9, 3.1	0.0	−2.5, 2.6	-	-
	Missing teeth (MT)	−0.9	−7.2, 5.4	−1.3	−7.5, 4.8	-	-
	Poor periodontal status	-	-	-	-	-	-

Second target population (employees from among registrants of an online research company) (n=435)

		Age- and sex-adjusted model		Fully adjusted model		Fully adjusted model simultaneously including dental caries, tooth loss, and poor periodontal status	
Dependent variable	**Independent variable**	Unstandardised coefficient	95% confidence interval	Unstandardised coefficient	95% confidence interval	Unstandardised coefficient	95% confidence interval
Absolute absenteeism (work hours lost)	Decayed and filled teeth (DFT)	1.1	−0.1, 2.2	1.0	−0.2, 2.1	1.0	−0.2, 2.1
	Missing teeth (MT)	0.8	−2.8, 4.4	0.1	−3.6, 3.8	−0.3	−4.0, 3.5
	Poor periodontal status	10.9	−10.8, 32.7	13.2	−9.5, 35.9	12.8	−10.2, 35.9

The fully adjusted model included age, sex, psychological distress, smoking status, history of diabetes, history of mental disorders, annual household income, education, years of service with the current company, job type, occupational status, and the effort-reward imbalance ratio.
When periodontal status was included as a dependent variable, smoking status was excluded because the screening questionnaire consists of current smoking status.
Among the first target population, only one participant was applicable for poor periodontal status; therefore, no analysis including periodontal status was conducted.

Table 4. Associations of dental caries, tooth loss, and poor periodontal status with presenteeism after imputation

First target population (employees at a medical university) (n=184)

		Age- and sex-adjusted model		Fully adjusted model		Fully adjusted model simultaneously including dental caries, tooth loss, and poor periodontal status	
Dependent variable	**Independent variable**	Unstandardised coefficient	95% confidence interval	Unstandardised coefficient	95% confidence interval	Unstandardised coefficient	95% confidence interval
Absolute presenteeism (percentage of work performance)	Decayed and filled teeth (DFT)	−0.5	−1.2, 0.1	−0.3	−0.9, 0.4	-	-
	Missing teeth (MT)	0.6	−1.0, 2.2	0.0	−1.6, 1.6	-	-
	Poor periodontal status	-	-	-	-	-	-

Second target population (employees from among registrants of an online research company) (n=435)

		Age- and sex-adjusted model		Fully adjusted model		Fully adjusted model simultaneously including dental caries, tooth loss, and poor periodontal status	
Dependent variable	**Independent variable**	Unstandardised coefficient	95% confidence interval	Unstandardised coefficient	95% confidence interval	Unstandardised coefficient	95% confidence interval
Absolute presenteeism (percentage of work performance)	Decayed and filled teeth (DFT)	0.0	−0.4, 0.3	−0.1	−0.4, 0.2	−0.1	−0.4, 0.2
	Missing teeth (MT)	−0.7	−1.8, 0.4	−0.7	−1.8, 0.4	−0.5	−1.6, 0.6
	Poor periodontal status	**−11.5**	**−18.1, −4.9**	**−8.4**	**−15.0, −1.7**	**−7.8**	**−14.5, −1.0**

The fully adjusted model included age, sex, psychological distress, smoking status, history of diabetes, history of mental disorders, annual household income, education, years of service with the current company, job type, occupational status, and the effort-reward imbalance ratio.
When periodontal status was included as a dependent variable, smoking status was excluded because the screening questionnaire consists of current smoking status.
Among the first target population, only one participant was applicable for poor periodontal status; therefore, no analysis including periodontal status was conducted.

solute presenteeism were −0.3 (95% CI = −0.9, 0.4) and 0.0 (95% CI = −1.6, 1.6), respectively. In the second population, when oral health indicators were simultaneously included in the fully adjusted model, the unstandardised coefficients of DFT, MT, and poor periodontal status for the absolute presenteeism were −0.1 (95% CI = −0.4, 0.2), −0.5 (95% CI = −1.6, 0.6), and −7.8 (95% CI = −14.5, −1.0), respectively.

Discussion

This cross-sectional study showed that, among 435 employees enrolled from among the registrants of an online research company, poor periodontal status was significantly associated with a 7.8% decline in work performance but was not associated with absenteeism. Dental caries and tooth loss were not significantly associated with either absenteeism or presenteeism in both populations.

