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# Work stress and oral conditions: A systematic review of observational studies



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**Title**

Work stress and oral conditions: A systematic review of observational studies

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**Abstract (290/300)**

**Objectives:** Psychological stress is a risk factor for oral diseases, but there seems to be no previous review on work stress. This study aimed to review the evidence on the association between work stress and oral conditions, including dental caries, periodontal status, and tooth loss.

**Design:** A systematic review of published observational studies.

**Data sources:** Systematic literature search was conducted in PubMed and Scopus databases on July 7, 2020.

**Study selection:** Articles were screened based on the following inclusion criteria: published in English; epidemiological studies on humans (except case studies, reviews, letters, commentaries, and editorials); and examined the association of work stress with dental caries, periodontal status, and tooth loss.

**Data extraction:** Data was extracted from eligible studies. Quality assessment was conducted using the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies.

**Results:** Of 402 articles identified, 11 met the inclusion criteria, and one study assessed the association of work stress with dental caries and periodontal status. Of 11 studies, one reported a nonsignificant association between work stress and dental caries; eight of nine studies reported a significant association between work stress and worse periodontal status; and one of two studies reported a significant association between work stress and tooth loss. Nine of eleven studies were cross-sectional while the remaining two studies were unclear. Only two studies were sufficiently adjusted for potential confounders. Eight studies assessed work stress, not using the current major measures. Three studies were rated as fair, while eight studies had poor quality.

**Conclusions:** There is a lack of evidence on the association of work stress with dental caries,

periodontal status, and tooth loss. In future research, a cohort studies including the potential confounding factors and use of the major measures of work stress, are needed.

**Keywords**

systematic review, work stress, job stress, occupational stress, oral health, oral diseases

**Strengths and limitations of this study**

► This is the first systematic review to evaluate and summarize the literature on the association between work stress and oral conditions, including dental caries, periodontal status, and tooth loss.

► This systematic review provides a comprehensive insight into the quality of the included papers.

► The protocol of this systematic review was not registered.

► A meta-analysis could not be conducted because of the heterogeneity and the small number of included studies.

## INTRODUCTION

Oral diseases, such as dental caries and periodontal disease, still matter worldwide. The Global Burden of Disease study has estimated that 2.3 billion individuals had untreated dental caries, 796 million had severe periodontal disease, and 267 million had complete loss of natural teeth in 2017.[1] Briefly, dental caries is the destruction of dental hard tissues in the crowns and roots of the teeth.[2] Periodontal diseases are chronic inflammatory conditions with disorders of the tissues surrounding and supporting the teeth.[3] Tooth loss is mainly the consequence of dental caries and periodontal disease.[2,3] Because oral diseases result not only in severe toothache, but also in eating, sleeping, and communication disabilities,[4,5] poor oral conditions can restrict work performance[4,5] and bring about significant economic burden.[6] Indeed, work productivity loss due to oral conditions is estimated at 187.61 billion US dollars annually.[6] The necessity of prevention of oral diseases for the working adults is highlighted.

Since the 1990s, rapid changes in the global economy and the diverse markets have occurred,[7] and psychological workplace stress has become more prevalent and severe, especially among industrialized countries.[7] Indeed, Kivimäki et al. reported 15% prevalence of job strain measured using job-content and demand-control questionnaires from 13 European cohorts' data (1985–2006).[8] Besides, work stress can have profound effects on health. There is accumulating evidence of the risk of work stress on cancer, cardiovascular diseases, diabetes, and depression.[9,10] Béjean and Sultan-Taïeb estimated that the work-related stress costs due to illnesses could be between €1,167 million and €1,975 million in France in 2000.[11] Work stress has impacts on the workers' health and productivity.

Psychological stress is recognized as a risk factor for dental caries and periodontal diseases. Psychological stress is related to oral diseases through immune system dysfunction, increases in stress hormones, cariogenic bacterial counts, and poor oral health behaviors.[12,13] However, although work stress is strongly linked with psychological and physical health,[9,10]

there seems to be no review on the association between work stress and oral diseases. Thus, the aim of this systematic review was to evaluate and summarize the literature on the association between work stress and oral conditions, including dental caries, periodontal status, and tooth loss. We set the following review question: Is work stress associated with dental caries, periodontal status, and tooth loss?

## METHODS

The reporting of this systematic review conforms to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[14,15] We also followed the Conducting Systematic Reviews and Meta-Analyses of Observational Studies of Etiology (COSMOS-E) guidance[16] and the reporting of Meta-analysis Of Observational Studies in Epidemiology (MOOSE).[17]

### Eligibility criteria

Published studies were eligible if they: 1) were published in English; 2) were epidemiological studies on humans (except case studies, reviews, letters, commentaries, and editorials); and 3) examined the association of work stress with dental caries, periodontal status, and tooth loss.

### Information sources and searches

On July 7, 2020, we identified potentially relevant published studies in PubMed (1966 to July 7, 2020) and Scopus (1966 to July 7, 2020) databases. We used the following script to obtain a wide range of literatures: ("job strain" OR "effort reward") AND (dental OR oral); ("job stress" OR "work stress" OR "occupational stress") AND (dental OR oral). In addtion, we manually hand-searched for potentially suitable studies through the reference lists of identified articles and Google scholar. After the exclusion of duplicate articles, one author (YuS) assessed the titles and abstracts according to the aforementioned criteria. Then, eligible

studies were selected for the full-text review.

**Data extraction**

The author (YuS) extracted the following information from each eligible study: 1) name of the first author; 2) study design; 3) study location (country); 4) number of participants and work-related characteristics; 5) exposures and its measurements; 6) outcomes and its measurements; 7) age range and proportion of women; 8) covariates included in the adjusted models; and 9) the main results.

**Quality assessment**

We used the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies to assess the quality of included studies.[18] This tool includes 14 questions for evaluating the internal validity of a study. For each question, the author (YuS) rated them as yes, no, or other (including cannot determine, not reported, and not applicable). The overall quality rating for the study was regarded as good if all the domains were assessed favorably.

**Synthesis of results**

A meta-analysis could not be conducted because of the heterogeneity and the small number of included studies.

**Patient and public involvement**

No patient involved.

## RESULTS

Figure 1 presents the flow diagram of information through the phases of the systematic review. Of the 402 articles identified in PubMed and Scopus databases, 129 duplicated articles were removed, the titles and abstract of 273 were screened, and 11 met the eligibility criteria. Three more articles identified through reference lists and hand-search were added. After full-text assessments of 14 articles, three were excluded (due to retraction [n=1][19] and

use of composite outcomes including dental caries and periodontal status [n=2]).[20,21] Finally, 11 articles were included in this systematic review.[22–32]

**Study characteristics and results of individual studies**

Table 1 shows the 12 summaries from the 11 studies. One of eleven studies reported on dental caries and periodontal status,[22] eight reported on periodontal status,[23–30] and two reported on tooth loss.[31,32] Three studies were conducted in Japan,[26,30–32] two in India,[28,29] and one each in the UK,[24] the US,[25] Brazil,[22] and Iraq.[27] One study did not report on the study location.[24] Among 11 studies, 9 studies were cross-sectional[22,25–32] and the remaining 2 studies were unclear; therefore, they were categorized as unknown.[23,24] The sample size was varied from 10 to 1,426 among included studies. Four studies included participants who were not working adults,[24–27] two did not include women,[22,31] and two did not report on sex.[27,28]

Three studies assessed work stress using the current major measures (Job Demand-Control Model and Effort-Reward Imbalance Model).[22,31,32] Work stress assessed using the Karasek job strain model,[22,31] the Effort-Reward Imbalance model,[32] the Brief Job Stress Questionnaire developed by referring to the demand-control-support model in Japan,[30] a single job stress question,[29] the Occupational Stress Indicator,[23,24] an occupational stress index by Srivastava and Singh,[28] the Life events scale,[26,27] and the Problems of Everyday Living Scale by Pearlin and Schooler.[25]

The assessment of the presence or absence of dental caries on unrestored or restored tooth surfaces was performed using the DMFS index (the number of decayed [D], missing [M], and filled [F] teeth surfaces per person).[22] The measurement of periodontal status varied across included studies. The measurements included probing pocket depth,[23,27,28] clinical attachment level,[24,25,27] alveolar bone loss,[25] gingival index,[27] bleeding on probing,[27] Community Periodontal Index and Treatment Needs protocol,[29] and a composite outcome including these measures.[22,30] Eight studies assessed periodontal status based on clinical

examinations, but one study based on visual inspection by dentists.[30] The assessment of tooth loss was through oral examination[31] or self-reported.[32]

Three studies presented only descriptive statistics.[25,27,28] Eight studies performed regression analyses;[22–24,26,29–32] but two studies of them did not report the types of a regression modeling used.[23,24] Only two studies sufficiently adjusted for potential confounders such as socioeconomic status and work-related variables.[22,32] One study reported a nonsignificant association between work stress and dental caries.[22] Eight of nine studies reported a significant association between work stress and worse periodontal status.[22–30] Two studies reported on association between work stress and tooth loss, but only one reported a significant association.[31,32]

**Study quality**

Table 2 presents the results of the quality assessments for each study. Eight studies (73%) had poor quality while three (27%) were rated as fair. None of the studies addressed question 6 ("For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?"); 7 ("Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?"); and 10 ("Was the exposure(s) assessed more than once over time?"); because all the studies were cross-sectional or the study design was unclear.

