Effort-reward Imbalance at Work and Oral Diseases: a Cross-sectional Study in Japan

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Research Article

Keywords: Work stress, dental caries, periodontal disease, tooth loss

Posted Date: October 5th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-941776/v1

Abstract

Psychological stress is a potential risk factor for oral diseases. However, evidence for association between work stress and oral diseases is lacking. We aimed to examine the associations of work stress, according to the effort-reward imbalance model, with dental caries, periodontal disease, and tooth loss. This cross-sectional study included 619 regular employees. Work stress was assessed using the effort-reward imbalance (ERI) ratio. Dental caries and tooth loss were assessed according to the number of decayed and filled teeth (DFT) and missing teeth (MT) among set of 28 teeth. Severe periodontitis was assessed using a questionnaire. The mean ERI ratio (with standard deviations) was 1.12 (0.47). In the pooled analysis, a one-unit increase in the ERI ratio was associated with -0.90 (95% CI = -1.67, -0.12) changes in the mean DFT and -0.20 (95% CI =-0.45, 0.06) changes in the mean MT from adjusted linear regression models. A one-unit increase in the ERI ratio was also associated with 1.66 (95% CI = 1.10, 2.52) of the risk for severe periodontitis based on Poisson regression models. ERI at work was associated with a low number of dental caries and tooth loss, and an increased risk of severe periodontitis.

Introduction

Work stress has become more prevalent at the workplaces of industrialised countries and can negatively impact workers' health.[1] The effort–reward imbalance model is a widely accepted model for assessment of work stress.[2,3] It focuses on the failure in reciprocity in terms of high efforts spent and low rewards received.[2,3] The model predicts increased risks for depression,[4] hypertension,[5] coronary heart disease,[6] and type 2 diabetes.[7]

The risk of developing oral diseases, such as dental caries and periodontal disease, remains high throughout life, with no decreases observed in the incidence of dental caries at any age. [8,9] The incidence of periodontal disease rapidly increases in the mid-to-late 30s, after which it decreases due to tooth loss, but the prevalence remains high. [10] Dental caries frequently cause severe pain which can negatively affect work performance. [11,12] Periodontal disease and dental caries can cause tooth loss, [13,14] in turn, affecting eating, sleeping, and communication. [11,12] Oral diseases potentially produced a $187.61 billion productivity loss in 2015. [15] The economic burden of oral diseases seems to worsen. [16]

Psychological stress is a potential risk factor for oral diseases. It can result in immune system dysfunction, increased stress hormones, cariogenic bacterial counts, and poor oral health behaviours, which exacerbate oral conditions.[17,18] Thus, psychological stress at work might also deteriorate oral health. However, upon conducting a systematic review, we found a lack of evidence on work stress and oral diseases.[19] Notably, most previous studies did not use the widely accepted measures for work stress assessment and did not include potential confounders, such as socioeconomic status and work-related variables. In this cross-sectional study, we aimed to examine the associations of work stress, according to the effort-reward imbalance model, with dental caries, periodontal disease, and tooth loss, taking potential confounders into consideration.

Methods

Ethics approval and informed consent

All experiments adhere 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. This study 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 source populations in Japan: the first source population included employees (mainly healthcare workers and office workers) at a medical university, and the second source population included registrants of a web research company.

In the first source population, a self-administered questionnaire survey was conducted for 2,006 employees of a medical university, between 19th October and 20th December, 2020, of which 910 responded. Of the 910, 568 were regular employees aged 20–64 years. We excluded 41 regular employees who disagreed with the use of a dental examination record. A dental examination was conducted between 7th December and 18th December 2020 in 184 of the 527 regular employees.

In the second source population, a self-administered questionnaire survey in a web research company was conducted from 30th November to 16th December 2020. The inclusion criterion comprised regular employees aged 20-64 years who filled in complete information on occupational status. Consequently, 3,852 participants who met the inclusion criterion completed the questionnaire survey. Subsequently, to assess the oral conditions, the participants were required to take intraoral photographs with their mobile phones and upload them between 3rd December 2020, and 12th January 2021. Among the 3,852 participants, 565 uploaded the photographs. The photographs were checked, and 435 participants who provided satisfactory photographs were included; thus, 435 regular employees aged 20–64 years were included.