This study had two strengths. First, we assessed absenteeism and presenteeism using the WHO-HPQ, which is a reliable questionnaire[19, 22, 23]. Therefore, this is the first study reporting that self-reported poor periodontal status was associated with a 7.8% decline in work performance. Second, potential confounders, such as socioeconomic status and work-related variables, were included in this study. Therefore, our study described more detailed results of the associations between oral diseases and work productivity loss compared to earlier previous studies. However, there were three limitations. First, periodontal status was determined by using a self-administered questionnaire[21]. Although a systematic review reported the validity of self-reported periodontal status[29], and the Japanese questionnaire used in this study were validated based on clinical measurements[21], the gold standard, based on the epidemiological definition of periodontal disease, is to assess periodontal status using clinical measurements, such as clinical attachment loss[30, 31]. Therefore, the possibility of bias cannot be ruled out. Furthermore, the periodontal outcome was only categorised as a dichotomous variable. Previous epidemiological studies indicated a significant prevalence of mild and moderate periodontitis[30, 31]. This means that the present study only focused on severe cases. Moreover, in the second source population, DMFT was determined using an unvalidated method, which can introduce a bias. Second, the response rate was relatively low, which might bring about healthy volunteer bias. The included participants were healthier than the general Japanese population. The prevalence of DFT, MT, and poor periodontal status was lower than in the general Japanese population[32]. In particular, only one participant had poor periodontal status, which means that the finding of a 7.8% decline in work performance applies to only a single target population. Furthermore, the study participants had a high socioeconomic status, as represented by their educational status. The low number of unhealthy employees with poor oral health status and lower socioeconomic status might weaken the impact of oral diseases on work productivity loss. Finally, this was a cross-sectional study. The time relationship between the independent and dependent variables was not established. In the future, a cohort study is needed to verify the results of this study.

This study reported no significant association of dental caries, tooth loss, and poor periodontal status with work hours lost. In the current study, we assessed total hours lost per month using 4-week estimates[19, 22, 23]. Based on the results of previous studies, work hours lost due to oral diseases were expected to be relatively small when examining hours in 1 month. In addition, the current results show a relatively large standard deviation of absolute absenteeism. Therefore, this study might not detect the work hours lost due to oral diseases. When capturing the impact of oral diseases on absenteeism, a larger sample size might be needed. Moreover, the Japanese oral healthcare system provides a wide range, of high-quality, and appropriate dental healthcare through the universal health insurance system[33]. Thus, employees with oral diseases can have easy access to treatment at any time. Therefore, the impact of oral diseases on absenteeism might be low in Japan. In addition, most participants had a good oral condition; therefore, they might have mainly visited a dental clinic for preventive or cosmetic care and thus have had no need of treatment during the course of their work lives.

Poor periodontal status was associated with presenteeism, although Japan has a universal health insurance system that covers dental healthcare. Periodontitis is a current chronic inflammation of the tissues surrounding teeth[34]. In this study, the cut-off point of the questionnaire for periodontal status was defined based on a 7 mm or greater clinical attachment loss[21]. Therefore, the applicable participants could have had severe periodontal conditions, which induces acute symptoms such as pain whereby poor periodontal status might contribute to the decline in work performance. In addition, chronic inflammation of periodontal disease also brings about an increased risk of general fatigue, pain, and discomfort[35], which can link to a work performance decline. Moreover, recent evidence indicates the potential associations of prolonged periodontal disease with an increased risk of hypertension[36], diabetes melli-

tus[37], cognitive impairment[38], and respiratory diseases[39]; thereby suggesting that periodontal disease might also affect work performance through these possible pathways.

Dental caries and tooth loss were not associated with presenteeism and were evaluated using DFT and MT, respectively. The indicators include not only the current status but also the experience of dental caries and tooth loss. Therefore, DFT and MT do not necessarily reflect the presence of dental pain or the need for dental treatment and dental clinic visits. Thus, our study may have failed to observe an association of dental caries and tooth loss with presenteeism. To detect the impact of dental caries on work productivity loss, dental pain due to dental caries within a month might be a more efficient indicator.

We found an association between poor periodontal status and a 7.8% decline in work performance. A previous review showed that the average decreases in work performance of arthritis, chronic lower-back pain, asthma, and depression were 5.9%, 5.5%, 5.2%, and 7.6%, respectively[2]. Direct comparisons are difficult due to the different measures used, but the impact of poor periodontal status on work performance can be massive. A previous study on the economic impacts of oral diseases did not consider presenteeism due to periodontal disease[17]; therefore, the economic burden of oral disease might be underestimated. Future studies should also focus on the impact of oral disease on declines in work performance when considering the economic impact of oral diseases.

Conclusions

Poor periodontal status was significantly associated with a 7.8% decline in work performance but was not associated with absenteeism. Dental caries and tooth loss were not associated with either absenteeism or presenteeism. Although Japan has a comprehensive oral healthcare system, a relatively severe periodontal status was potentially associated with a 7.8% decline in work performance. This result highlights the importance of preventive care for severe periodontitis. Occupational specialists and managers, as well as dental health professionals, should be aware of the impact of oral diseases on work productivity and they should focus on not only dental treatment but also on preventive care.

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Conflict of Interest

The authors report no conflicts of interest.

Authors' Contributions

Y. Sato contributed to the acquisition and interpretation of data and drafting of the work. Y. Saijo, EY, and MT revised the manuscript critically for important intellectual content. All authors contributed to the concept and design of the work, approved the final version to be published, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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