## DISCUSSIONS

This is the first systematic review to evaluate and summarize the existing literatures on the associations between work stress and oral conditions. Based on the findings of this review, evidence is lacking on the association of work stress with dental caries, periodontal status, and tooth loss. As our findings showed, only one study reported on dental caries and periodontal status, eight reported on periodontal status, and two on tooth loss. The quality of the 11 studies were either fair (n=3) or poor (n=8). Only two studies sufficiently adjusted for

potential confounders.[22,32] One study reported a non-significant association between work stress and dental caries.[22] Eight of nine studies reported the significant association between work stress and worse periodontal status.[22–30] One of two studies reported a significant association between work stress and tooth loss.[31,32] We could not conduct a meta-analysis due to the small number of included studies and varied outcomes and exposure variables. In particular, only 3 of 11 studies assessed work stress using the current major measures such as the Job Demand-Control Model and the Effort-Reward Imbalance Model.[22,31,32]

**Dental caries and work stress**

We found only one study on the cross-sectional association between work stress and dental caries, [22] which included 164 paid male workers aged 35 to 44 years in Brazil. Work stress was assessed according to the Karasek job strain model.[33] Dental caries status was assessed using the DMFS index. After adjusting for covariates, one-point increases in the work mental demand, work control, and work variety scores were associated with 0.19 (95% confidence interval [CI] = -0.91, 1.29), 0.87 (95% CI = -0.18, 1.91), and -0.06 (95% CI = -1.57, 1.45) increases in the DMFS index, respectively, in a multivariable regression analysis. They concluded that there was no significant association between work stress and dental caries. However since the sample size was relatively small (n=164), there is the possibility of a false negative association. Besides, as there was no cohort study, we could not assess the prospective associations. Due to the above limitations, it was difficult to determine whether work stress is associated with dental caries. A further study should include a cohort design and have a relatively large sample size.

**Periodontal status and works stress**

Nine studies reported on the associations between work stress and periodontal status.[22–30] Although eight studies reported a significant association between work stress and periodontal status, the outcome measures were varied. There is a wide range of accepted epidemiological

definitions for periodontitis;[34,35] but as previous studies pointed, the definition of periodontal disease has been numerous and lacked the consensus.[36] Thus, it was difficult to estimate periodontal disease prevalence.[37] None of the included studies used the accepted epidemiological definition of periodontal disease. In addition to the above limitation, how work stress was measured also varied across studies. Each measure assessed different dimensions of work stress.[38] Due to the heterogeneity of exposures and outcomes, we could not conduct a meta-analysis.

The quality of most studies was poor. The study design was unclear in two.[23,24] Freeman and Goss assessed work stress and periodontal status over a 12-month period.[23] However, they did not clearly report when work stress and periodontal status variables were assessed and how they were used in the statistical models. Besides, the type of regression model could not be identified. Linden et al. followed-up patients for 5.5 years,[24] but work stress was only assessed at follow-up examination, not at baseline survey. In addition, the study included patients with moderate or established periodontitis, and the type of regression model could not be identified. Three studies presented only descriptive statistics.[25,27,28] The remaining four papers reported significant associations following regression analyses.[22,26,29,30] However, Akhter et al. did not use a questionnaire specific to work stress and included also nonworking adults.[26] Islam et al. used the Brief Job Stress Questionnaire developed by referring to the demand-control-support model in Japan and, periodontal status was assessed based on the visual inspection by dentists.[30] Important potential confounders such as socioeconomic status and work-related variables were not included. Ramji assessed work stress using a single job stress question and did not adjust for covariates in the statistical models.[29] Therefore, only one study was assessed as fair.[22,30] Marcenes and Sheiham assessed the association between periodontal status and work stress.[22] Periodontal status was assessed by the presence or absence of gums bleeding on probing, or with pockets. They divided them

into groups based on "complete absence of teeth with gums bleeding on probing and with pockets," or "presence of any tooth with gums bleeding on probing or pockets," and defined the latter as those with periodontal disease. After adjusting for covariates, one-point increases in work mental demand scores, work control scores, and work variety scores were associated with ORs of 1.22 (95%CI = 1.06, 1.37), 0.97 (95%CI = 0.88, 1.07), and 0.99 (95%CI = 0.85, 1.16) , respectively, for having periodontal disease, in a logistic regression model. A further cohort study, using the validated definitions of periodontal disease, including the potential confounding factors, and current major measurements of work stress should be performed.

**Tooth loss and work stress**

Two studies were identified on the association between work stress and tooth loss. One of the two reported a significant association between work stress and tooth loss.[31,32] Hayashi et al. reported the association between work stress, assessed using the Karasek job strain model, and tooth loss.[31] A total of 322 male workers employed at a manufacturing company were included. They dichotomized the number of tooth loss into ≤3 and ≥4. After adjusting for covariates, high job demand and low control conditions were associated with high odds of having ≥4 teeth loss but not significant (OR = 1.2 [95% CI = 0.40, 3.42]). This study did not adjust for the important potential confounders. Sato et al. reported the association between work stress, assessed using the effort–reward imbalance model, and self-reported tooth loss.[32] After adjusting for covariates including socioeconomic status and work-related variables, a high effort-reward imbalance ratio was significantly associated with a high prevalence of ≥1 tooth loss (prevalence ratio = 1.20 [95% CI = 1.01, 1.42]). A further study should include a cohort design and potential confounding factors.

**Conclusions**

Based on the findings, this systematic review suggests a lack of evidence on the association of work stress with dental caries, periodontal status, and tooth loss. For future research, well-

designed cohort studies including potential confounding factors and the use of generally accepted measurements of work stress are needed.

**Contributors**

YuS contributed to the acquisition and the interpretation of data and drafting of the work. YaS and EY revised it critically for important intellectual content. The all authors contributed to the conception and design of the work, and confirmed final approval of the 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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**Competing interests**

The authors declare no potential conflicts of interest with respect to the research, authorship, and publication of this article.

**Patient consent for publication**

Not required.

**Provenance and peer review**

Not commissioned; externally peer reviewed.

**Data availability statement**

No additional data are available.

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## Tables

Table 1. Summary of included studies on work stress and oral conditions

| Author's name (year of publication) | Study design | Study location | Exposure (work stress) | Outcome | Number of participants | Mean age of the participants and proportion of women | Covariates | Main results |
|---|---|---|---|---|---|---|---|---|
| **Dental caries** | | | | | | | | |
| Marcenes and Sheiham (1992) [22] | Cross-sectional | Brazil | Karasek job strain model | DMFS index (number of decayed (D), missing (M), and Filled (F) teeth surfaces per persons) | 164 male paid workers aged from 35 to 44 years | Mean age = 41.2 (standard deviation = 2.2) 0% | Marital quality, toothbrushing frequency, sugar consumption, age, years of residence, type of toothpaste, frequency dental attendance, and socio-economic status | Work mental demand: Coefficients = 0.19 (95% CI = -0.91, 1.29) Work control: Coefficients = 0.87 (95% CI = -0.18, 1.91) Work variety: Coefficients = -0.06 (95% CI = -1.57, 1.45) From a linear regression analysis |
| **Periodontal status** | | | | | | | | |
| Marcenes and Sheiham (1992) [22] | Cross-sectional | Brazil | Karasek job strain model | The presence or absence of teeth either with gums bleeding on probing or with pockets was used. The indicator was labelled as 'complete absence of teeth with gums bleeding on probing and with pockets', and 'presence of any tooth with gums bleeding on probing or pockets'. | 164 male paid workers aged from 35 to 44 years | Mean age = 41.2 (standard deviation = 2.2) 0% | Marital quality, toothbrushing frequency, sugar consumption, age, years of residence, type of toothpaste, frequency dental attendance, and socio-economic status | Work mental demand: Odds ratio = 1.22 (95% confidence interval = 1.06, 1.37) Work control: Odds ratio = 0.97 (95% confidence interval = 0.88, 1.07) Work variety: Odds ratio = 0.99 (95% confidence interval = 0.85, 1.16) From a logistic regression analysis |
| Freeman and Goss (1993) [23] | Unknown | Not reported | Occupational Stress Indicator | Mean increases in pocket depth | 10 women and 8 men from the head office of a large company | Mean age = 39 55.6% | None | Type A behavior: Coefficients = 0.41 (p-value=0.003) Work environment (organization/climate): Coefficients = -0.34 (p-value=0.007) (statistical model was not reported) |
| Linden et al. (1996) [24] | Unknown | UK | Occupational Stress Indicator assessed at the second examination | Changes in clinical attachment level after an interval of 5.5 (SD 0.6) years. | 23 regular dental attendees aged between 20 and 50 years who had moderate or | Mean age = 41.1 (standard deviation = 7.3) 43.5% | Age and social class of the household | Job satisfaction: Coefficients = -0.014 (p-value < 0.01) Type A: Coefficients = 0.026 (p-value < 0.05) |