Independent variable: Work stress according to the effort-reward imbalance model

Work stress was assessed using a standardised short version of the effort-reward imbalance (ERI) questionnaire in Japanese.[20,21] The questionnaire comprised 10 items with a 4-point Likert scale: three items on the effort scale (ranging between 3 and 13) and seven items on the reward scale (ranging between 7 and 28). The effort included work pressure and immersion. Rewards included money, career opportunities, job security, and esteem. The ERI ratio was calculated using an established procedure.[22] A high ERI ratio indicates a failure in the reciprocity of the high efforts spent and low rewards received.[2,3] The ERI ratio was used as a numerical variable, as per the manual.[22]

Dependent variable: The number of decayed, missing, filled teeth (DMFT) and self-reported periodontal status

Dental caries and tooth loss were assessed according to the number of decayed, missing, and filled teeth (DMFT) among the set of 28 teeth (excluding the wisdom teeth).[23] To independently assess dental caries and tooth loss, the numbers of decayed and filled teeth (DFT) and missing teeth (MT) were also used as dependent variables. In the first source population, DMFT was examined through a dental examination conducted by one dentist, in accordance with standardised oral health survey methods following the World Health Organization (WHO) guidelines.[23]

In the second source population, DMFT was obtained from intraoral photographs taken with mobile phones. The participants took two intraoral photographs in line with examples provided. Two dental clinicians independently assessed each tooth's status according to the WHO guidelines.[23] The following diagnostic criteria were created to avoid the overestimation of DMFT while assessing intraoral photographs: "tooth was detected, but the condition is unknown" and "it is unclear whether the tooth is present or not." Any differences between the two dental clinicians' diagnoses were resolved by discussion.

In both source populations, periodontal status was assessed using the same self-administered questionnaire. The valid questionnaire for screening periodontitis in employees consisted of four questions: smoking status, signs of periodontitis, symptoms of periodontitis, and experience of periodontal treatment.[24] At least three questions were asked, and the participants were defined as having severe periodontitis according to a cut-off point in the previous study.[24]

Covariates

Based on a previous review, the following variables were selected as covariates:[19] age, sex (men and women), smoking status (never, former, and current), 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), education (high school or lower, professional training college, junior college, technical college, and university or higher). Work characteristics included were, years of service with the current company, job type (administrative and managerial, professional and engineering, clerical, and others), occupational status (untitled and titled), and working hours per week. Job type categories were defined based on the Japan Standard Occupational Classification.[25] All covariates were obtained using a self-administered questionnaire.

Statistical analysis

Two models were built: the age-and sex-adjusted model and the fully adjusted model including age, sex, smoking status, annual household income, education, years of service with the current company, job type, occupational status, and working hours per week. Pooled analysis was carried out using the two models, adding a dummy category for the type of population. Stratified analyses of the source population were also conducted. In the models for periodontitis, smoking status was excluded because the periodontitis screening questionnaire included current smoking status. Linear regression analysis was employed to

estimate the mean difference in DMFT (and DFT, MT). Although the distribution of DMFT (and DFT, MT) is right-skewed, linear regression models can provide valid estimations.[26] To estimate the ratio of the mean number of DMFT (and DFT, MT), a negative binomial regression analysis was employed.[27] A Poisson regression analysis with robust error variance was conducted to estimate the prevalence ratios (PRs) of severe periodontitis.[28] PRs can be interpreted as relative risk.[28] In the first source population, only one participant had periodontitis; therefore, no analysis was conducted.

Based on the assumption of missing at random, the k-nearest neighbour imputation method using the R package "VIM" was employed independently for each source population.[29] Two-tailed P values of <0.05 were considered statistically significant, and 95% confidence intervals (CIs) were applied. All analyses were conducted using the R (ver. 4.1.0; R Foundation for Statistical Computing) for macOS.