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|---|---|---|---|---|---|---|---|---|
| | | | | | established periodontitis (13 men and 10 women) | | | Locus of control: Coefficients = -0,035 (p-value ≥ 0.05) (statistical model was not reported) Job strain score among Attachment Loss categories (mean ± standard error) Healthy: 2.12 ± 0.05 Low: 2.09 ± 0.02 Moderate: 2.16 ± 0.02 High: 2.09 ± 0.05 Severe: 2.22 ± 0.05 From analysis of covariance |
| Genco et al. (1999) [25] | Cross-sectional | US | Problems of Everyday Living Scale of Pearlin and Schooler | Severity of Attachment Loss Healthy (0 to 1 mm clinical attachment level), low (1.1 to 2.0 mm), moderate (2.1 to 3.0 mm), high (3.1 to 4.0 mm) and severe (4.1 to 8.0 mm) Severity of Alveolar Bone Loss Healthy (0.4 to 1.9 mm alveolar crestal height), low (2.0 to 2.9 mm), moderate (3.0 to 3.9 mm), and severe (≥4.0 mm) | 1,426 inhabitants aged 25 to 74 years (741 women and 685 men) | Mean age = 48.9 (standard deviation = 13.9) 52.0% | Age, gender, and levels of smoking. | Job strain score among Alveolar Bone Loss categories (mean ± standard error) Healthy: 2.12 ± 0.02 Low: 2.10 ± 0.03 Moderate: 2.09 ± 0.04 Severe: 2.19 ± 0.04 From analysis of covariance |
| Akhter et al. (2005) [26] | Cross-sectional | Japan | Life events scale (yes or no) | Mean clinical attachment loss <1.5 mm were assigned to a non-diseased group and those with mean clinical attachment loss ≥1.5 mm were assigned to a diseased group | 1,089 residents ranging in age from 18 to 96years of a farming village in the northernmost island of Japan (531 men and 558 women) | Mean age = 55.0 (standard deviation = 1.7) 51.2% | Age, gender, employment status, smoking behavior, stress within 1 month, self-health-related stress, family health-related stress, frequency of dental attendance, hyperlipidemia, and diabetes mellitus | Job stress (reference: No): Odds ratio = 1.71 (95% confidence interval = 1.10, 2.67) from a logistic regression analysis |
| Talib Bandar (2009) [27] | Cross-sectional | Iraq | Life events scale (yes or no) | Gingival Index, probing pocket depth, bleeding on probing, and clinical attachment level | 64 patients of both genders with ages ranging from 23 to 65 years | Not reported | None | The mean gingival index yes = 1.851 and no = 1.586 (p-value > 0.05) Total mean percentage of sites with probing pocket depth ≥ 4 mm yes = 6.277% and no = 4.762% (p-values <0.05) Total mean Bleeding On Probing yes = 41.534% and no = 32.137% (p-value > 0.05) The mean of the clinical |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | attachment level<br>yes = 2.837 and no = 2.275 (p-value > 0.05)<br>(p-values from t-test) |
| Mahendra et al. (2011) [28] | Cross-sectional | India | An occupational stress index of Srivastava, A. K. and Singh, A. P. | Control group (n=30): probing pocket depth (PPD) ≤ 3 mm<br>Test group 1 (n=40): at least four sites with probing pocket depth > 4mm and ≤ 6 mm<br>Test group 2 (n=30): at least four sites with probing pocket depth > 6mm | 110 police personnel aged 35-48 years with moderate or established periodontitis | Mean age was around 40 years.<br>Sex was not reported. | None | Mean Occupational Stress Index Score (standard deviation)<br>Control: 79.53 (23.57)<br>Test group 1: 133.68 (33.23)<br>Test group 2: 158.13 (32.44)<br>p-value <0.001<br>(p-values from ANOVA with the Scheffe Test) |
| Ramji, (2011) [29] | Cross-sectional | India | Self-reported job stress from one question (having or not) | Community Periodontal Index and Treatment Needs protocol<br>(a tooth scored 3 or 4 indicating increased pocket depth of over 2 mm indicates presence of periodontitis) | 198 industrial labor full time workers from a small scale sector (SS) and 68 from a large scale sector (LS) between the age of 18-64 years | Age groups (SS [n=130], LS [n=68])<br>15-19 years 0%, 1%<br>20-29 years 38%, 60%<br>30-44 years 45%, 20%<br>45-64 years 17%, 19%<br>Sex was unknown. | None | Having self-reported job stress: Odds ratio = 7.5 (95% confidence interval = 3.7, 15.02) from a logistic regression analysis |
| Islam et al. (2019) [30] | Cross-sectional | Japan | Brief Job Stress Questionnaire developed by referring the demand-control-support model in Japan<br>(low stress, High stress-High coping, and High stress-low coping)<br>*coping was assessed using a questionnaire developed by a Japanese company | No inflammation of the gingiva or redness and/or swelling of the interdental papilla without gingival recession was classified as non-periodontitis, and any redness and/or swelling in the gingiva with gingival recession and/or tooth mobility was classified as periodontitis, based on visual inspection by dentists | 738 workers of a Japanese crane manufacturing company (92 were women) | Mean age = 40.7 (standard deviation = 10.5)<br>12.5% | Age, gender, daily flossing, regular dental checkup, body mass index, sleeping duration, current smoker, daily alcohol drinking, monthly overtime work, and worker type | High stress-High coping: Odds ratio = 0.30 (95% confidence interval = 0.14, 0.66)<br>High stress-Low coping: Odds ratio = 2.79 (95% confidence interval = 1.05, 7.43)<br>(reference: low stress)<br>From a logistic regression analysis |
| **Tooth loss** | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Hayashi et al. (2001) [31] | Cross-sectional | Japan | Karasek job strain model (high job demand and low control and other categories) | Tooth loss via oral examination (≥4 teeth lost and 3≤ teeth lost) | 252 male workers employed at a manufacturing company aged 20–59 years | Mean age = 38.7 (standard deviation = 11.0)<br>0% | Age, type A behavior, alexythymia, depression, job satisfaction, and life satisfaction | High job demand and low control: Odds ratio = 1.2 (95% confidence interval = 0.40, 3.42) from a logistic regression analysis (reference: other categories) |
| Sato et al. (2020) [32] | Cross-sectional | Japan | Effort-Reward Imbalance model (having or not) | Self-reported tooth loss<br>Having tooth loss or not (= no experience of tooth loss) | 1,195 employees aged 25–50 years old who work 20 h per week or more (women = 569) | Median age = 37 (1st and 3rd quartiles = 31 and 43)<br>48% | Age, sex, marital status, annual household income, years of education, employment status, occupation, working hours per week, job position, company size, body mass index, and smoking status | High effort-reward imbalance ratio: Prevalence ratio = 1.20 (95% confidence interval = 1.01, 1.42) from Poisson regression models with a robust error variance |

Table 2. Quality assessment of included studies

| | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 | Q12 | Q13 | Q14 | Quality Rating (Good, Fair, or Poor) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Marcenes and Sheiham (1992) [22] | Yes | Yes | NR | Yes | Yes | No | No | Yes | Yes | No | Yes | Yes | NA | Yes | Fair |
| Freeman and Goss (1993) [23] | Yes | Yes | NR | No | Yes | No | No | Yes | Yes | No | Yes | Yes | NA | No | Poor |
| Linden et al. (1996) [24] | Yes | Yes | NR | Yes | Yes | No | No | Yes | Yes | No | Yes | Yes | NA | No | Poor |
| Genco et al. (1999) [25] | Yes | Yes | NR | No | Yes | No | No | Yes | No | No | Yes | Yes | NA | No | Poor |
| Akhter et al. (2005) [26] | Yes | Yes | NR | No | Yes | No | No | NA | No | No | Yes | Yes | NA | No | Poor |
| Talib Bandar (2009) [27] | Yes | Yes | NR | No | No | No | No | NA | No | No | Yes | Yes | NA | No | Poor |
| Mahendra et al. (2011) [28] | Yes | Yes | NR | Yes | Yes | No | No | NA | Yes | No | Yes | Yes | NA | No | Poor |
| Ramji (2011) [29] | Yes | Yes | No | Yes | Yes | No | No | NA | No | No | Yes | Yes | NA | No | Poor |
| Islam et al. (2019) [30] | Yes | Yes | NR | Yes | Yes | No | No | NA | No | No | Yes | Yes | NA | No | Poor |
| Hayashi et al. (2001) [31] | Yes | Yes | Yes | Yes | Yes | No | No | NA | Yes | No | Yes | Yes | NA | No | Fair |
| Sato et al. (2020) [32] | Yes | Yes | No | Yes | Yes | No | No | NA | Yes | No | Yes | No | NA | Yes | Fair |

Q1. Was the research question or objective in this paper clearly stated?