Results

The first source population included 184 regular employees of a medical university and the second source population included 435 regular employees from registrants of a web research company. The total analytic population was 619. Table 1 shows the characteristics, including the effort-reward imbalance ratio and dental status of the participants stratified by the types of population. The mean ERI ratios (with standard deviations) of the first source population and the second source population were 1.08 (0.34) and 1.14 (0.52), respectively. Among the pooled population, the mean ERI ratio (with standard deviations) was 1.12 (0.47). The median number of DMFT (with 1st and 3rd quantiles) of the first and second source populations were 6 (3, 11) and 8 (4, 12), respectively. Among the pooled population, the median number of DMFT (with 1st and 3rd quantiles) was 7 (3.5, 12). The median numbers of DFT and MT (with 1st and 3rd quantiles) of the first and second source populations were 5 (1, 7) and 3 (2, 3), and 7 (3, 11) and 0 (0, 0), respectively. Among the pooled population, the median number of DFT and MT (with 1st and 3rd quantiles) was 6 (2, 11) and 0 (0, 2), respectively. The percentages of patients with severe periodontitis among the first and the second source populations were 0.6% and 6.7%, respectively. Among the pooled population, the percentage of patients with severe periodontitis was 4.8%. Compared to the second source population, the first source population included younger employees. In both source populations, more than 70% of the participants had university degrees or higher. In the first source population, over 70% were professional or engineering workers. The second source population mainly included administrative and managerial, professional and engineering, and clerical workers.

Table 2 shows the association of the effort-reward imbalance ratio with the number of decayed, missing, and filled teeth. In the pooled analysis, a one-unit increase in the ERI ratio was associated with -1.09 (95%CI = -1.92, -0.26) changes in the mean DMFT from a fully adjusted linear regression model. A one-unit increase in the ERI ratio was associated with a 0.89 (95% CI = 0.79, 0.99) fold change in the mean number of DMFT from a negative binomial regression model. A one-unit increase in the ERI ratio was associated with -0.90 (95% CI = -1.67, -0.12) changes in the mean number of DFT. A negative binomial regression model shows a 0.89 (95% CI = 0.78, 1.01) fold change in the mean number of DFT with a one-unit increase in the ERI ratio. A one-unit increase in the ERI ratio was associated with -0.20 (95% CI =

-0.45, 0.06) changes in the mean number of MT, but this was not significant. A negative binomial regression model shows a 0.76 (95% CI = 0.58, 0.98) fold change in the mean number of MT with a one-unit increase in the ERI ratio. Table 3 shows that a one-unit increase in the ERI ratio was associated with a 1.66 (95% CI = 1.10, 2.52) risk of severe periodontitis. These trends were consistent in both populations.

Discussion

This study reports the cross-sectional associations of work stress, according to the ERI, with dental caries, periodontal disease, and tooth loss. ERI was associated with a low number of dental caries and tooth loss, and an increased risk for periodontitis.

This study has two strengths. First, work stress was assessed using a widely accepted measure. Previous studies on work stress and oral diseases have often used nonspecific questionnaires.[19] This study captured work stress more accurately than previous studies. Second, this study included potential confounders such as socioeconomic status and work-related variables. Our review revealed only two studies among the 11 studies included in the systematic review considered the potential confounders sufficiently.[19] Our study is superior to previous studies in terms of these two points. However, our study had three limitations. First, periodontal status was assessed using a self-reported questionnaire. It is possible that participants with work stress exaggerated responses for questions on periodontitis screening. However, as the questionnaire about periodontitis has been validated among workers, there can be no significant bias. In the second source population survey, DMFT was estimated using intraoral photographs with mobile phones. Although an early study indicated the usefulness of intraoral photographs with mobile phones for assessment of oral conditions,[30] some decayed and filled teeth could be missed because our study included fewer photographs than the previous study. Therefore, DMFT can be underestimated. However, the results in the second source population were consistent with those in the first source population, for which DMFT was assessed on clinical examination. Second, in the two-source population, many participants had a high socioeconomic status. More than 70% of participants had university degrees or higher. The social gradients of oral diseases have been reported.[31,32] Additionally, blue-collar workers were also small. Participants in the two-source population had a better oral condition than those in the national survey.[33] The results of people with low socioeconomic status and blue-collar workers might have been underestimated in this study. Finally, this study was cross-sectional; therefore, a temporal association was not established. Further cohort studies are required.