Q2. Was the study population clearly specified and defined?

Q3. Was the participation rate of eligible persons at least 50%?

Q4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?

Q5. Was a sample size justification, power description, or variance and effect estimates provided?

Q6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?

Q7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?

Q8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of

exposure, or exposure measured as continuous variable)?

Q9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?

Q10. Was the exposure(s) assessed more than once over time?

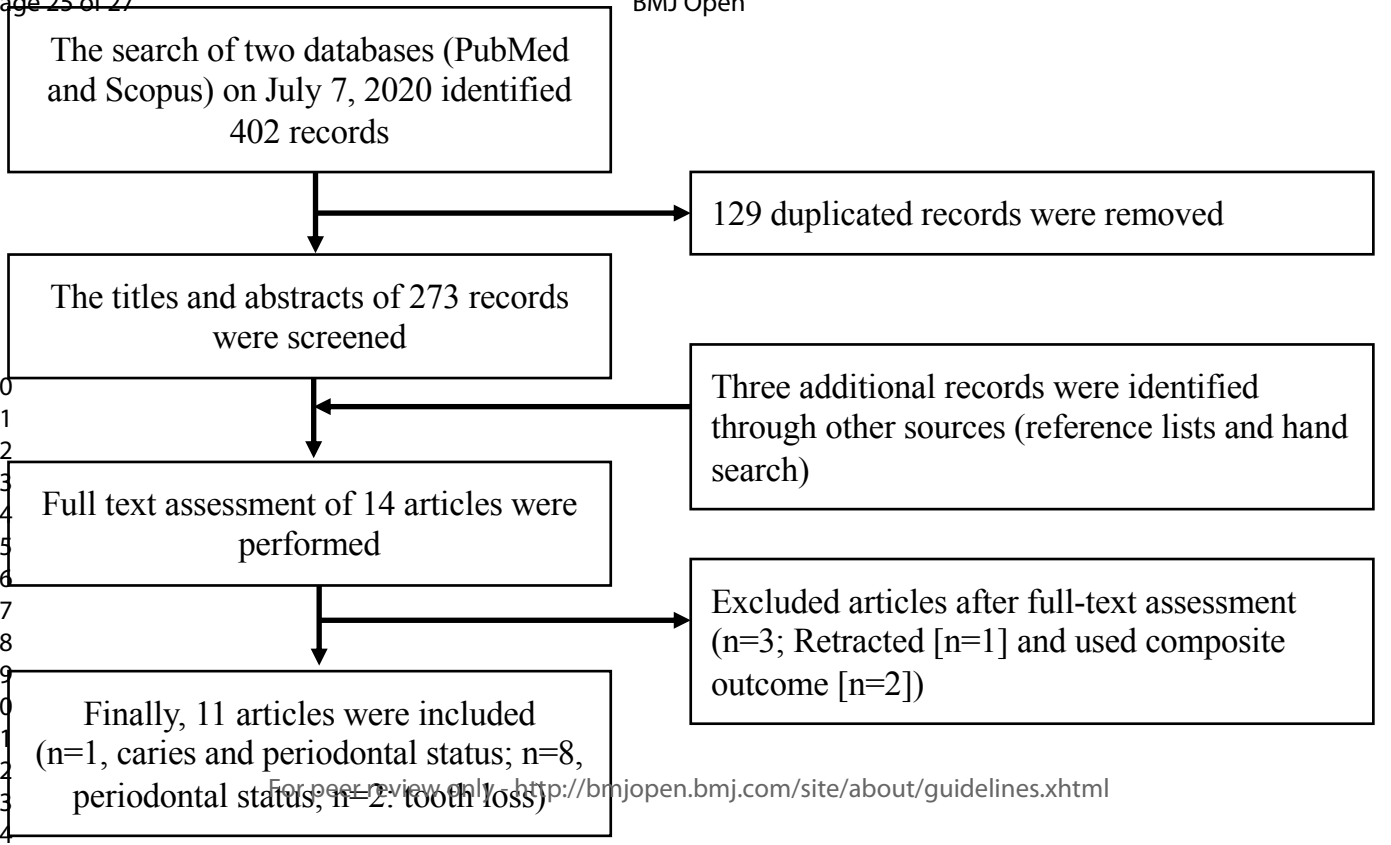
Q11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?

Q12. Were the outcome assessors blinded to the exposure status of participants?

Q13. Was loss to follow-up after baseline 20% or less?

Q14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?

Abbreviation: CD, cannot determine; NA, not applicable; NR, not reported



# PRISMA 2009 Checklist

| Section/topic | # | Checklist item | Reported on page # |
|---|---|---|---|
| **TITLE** | | | |
| Title | 1 | Identify the report as a systematic review, meta-analysis, or both. | p1 |
| **ABSTRACT** | | | |
| Structured summary | 2 | Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number. | p2 |
| **INTRODUCTION** | | | |
| Rationale | 3 | Describe the rationale for the review in the context of what is already known. | p5, 6 |
| Objectives | 4 | Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS). | p6 |
| **METHODS** | | | |
| Protocol and registration | 5 | Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number. | Not applicable |
| Eligibility criteria | 6 | Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale. | p6 |
| Information sources | 7 | Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched. | p6 |
| Search | 8 | Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated. | p6 |
| Study selection | 9 | State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis). | p6 |
| Data collection process | 10 | Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators. | p7 |
| Data items | 11 | List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made. | p7 |
| Risk of bias in individual studies | 12 | Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis. | p7 |
| Summary measures | 13 | State the principal summary measures (e.g., risk ratio, difference in means). | Not applicable |

# PRISMA 2009 Checklist

| | | | |
|---|---|---|---|
| Synthesis of results | 14 | Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., $I^2$) for each meta-analysis. | Not applicable |



| Section/topic | # | Checklist item | Reported on page # |
|---|---|---|---|
| Risk of bias across studies | 15 | Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies). | Not applicable |
| Additional analyses | 16 | Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified. | Not applicable |
| **RESULTS** | | | |
| Study selection | 17 | Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram. | p7 |
| Study characteristics | 18 | For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations. | p8, 9 |
| Risk of bias within studies | 19 | Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12). | p9 |
| Results of individual studies | 20 | For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot. | p9 |
| Synthesis of results | 21 | Present results of each meta-analysis done, including confidence intervals and measures of consistency. | Not applicable |
| Risk of bias across studies | 22 | Present results of any assessment of risk of bias across studies (see Item 15). | Not applicable |
| Additional analysis | 23 | Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]). | Not applicable |
| **DISCUSSION** | | | |
| Summary of evidence | 24 | Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers). | p9, 10 |
| Limitations | 25 | Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias). | p10,11, 12 |
| Conclusions | 26 | Provide a general interpretation of the results in the context of other evidence, and implications for future research. | p10,11, 12 |
| **FUNDING** | | | |

# PRISMA 2009 Checklist

| | | | |
|---|---|---|---|
| Funding | 27 | Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review. | p13 |

*From:* Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

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BMJ Open

# Work stress and oral conditions: A systematic review of observational studies



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**Title**

Work stress and oral conditions: A systematic review of observational studies

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**Abstract (300/300)**

**Objectives:** Although psychological stress is a risk factor for oral diseases, there seems to be no review on work stress. This study aimed to review the evidence on the association between work stress and oral conditions, including dental caries, periodontal status, and tooth loss.

**Design:** A systematic review of published observational studies.

**Data sources:** A systematic literature search was conducted in PubMed and Scopus databases on August 12, 2020.

**Study selection:** Articles were screened based on the following inclusion criteria: published after 1966; in English only; epidemiological studies on humans (except case studies, reviews, letters, commentaries, and editorials); and examined the association of work stress with dental caries, periodontal status, and tooth loss.

**Data extraction:** Data was extracted from eligible studies. A quality assessment was conducted using the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies.

**Results:** Of 402 articles identified, 11 met the inclusion criteria, and one study assessed the association of work stress with dental caries and periodontal status. Of 11 studies, one reported a nonsignificant association between work stress and dental caries; eight of nine studies reported a significant association between work stress and worse periodontal status; and one of two studies reported a significant association between work stress and tooth loss. Nine of eleven studies were cross-sectional, while the remaining two studies had unclear methodology. Only two studies were sufficiently adjusted for potential confounders. Eight studies assessed work stress but did not use the current major measures. Three studies were rated as fair, while eight studies had poor quality.

**Conclusions:** There is a lack of evidence on the association of work stress with dental caries and tooth loss. Eight studies suggested potential associations between periodontal status and

work stress. Cohort studies using the major work stress measures and adjusting for the potential confounders are needed.

**Keywords**

systematic review, work stress, job stress, occupational stress, oral health, oral diseases

**Strengths and limitations of this study**

► This is the first systematic review to evaluate and summarise the literature on the association between work stress and oral conditions, including dental caries, periodontal status, and tooth loss.

► This systematic review provides a comprehensive insight into the quality of the included papers.

► The systematic literature search, screening, and quality assessments were conducted by only one investigator.

► A meta-analysis could not be conducted because of the heterogeneity of work stress measures and outcome definitions.

## INTRODUCTION

Oral diseases, such as dental caries and periodontal disease, are a major health concern worldwide. The Global Burden of Disease study has estimated that 2.3 billion individuals had untreated dental caries, 796 million had severe periodontal disease, and 267 million had a complete loss of natural teeth in 2017.[1] Dental caries is the destruction of dental hard tissues in the crowns and roots of the teeth.[2] Periodontal diseases are chronic inflammatory conditions with disorders of the tissues surrounding and supporting the teeth.[3] Tooth loss is mainly the consequence of dental caries and periodontal disease.[2,3] Because oral diseases result in severe toothache and eating, sleeping, and communication disabilities,[4,5] poor oral conditions can restrict work performance[4,5] and create a significant economic burden.[6] Indeed, work productivity loss due to oral conditions is estimated at 187.61 billion US dollars annually.[6] The necessity of preventing oral diseases for working adults is highlighted.

Since the 1990s, rapid changes in the global economy and the diverse markets have occurred, and psychological workplace stress has become more prevalent and severe, especially among industrialised countries.[7] Indeed, Kivimäki et al. reported a 15% prevalence of job strain measured using job-content and demand-control questionnaires from 13 European cohorts' data (1985–2006).[8] Besides, work stress can have profound effects on health. There is accumulating evidence of the risk of work stress on cancer, cardiovascular diseases, diabetes, and depression.[9,10] Béjean and Sultan-Taïeb estimated that the work-related stress costs due to illnesses could range between €1,167 million and €1,975 million in France in 2000.[11] Work stress affects workers' health and productivity.

Psychological stress is recognised as a risk factor for dental caries and periodontal diseases. Psychological stress is related to oral diseases through immune system dysfunction, increased stress hormones, cariogenic bacterial counts, and poor oral health behaviours.[12,13] Work stress is strongly linked with psychological and physical health.[9,10] Previous systematic

reviews suggested potential associations of psychological stress with dental caries and periodontitis.[14,15] However, there seems to be no review on the association between work stress and oral diseases. Today, work stress has become an increasingly serious problem. Besides, the number of women in the workforce and dual-earner families have been increasing.[16] A wide range of populations can suffer the risk of oral diseases from exposure to work stress. Thus, the aim of this systematic review was to evaluate and summarise the literature on the association between work stress and oral conditions, including dental caries, periodontal status, and tooth loss. We set the following review question: Is work stress associated with dental caries, periodontal status, and tooth loss among working adults?

## METHODS

The reporting of this systematic review conforms to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[17,18] We also followed the Conducting Systematic Reviews and Meta-Analyses of Observational Studies of Etiology (COSMOS-E) guidance[19] and the reporting of Meta-analysis Of Observational Studies in Epidemiology (MOOSE).[20] The protocol of this systematic review was not registered.

### Eligibility criteria

Published studies were eligible if they: 1) were published in English; 2) were epidemiological studies on humans (except case studies, reviews, letters, commentaries, and editorials); and 3) examined the association of work stress with dental caries, periodontal status, and tooth loss.

### Information sources and searches

On August 12, 2020, we identified potentially relevant published studies in PubMed (1966 to August 12, 2020) and Scopus (1966 to August 12, 2020) databases. As PubMed and Scopus have only data back to 1966, we focused on articles published after 1966. We used

the following script to obtain a wide range of literature: ("job strain" OR "effort reward") AND (dental OR oral); ("job stress" OR "work stress" OR "occupational stress") AND (dental OR oral). The details of the search strategies for each database are shown in Supplemental Table 1. Besides, we manually hand-searched for potentially suitable studies through the reference lists of identified articles and Google scholar. After excluding duplicate articles, one author (YuS) assessed the titles and abstracts according to the aforementioned criteria. Then, eligible studies were selected for the full-text review.

**Data extraction**

The author (YuS) extracted the following information from each eligible study: 1) name of the first author; 2) study design; 3) study location (country); 4) number of participants and work-related characteristics; 5) exposure and its measurements; 6) outcome and its measurements; 7) age range and proportion of women; 8) covariates included in the adjusted models; and 9) the main results. The results were shown in Table 1.

**Quality assessment**

We used the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies to assess the quality of included studies.[21] This tool includes 14 questions for evaluating the internal validity of a study. For each question, the author (YuS) rated them as yes, no, or other (including cannot determine, not reported, and not applicable). The overall quality rating for the study was regarded as good if all the domains were assessed favourably. Each document of the question was shown in the footnote of Table 2.

**Synthesis of results**

A meta-analysis could not be conducted because of the heterogeneity of work stress measures and outcome definitions.

**Patient and public involvement**

No patient involved.

## RESULTS

Figure 1 presents the flow diagram of information through the phases of the systematic review. Of the 402 articles identified in PubMed and Scopus databases, 129 duplicated articles were removed, the titles and abstracts of 273 were screened, and 11 met the eligibility criteria. Three more articles identified through reference lists and hand-search were added. After full-text assessments of 14 articles, three were excluded due to retraction (n=1)[22] and the use of composite outcomes including dental caries and periodontal status (n=2).[23,24] Finally, 11 articles were included in this systematic review.[25–35]

### Study characteristics of individual studies

Table 1 shows the 12 summaries from the 11 studies. One of eleven studies reported on dental caries and periodontal status,[25] eight reported on periodontal status,[26–33] and two reported on tooth loss.[34,35] Three studies were conducted in Japan,[29,33–35] two in India,[31,32] and one each in the UK,[27] the US,[28] Brazil,[25] and Iraq.[30] One study did not report on the study location.[27] The sample size varied from 18 to 1,426 among included studies. In one study, working status was not reported.[28] One study included employed and unemployed participants.[29] Two studies did not include women,[25,34] and three did not report on sex.[30–32]

Three studies assessed work stress using the current major measures (Job Demand-Control Model and Effort-Reward Imbalance Model).[25,34,35] Work stress was assessed using the Karasek job strain model,[25,34] the Effort-Reward Imbalance model,[35] the Brief Job Stress Questionnaire developed by referring to the demand-control-support model in Japan,[33] a self-reported job stress,[32] the Occupational Stress Indicator,[26,27] an occupational stress index by Srivastava and Singh,[31] the Life events scale,[29,30] and the Problems of Everyday Living Scale by Pearlin and Schooler.[28]

Three studies presented only descriptive statistics.[28,30,31] Eight studies performed

regression analyses;[25–27,29,32–35] but two of the eight studies did not report the types of a regression modeling used.[26,27] Only two studies sufficiently adjusted for potential confounders such as socioeconomic status and work-related variables.[25,35]

**Dental caries and work stress**

One study reported the cross-sectional association between work stress and dental caries, which included 164 paid male workers aged 35 to 44 years in Brazil.[25] Work stress was assessed according to the Karasek job strain model.[36] Dental caries status was assessed using the DMFS index (the number of decayed [D], missing [M], and filled [F] teeth surfaces per person). After adjusting for covariates, one-point increases in the work mental demand, work control, and work variety scores were associated with 0.19 (95% confidence interval [CI] = -0.91, 1.29), 0.87 (95% CI = -0.18, 1.91), and -0.06 (95% CI = -1.57, 1.45) increases in the DMFS index, respectively, in a multivariable regression analysis. Consequently, this study reported a nonsignificant association between work stress and dental caries.[25]

**Periodontal status and work stress**

Eight of nine studies reported a significant association between work stress and worse periodontal status.[25–33] The measurements of periodontal status varied across the included studies. The measurements included probing pocket depth,[26,30,31] clinical attachment level,[27,28,30] alveolar bone loss,[28] gingival index,[30] bleeding on probing,[30] the Community Periodontal Index and Treatment Needs protocol,[32] and a composite outcome, including these measures.[25,33] Eight studies assessed periodontal status based on oral examination with probe, but one study was based on only visual inspection by dentists.[33]

Among the nine studies, two studies had unclear methodology; therefore, they were categorised as unknown.[26,27] Freeman and Goss assessed work stress and periodontal status over a 12-month period.[26] However, they did not clearly report when work stress and periodontal status variables were assessed and how they were used in the statistical models.