The current results show a negative association between work stress and the number of decayed or filled teeth (caries experienced teeth). There is only one previous study on work stress and the number of teeth with caries.[19,34] In a previous study, work stress was assessed using the demand-control model, and the dependent variable was DMF tooth surfaces. One unit increases in work mental demand and work control score were associated with 0.19 (95%CI = -0.91, 1.29) and 0.87 (95% CI = 0.18, 1.91) increases in DMF teeth surfaces.[34] This inconsistency might be due to the DMFT and DMF teeth surfaces which included

caries experiences that occurred before exposure to work stress. For a more accurate understanding of the association between work stress and dental caries, the incidence of dental caries should be measured.

In the present study, work stress was negatively associated with tooth loss. There were two previous cross-sectional studies in which the dependent variables were self-reported tooth loss and having four or more lost teeth.[19,35,36] Two studies have reported an increased risk of tooth loss due to work stress. Our results are inconsistent with those of the two previous studies. In this study, the number of tooth losses were few. Furthermore, as with dental caries, this inconsistency might be due to the characteristic of the dependent variable, missing teeth, which included tooth loss that occurred before exposure to work stress. Owing to these limitations, it is difficult to derive conclusions from the current results. The incidence of tooth loss should be used as an outcome in future research.

Work stress was associated with an increased risk of severe periodontitis, which is consistent with previous studies.[19] Eight of nine previous studies reported a significant association between work stress and periodontal status, but only one study used the accepted measure for work stress and adjusted for potential confounders.[19,34] Our results provide additional evidence based on the more accurate work stress status considering the potential confounders.

Work stress was associated with a risk of severe periodontitis and not with dental caries and tooth loss. According to previous reviews,[37,38] periodontal disease seems to be more sensitive to psychological stress than dental caries. Work stress brings about uncontrolled metabolism and impaired immune system, which can exacerbate periodontal disease.[14] Besides, the definition of periodontal disease is based on current inflammation activities in the supporting structures of the teeth.[39] The above features might facilitate the observation of the cross-sectional association between work stress and severe periodontitis than dental caries and tooth loss.

Conclusions

Effort-reward imbalance at work was associated with a low number of dental caries and tooth loss, and increased risk for periodontitis Occupational specialists should recognise that work stress is associated not only with mental health, cardiovascular disease, and metabolic disease, but also with periodontal disease. Moreover, periodontal disease potentially brings about presenteeism among workers.[40] The importance of periodontal health in the workplace should be noted. For dental caries and tooth loss, a further cohort study including the incidence of oral diseases is needed to describe the association of work stress more accurately.

Declarations

Acknowledgements

We appreciate their participants and their volunteerism.

Author contributions

YSato contributed to the acquisition and interpretation of data and drafting of the work. YSaijo, 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.

Competing Interests

The authors declare no conflicts of interest.

Funding

This study was supported by a Grant-in-Aid for Early-Career Scientists from the Japan Society for the Promotion of Science KAKENHI (grant number JP19K19306).

Availability of data and materials

The datasets are available from the corresponding author on reasonable request.

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Tables

Table 1
The characteristics, including the effort-reward imbalance ratio and dental status of the participants stratified by the types of population.