Linden et al. followed-up patients for 5.5 years, but work stress was only assessed at the follow-up examination, not at the baseline survey.[27]

Among the remaining seven studies, after excluding the above two studies, three studies presented only descriptive statistics.[28,30,31] The remaining four papers reported significant associations following regression analyses.[25,29,32,33] However, Akhter et al. used general stress questions not specific to work stress and included nonworking adults.[29] Islam et al. used the Brief Job Stress Questionnaire derived from the demand-control-support model in Japan, and periodontal status was assessed based on the visual inspection by dentists.[33] Important potential confounders such as socioeconomic status and work-related variables, were not included. Ramji assessed work stress using a single job stress question and did not adjust for covariates in the statistical models.[32] Marcenes and Sheiham reported a significant association between periodontal status and work stress.[25] Periodontal status was assessed by the presence or absence of gums bleeding on probing or with pockets. The authors divided periodontal measures into groups based on "complete absence of teeth with gums bleeding on probing and with pockets," or "the presence of any tooth with gums bleeding on probing or pockets," and defined the latter as those with periodontal disease. After adjusting for covariates, one-point increases in work mental demand scores, work control scores, and work variety scores were associated with ORs of 1.22 (95%CI = 1.06, 1.37), 0.97 (95%CI = 0.88, 1.07), and 0.99 (95%CI = 0.85, 1.16), respectively, for having periodontal disease, in a logistic regression model.

**Tooth loss and work stress**

Two studies on the association between work stress and tooth loss were identified. One of the two reported a significant association between work stress and tooth loss.[34,35] Hayashi et al. reported the association between work stress, assessed using the Karasek job strain model, and tooth loss.[34] A total of 322 male workers employed at a manufacturing company were

included. They dichotomised the number of tooth loss into ≤3 and ≥4. After adjusting for covariates, high job demand and low control conditions were associated with high odds of having ≥4 teeth loss but not significant (OR = 1.2 [95% CI = 0.40, 3.42]). This study did not adjust for the important potential confounders such as socioeconomic status and work-related variables. Sato et al. reported the association between work stress, assessed using the effort–reward imbalance model, and self-reported tooth loss.[35] After adjusting for covariates including socioeconomic status and work-related variables, a high effort-reward imbalance ratio was significantly associated with a high prevalence of ≥1 tooth loss (prevalence ratio = 1.20 [95% CI = 1.01, 1.42]).

**Study quality**

Table 2 presents the results of the quality assessments for each study. Eight studies (73%) had poor quality, while three (27%) were rated as fair. None of the studies addressed question 6 ("For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?"); 7 ("Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?"); and 10 ("Was the exposure(s) assessed more than once over time?"); because all the studies were cross-sectional or the study design was unclear.

## DISCUSSION

This is the first systematic review to evaluate and summarise the existing literature on the associations between work stress and oral conditions. As our findings showed, only one study reported on dental caries and periodontal status, nine on periodontal status, and two on tooth loss. Based on the findings of this review, the evidence is lacking on the association of work stress with dental caries and tooth loss. Eight of nine studies reported the significant associations between multiple periodontal measures and work stress.

## Limitations of the review

This systematic review has four limitations. First, the systematic literature search, screening, and quality assessments were conducted by only one investigator. A single screening could miss more studies than a double screening.[37] Second, only English language literature was included. Although a systematic review found no bias due to English-language restriction in systematic reviews,[38] this review might include bias. Third, there was no protocol for this systematic review. A priori systematic review protocol registration provides the rigor and trustworthiness of the reviews.[39] This might weaken the rigor and trustworthiness of our review. Finally, a meta-analysis could not be conducted owing to the heterogeneity of the included studies. Work stress was assessed using varied measures. Particularly, only a few studies used the current major measures of work stress. Indicators of periodontal status were also varied. No study used valid epidemiological definitions for periodontal disease as the outcome. The cut-off points differed between the two studies on tooth loss and work stress. Besides, there was only one study on dental caries and work stress. These limitations hindered us from performing a meta-analysis.

## Dental caries and work stress

We found only one study on the cross-sectional association between work stress and dental caries.[25] The conclusion was that there was no significant association between work stress and dental caries. However, since the sample size was relatively small (n=164), there is the possibility of a false negative association. Besides, each subscale of the Karasek job strain model was simultaneously included in the statistical model. Generally, in the Karasek job strain model, the recommendation is to use four categories of job strain generated by the interaction of the subscales: High-strain jobs, active jobs, low-strain jobs, and passive jobs.[9] Due to the above treatments of the subscales, it is possible that the association was underestimated. Additionally, as there was no cohort study, we could not assess the

prospective associations. Considering the above limitations, it was difficult to determine whether work stress is associated with dental caries. A further study should include a cohort design and a relatively large sample size with appropriate work stress measures.

**Periodontal status and work stress**

Nine studies reported on the association between work stress and periodontal status.[25–33] However, the outcome measures were varied across the included studies. Although there are the accepted epidemiological definitions of periodontitis according to the European Workshop in Periodontology and the Centers for Disease Control/American Academy of Periodontology,[40,41] there was no study that used the definitions. It means that the included studies reported the associations between work stress and periodontal measures, not periodontal disease. In addition, the measurement of work stress was measured also varied across studies. Each measure assessed different dimensions of work stress.[42] Due to the heterogeneity of exposures and outcomes, we could not conduct a meta-analysis.

Of the nine studies, only one study adjusted for the potential confounders, such as socioeconomic status and work-related variables.[25] Besides, no cohort study was found. The failure to adjust for the confounders and consider the induction time weakens the research evidence. However, despite the above limitations, the consistent association between work stress and worse periodontal status is noteworthy. To verify the current results, a further cohort study using the validated definitions of periodontal disease and current measurements of work stress, in addition to adjusting for the potential confounders should be performed.

**Tooth loss and work stress**

Two studies on the association between work stress and tooth loss were identified. Hayashi's study included only male workers employed at one manufacturing company.[34] In contrast, Sato's study included active workers sampled from a general population.[35] However, the response rate was relatively low (32%). The generalisability of both studies could be limited.

The two studies had different cut-off points of tooth loss. Hayashi's study used the cut-off point of more than 4 teeth lost. The cutoff point is higher than the mean number of teeth loss (at 25 to 34, 35 to 45, 46 to 54, and 55 to 64 years = 0.16, 0.58, 1.48, and 4.00, respectively) reported by the national statistical surveys.[43] This study targeted severe cases only. In Sato's study, the outcome was the loss of at least more than one tooth. However, this outcome relied on self-reported answers; therefore, self-reported bias might exist.

Both studies showed an increased risk of tooth loss, although only one of the two studies reported a significant association between work stress and tooth loss. However, due to the above limitations, it is difficult to derive any form of conclusion. In the future, a cohort study including general workers should be conducted to confirm these findings.

**Conclusions**

Based on the findings, this systematic review suggests a lack of evidence on the association of work stress with dental caries and tooth loss. Although eight of the nine studies reported significant associations between multiple periodontal measures and work stress, no study used valid epidemiological definitions of periodontal disease. For future research, well-designed cohort studies including potential confounding factors and the use of generally accepted measurements of work stress and periodontal disease are needed.

**Ethical Approval Statement**

Not applicable

**Contributors**

YuS contributed to the acquisition and the interpretation of data and drafting of the work. YaS and EY revised it critically for important intellectual content. All authors contributed to the conception 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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**Competing interests**

The authors declare no potential conflicts of interest with respect to the research, authorship, and publication of this article.

**Patient consent for publication**

Not required.

**Provenance and peer review**

Not commissioned; externally peer-reviewed.

**Data availability statement**

Not applicable.