		First source population (employees at a medical university)		**Second source population (registrants of a web research company)**		**Pooled population (after imputation)**	
		(n=184)		(n=435)		(n=619)	
		n	%	n	%	n	%
Effort-reward imbalance ratio	(mean, standard deviation)	1.08	0.34	1.14	0.52	1.12	0.47
	Missing	4	2.2	0	0	-	
Age	(median, 1st and 3rd quantile)	31	26, 42	46	37, 53	43	32, 51
Sex	Men	79	42.9	302	69.4	382	61.7
	Women	104	56.5	133	30.6	237	38.3
	Missing	1	0.5	0	9.0	-	
Smoking status	Never	150	81.5	249	57.2	401	64.8
	Former	26	14.1	100	23.0	126	20.4
	Current	6	3.3	86	19.8	92	14.9
	Missing	2	1.1	0	0	-	
Annual household income	less than 5 million yen	65	35.3	166	38.2	244	39.4
	5 to 7.9 million yen	40	21.7	159	36.6	208	33.6
	8 to 9.9 million yen	23	12.5	51	11.7	75	12.1
	over 10 million yen	37	20.1	49	11.3	92	14.9
	Missing	19	10.3	10	2.3	-	
Education	High school or lower	6	3.3	42	9.7	48	7.8
	Professional training college, junior college, and technical college	42	22.8	53	12.2	95	15.3
	University or higher	136	73.9	339	77.9	476	76.9
	Missing	0	0.0	1	0.2	-	

		First source population (employees at a medical university)		Second source population (registrants of a web research company)		Pooled population (after imputation)	
Years of service with the current company	(median, 1st and 3rd quantile)	5	2, 10	13	7, 23	10	4, 20
	Missing	6	3.3	0	0	-	
Job type	Administrative and managerial	31	16.8	91	20.9	122	19.7
	Professional and engineering	139	75.5	110	25.3	249	40.2
	Clerical	0	0.0	145	33.3	145	23.4
	Others	14	7.6	89	20.5	103	16.6
Occupational status	Untitled	98	53.3	212	48.7	316	51.1
	Titled	85	46.2	215	49.4	303	48.9
	Missing	1	0.5	8	1.8	-	
Working hours per week	(median, 1st and 3rd quantile)	50	40, 60	45	40, 50	45	40, 55
	Missing	7	3.8	0	0	-	
Decayed, missing, filled teeth (DMFT)	(median, 1st and 3rd quantile)	6	3, 11	8	4, 12	7	3.5, 12
Decayed and filled teeth (DFT)	(median, 1st and 3rd quantile)	5	1, 7	7	3, 11	6	2, 11
Missing teeth (MT)	(median, 1st and 3rd quantile)	3	2, 3	0	0, 0	0	0, 2
Severe periodontitis	None	178	96.7	406	93.3	589	95.2
	Having	1	0.5	29	6.7	30	4.8
	Missing	5	2.7	0	0	-	

Table 2
Associations between the effort-reward imbalance ratio and the number of decayed, missing, and filled teeth after imputation.

		Pooled population			
		(n=619)			
Linear regression models		Age and sex-adjusted model		Fully adjusted model	
Dependent variable	**Independent variable**	Mean difference	95%CI	Mean difference	95%CI
Decayed, missing, filled teeth (DMFT)	Effort-reward imbalance ratio	-1.06	-1.86, -0.26	-1.09	-1.92, -0.26
Decayed and filled teeth (DFT)	Effort-reward imbalance ratio	-0.86	-1.62, -0.11	-0.90	-1.67, -0.12
Missing teeth (MT)	Effort-reward imbalance ratio	-0.20	-0.45, 0.05	-0.20	-0.45, 0.06
Negative binomial regression models		Mean ratio	95%CI	Mean ratio	95%CI
Decayed, missing, filled teeth (DMFT)	Effort-reward imbalance ratio	0.89	0.80, 0.99	0.89	0.79, 0.99
Decayed and filled teeth (DFT)	Effort-reward imbalance ratio	0.90	0.79, 1.02	0.89	0.78, 1.01
Missing teeth (MT)	Effort-reward imbalance ratio	0.73	0.57, 0.93	0.76	0.58, 0.98
		First source population (employees at a medical university)			
		(n=184)			
Linear regression models		Age and sex-adjusted model		Fully adjusted model	
Dependent variable	**Independent variable**	Mean difference	95%CI	Mean difference	95%CI
Decayed, missing, filled teeth (DMFT)	Effort-reward imbalance ratio	-2.50	-4.30, -0.69	-2.84	-4.73, -0.94
Decayed and filled teeth (DFT)	Effort-reward imbalance ratio	-2.45	-4.08, -0.81	-2.65	-4.36, -0.95
Missing teeth (MT)	Effort-reward imbalance ratio	-0.05	-0.71, 0.62	-0.18	-0.89, 0.52
Negative binomial regression models		Mean ratio	95%CI	Mean ratio	95%CI