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## Tables

Table 1. Summary of included studies on work stress and oral conditions

| Author's name (year of publication) | Study design | Study location | Exposure (work stress) | Outcome | Number of participants | Mean age of the participants and proportion of women | Covariates | Main results |
|---|---|---|---|---|---|---|---|---|
| **Dental caries** | | | | | | | | |
| Marcenes and Sheiham (1992)[25] | Cross-sectional | Brazil | Karasek job strain model | DMFS index (number of decayed (D), missing (M), and Filled (F) teeth surfaces per persons) | 164 male paid workers aged from 35 to 44 years | Mean age = 41.2 (standard deviation = 2.2)<br>0% | Marital quality, toothbrushing frequency, sugar consumption, age, years of residence, type of toothpaste, frequency dental attendance, and socio-economic status | Work mental demand: Coefficients = 0.19 (95% CI = -0.91, 1.29)<br>Work control: Coefficients = 0.87 (95% CI = -0.18, 1.91)<br>Work variety: Coefficients = -0.06 (95% CI = -1.57, 1.45)<br>From a linear regression analysis |
| **Periodontal status** | | | | | | | | |
| Marcenes and Sheiham (1992)[25] | Cross-sectional | Brazil | Karasek job strain model | The presence or absence of teeth either with gums bleeding on probing or with pockets was used. The indicator was labelled as 'complete absence of teeth with gums bleeding on probing and with pockets', and 'presence of any tooth with gums bleeding on probing or pockets'. | 164 male paid workers aged from 35 to 44 years (16 workers were excluded from 164 participants due to missing values and edentulous) | Mean age = 41.2 (standard deviation = 2.2)<br>0% | Marital quality, toothbrushing frequency, sugar consumption, age, years of residence, type of toothpaste, frequency dental attendance, and socio-economic status | Work mental demand: Odds ratio = 1.22 (95% confidence interval = 1.06, 1.37)<br>Work control: Odds ratio = 0.97 (95% confidence interval = 0.88, 1.07)<br>Work variety: Odds ratio = 0.99 (95% confidence interval = 0.85, 1.16)<br>From a logistic regression analysis |
| Freeman and Goss (1993)[26] | Unknown | Not reported | Occupational Stress Indicator | Mean increases in pocket depth | 10 women and 8 men from the head office of a large company | Mean age = 39<br>55.6% | Unknown | Type A behaviour: Coefficients = 0.41 (p-value=0.003)<br>Work environment (organisation/climate): Coefficients = -0.34 (p-value = 0.007)<br>(statistical model was not reported) |
| Linden et al. (1996)[27] | Unknown | UK | Occupational Stress Indicator assessed at the second examination | Changes in clinical attachment level after an interval of 5.5 (SD 0.6) years. | 23 employed regular dental attendees aged between 20 and 50 years who had moderate or | Mean age = 41.1 (standard deviation = 7.3)<br>43.5% | Age and social class of the household | Job satisfaction: Coefficients = -0.014 (p-value < 0.01)<br>Type A: Coefficients = 0.026 (p-value < 0.05) |

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| | | | | established periodontitis (13 men and 10 women) | | | Locus of control: Coefficients = -0.035 (p-value ≥ 0.05) (statistical model was not reported) |
| Genco et al. (1999)[28] | Cross-sectional | US | Problems of Everyday Living Scale of Pearlin and Schooler | Severity of Attachment Loss Healthy (0 to 1 mm clinical attachment level), low (1.1 to 2.0 mm), moderate (2.1 to 3.0 mm), high (3.1 to 4.0 mm) and severe (4.1 to 8.0 mm)<br>Severity of Alveolar Bone Loss Healthy (0.4 to 1.9 mm alveolar crestal height), low (2.0 to 2.9 mm), moderate (3.0 to 3.9 mm), and severe (≥4.0 mm) | 1,426 inhabitants aged 25 to 74 years (741 women and 685 men) *working status was unknown | Mean age = 48.9 (standard deviation = 13.9)<br>52.0% | Age, gender, and levels of smoking. | Job strain score among Attachment Loss categories (mean ± standard error)<br>Healthy: 2.12 ± 0.05<br>Low: 2.09 ± 0.02<br>Moderate: 2.16 ± 0.02<br>High: 2.09 ± 0.05<br>Severe: 2.22 ± 0.05<br>(nonsignificant)<br>From analysis of covariance<br><br>Job strain score among Alveolar Bone Loss categories (mean ± standard error)<br>Healthy: 2.12 ± 0.02<br>Low: 2.10 ± 0.03<br>Moderate: 2.09 ± 0.04<br>Severe: 2.19 ± 0.04<br>(nonsignificant)<br>From analysis of covariance |
| Akhter et al. (2005)[29] | Cross-sectional | Japan | Life events scale (yes or no) | Mean clinical attachment loss <1.5 mm were assigned to a non-diseased group and those with mean clinical attachment loss ≥1.5 mm were assigned to a diseased group | 1,089 employed and unemployed residents ranging in age from 18 to 96 years of a farming village in the northernmost island of Japan (531 men and 558 women) | Mean age = 55.0 (standard deviation = 1.7)<br>51.2% | Age, gender, employment status, smoking behaviour, stress within 1 month, self-health-related stress, family health-related stress, frequency of dental attendance, hyperlipidaemia, and diabetes mellitus | Job stress (reference: No): Odds ratio = 1.71 (95% confidence interval = 1.10, 2.67) from a logistic regression analysis |
| Talib Bandar (2009)[30] | Cross-sectional | Iraq | Life events scale (yes or no) | Gingival Index, probing pocket depth, bleeding on probing, and clinical attachment level | 64 working dental patients of both genders with ages ranging from 23 to 65 years | Mean age and sex were not reported. | None | The mean gingival index yes = 1.851 and no = 1.586 (p-value > 0.05)<br><br>Total mean percentage of sites with probing pocket depth ≥ 4 mm<br>yes = 6.277% and no = 4.762% (p-values <0.05) |

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|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Total mean Bleeding On Probing<br>yes = 41.534% and no = 32.137% (p-value > 0.05)<br><br>The mean of the clinical attachment level<br>yes = 2.837 and no = 2.275 (p-value > 0.05)<br>(all p-values from t-test) |
| Mahendra et al. (2011)[31] | Cross-sectional | India | An occupational stress index of Srivastava, A. K. and Singh, A. P. | Control group (n=30): probing pocket depth (PPD) ≤ 3 mm<br>Test group 1 (n=40): at least four sites with probing pocket depth > 4mm and ≤ 6 mm<br>Test group 2 (n=30): at least four sites with probing pocket depth > 6mm | 110 police personnel aged 35-48 years with moderate or established periodontitis | Mean age (standard deviation); control group: 40.23 (3.46); test group 1: 40.42 (3.54); test group 2: 41.18 (3.78)<br>Sex was not reported. | None | Mean Occupational Stress Index Score (standard deviation)<br>Control: 79.53 (23.57)<br>Test group 1: 133.68 (33.23)<br>Test group 2: 158.13 (32.44)<br>p-value <0.001<br>(p-values from ANOVA with the Scheffe Test) |
| Ramji, (2011)[32] | Cross-sectional | India | Self-reported job stress (having or not) | Community Periodontal Index and Treatment Needs protocol<br>(a tooth scored 3 or 4 indicating increased pocket depth of over 2 mm indicates presence of periodontitis) | 198 industrial labour full time workers from a small scale sector (SS) and 68 from a large scale sector (LS) between the age of 18-64 years | Age groups (SS [n=130], LS [n=68])<br>15-19 years: 0%, 1%<br>20-29 years: 38%, 60%<br>30-44 years: 45%, 20%<br>45-64 years: 17%, 19%<br>Sex was not reported. | None | Having self-reported job stress: Odds ratio = 7.5 (95% confidence interval = 3.7, 15.02) from a logistic regression analysis |
| Islam et al. (2019)[33] | Cross-sectional | Japan | Brief Job Stress Questionnaire developed by referring the demand-control-support model in Japan<br>(low stress, High stress-High coping, | No inflammation of the gingiva or redness and/or swelling of the interdental papilla without gingival recession was classified as non-periodontitis, and any redness and/or swelling in the gingiva with gingival recession and/or tooth mobility was classified as periodontitis, based on visual inspection by dentists | 738 workers of a Japanese crane manufacturing company (92 were women) | Mean age = 40.7 (standard deviation = 10.5)<br>12.5% | Age, gender, daily flossing, regular dental checkup, body mass index, sleeping duration, current smoker, daily alcohol drinking, monthly overtime work, and worker type | High stress-High coping: Odds ratio = 0.30 (95% confidence interval = 0.14, 0.66)<br>High stress-Low coping: Odds ratio = 2.79 (95% confidence interval = 1.05, 7.43)<br>(reference: low stress)<br>from a logistic regression analysis |