		Pooled population			
Decayed, missing, filled teeth (DMFT)	Effort-reward imbalance ratio	0.74	0.58, 0.96	0.71	0.55, 0.91
Decayed and filled teeth (DFT)	Effort-reward imbalance ratio	0.65	0.43, 0.99	0.62	0.41, 0.95
Missing teeth (MT)	Effort-reward imbalance ratio	0.98	0.75, 1.28	0.93	0.70, 1.24
		Second source population (registrants of a web research company)			
		(n=435)			
Linear regression models		Age and sex-adjusted model		Fully adjusted model	
Dependent variable	**Independent variable**	Mean difference	95%CI	Mean difference	95%CI
Decayed, missing, filled teeth (DMFT)	Effort-reward imbalance ratio	-0.82	-1.75, 0.10	-0.84	-1.80, 0.12
Decayed and filled teeth (DFT)	Effort-reward imbalance ratio	-0.62	-1.49, 0.26	-0.63	-1.54, 0.28
Missing teeth (MT)	Effort-reward imbalance ratio	-0.21	-0.48, 0.07	-0.21	-0.49, 0.07
Negative binomial regression models		Mean ratio	95%CI	Mean ratio	95%CI
Decayed, missing, filled teeth (DMFT)	Effort-reward imbalance ratio	0.91	0.80, 1.03	0.90	0.79, 1.03
Decayed and filled teeth (DFT)	Effort-reward imbalance ratio	0.92	0.81, 1.05	0.92	0.80, 1.05
Missing teeth (MT)	Effort-reward imbalance ratio	0.76	0.49, 1.17	0.77	0.48, 1.24
The fully adjusted model included age, sex, smoking status, annual household income, education, years of service with the current company, job type, occupational status, and working hours per week.					
The dummy variable for the population types was included only in the models of the pooled population.					

Table 3
Associations between the effort-reward imbalance ratio and severe periodontitis after imputation.

		Pooled population			
		(n=619)			
Poisson regression models with a robust error variance		Age and sex-adjusted model		Fully adjusted model	
Dependent variable	**Independent variable**	PR	95%CI	PR	95%CI
Periodontitis	Effort-reward imbalance ratio	1.62	1.11, 2.37	1.66	1.10 2.52
		First source population (employees at a medical university)			
		(n=184)			
Poisson regression models with a robust error variance		Age and sex-adjusted model		Fully adjusted model	
Dependent variable	**Independent variable**	PR	95%CI	PR	95%CI
Periodontitis	Effort-reward imbalance ratio	-		-	
		Second source population (registrants of a web research company)			
		(n=435)			
Poisson regression models with a robust error variance		Age and sex-adjusted model		Fully adjusted model	
Dependent variable	**Independent variable**	PR	95%CI	PR	95%CI
Periodontitis	Effort-reward imbalance ratio	1.56	1.06, 2.29	1.55	1.04, 2.32

The fully adjusted model included age, sex, annual household income, education, years of service with the current company, job type, occupational status, and working hours per week.

The dummy variable for the population types was included only in the models of the pooled population.

In the first source population, the number of participants with periodontitis was only one; therefore, no analysis was conducted.