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|---|---|---|---|---|---|---|---|---|
| | | | and High stress-low coping)<br>*coping was assessed using a questionnaire developed by a Japanese company | | | | | |
| **Tooth loss** | | | | | | | | |
| Hayashi et al. (2001)[34] | Cross-sectional | Japan | Karasek job strain model (high job demand and low control and other categories) | Tooth loss via oral examination (≥4 teeth lost and 3≤ teeth lost) | 252 male workers employed at a manufacturing company aged 20–59 years | Mean age = 38.7 (standard deviation = 11.0)<br>0% | Age, type A behaviour, alexythymia, depression, job satisfaction, and life satisfaction | High job demand and low control (reference: other categories): Odds ratio = 1.2 (95% confidence interval = 0.40, 3.42) from a logistic regression analysis |
| Sato et al. (2020)[35] | Cross-sectional | Japan | Effort-Reward Imbalance model (having or not) | Self-reported tooth loss<br>Having tooth loss or not (= no experience of tooth loss) | 1,195 employees aged 25–50 years old who work 20 h per week or more (women = 569) | Median age = 37 (1st and 3rd quartiles = 31 and 43)<br>48% | Age, sex, marital status, annual household income, years of education, employment status, occupation, working hours per week, job position, company size, body mass index, and smoking status | High effort-reward imbalance ratio: Prevalence ratio = 1.20 (95% confidence interval = 1.01, 1.42) from Poisson regression models with a robust error variance |

Table 2. Quality assessment of included studies

| | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 | Q12 | Q13 | Q14 | Quality Rating (Good, Fair, or Poor) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Marcenes and Sheiham (1992)[25] | Yes | Yes | NR | Yes | Yes | No | No | Yes | Yes | No | Yes | Yes | NA | Yes | Fair |
| Freeman and Goss (1993)[26] | Yes | Yes | NR | No | Yes | No | No | Yes | Yes | No | Yes | Yes | NA | No | Poor |
| Linden et al. (1996)[27] | Yes | Yes | NR | Yes | Yes | No | No | Yes | Yes | No | Yes | Yes | NA | No | Poor |
| Genco et al. (1999)[28] | Yes | Yes | NR | No | Yes | No | No | Yes | No | No | Yes | Yes | NA | No | Poor |
| Akhter et al. (2005)[29] | Yes | Yes | NR | No | Yes | No | No | NA | No | No | Yes | Yes | NA | No | Poor |
| Talib Bandar (2009)[30] | Yes | Yes | NR | No | No | No | No | NA | No | No | Yes | Yes | NA | No | Poor |
| Mahendra et al. (2011)[31] | Yes | Yes | NR | Yes | Yes | No | No | NA | Yes | No | Yes | Yes | NA | No | Poor |
| Ramji (2011)[32] | Yes | Yes | No | Yes | Yes | No | No | NA | No | No | Yes | Yes | NA | No | Poor |
| Islam et al. (2019)[33] | Yes | Yes | NR | Yes | Yes | No | No | NA | No | No | Yes | Yes | NA | No | Poor |
| Hayashi et al. (2001)[34] | Yes | Yes | Yes | Yes | Yes | No | No | NA | Yes | No | Yes | Yes | NA | No | Fair |
| Sato et al. (2020)[35] | Yes | Yes | No | Yes | Yes | No | No | NA | Yes | No | Yes | No | NA | Yes | Fair |

Abbreviation: CD, cannot determine; NA, not applicable; NR, not reported

Q1. Was the research question or objective in this paper clearly stated?

Q2. Was the study population clearly specified and defined?

Q3. Was the participation rate of eligible persons at least 50%?

Q4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?

Q5. Was a sample size justification, power description, or variance and effect estimates provided?

Q6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?

Q7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?

Q8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of

exposure, or exposure measured as continuous variable)?

Q9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?

Q10. Was the exposure(s) assessed more than once over time?

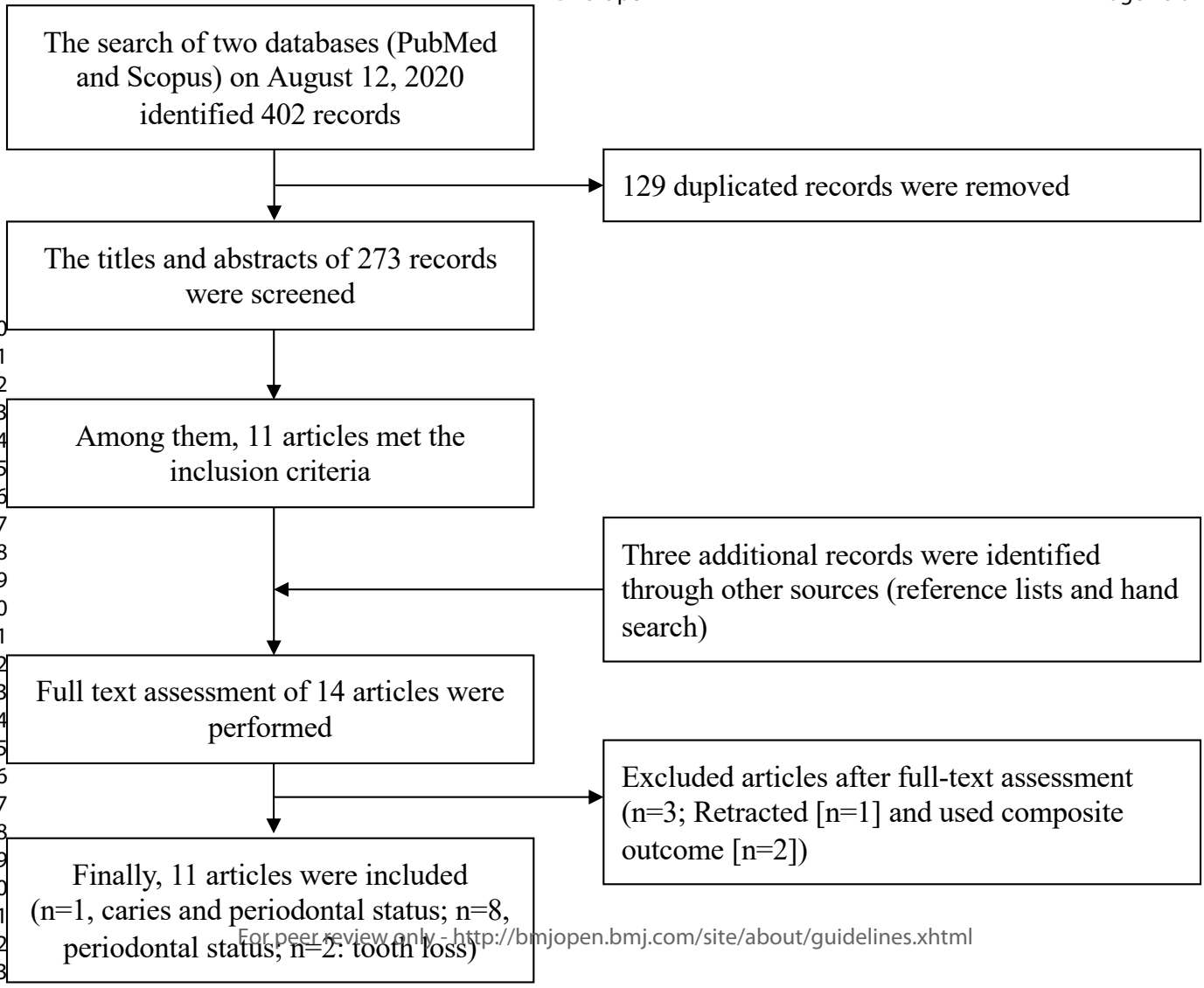
Q11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?

Q12. Were the outcome assessors blinded to the exposure status of participants?

Q13. Was loss to follow-up after baseline 20% or less?

Q14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?

Figure 1. Flow of search strategy and selection of studies for a systematic review.



Supplemental Table 1. The precise search strategies for each database.

| Database | Date | Combination of terms used | Limitation | Result |
|---|---|---|---|---|
| PubMed | August 12, 2020 | ("job strain" OR "effort reward") AND (dental OR oral) | English | 22 |
| PubMed | August 12, 2020 | ("job stress" OR "work stress" OR "occupational stress") AND (dental OR oral) | English | 143 |
| Scopus | August 12, 2020 | ("job strain" OR "effort reward") AND (dental OR oral) | English | 20 |
| Scopus | August 12, 2020 | ("job stress" OR "work stress" OR "occupational stress") AND (dental OR oral) | English | 217 |

# MOOSE Checklist for Meta-analyses of Observational Studies

| Item No | Recommendation | Reported on Page No |
|---|---|---|
| Reporting of background should include | | |
| 1 | Problem definition | 5-6 |
| 2 | Hypothesis statement | 6 |
| 3 | Description of study outcome(s) | 6 |
| 4 | Type of exposure or intervention used | 6 |
| 5 | Type of study designs used | 6 |
| 6 | Study population | 6 |
| Reporting of search strategy should include | | |
| 7 | Qualifications of searchers (eg, librarians and investigators) | 7 |
| 8 | Search strategy, including time period included in the synthesis and key words | 6-7, Supplemental Table 1 |
| 9 | Effort to include all available studies, including contact with authors | 7 |
| 10 | Databases and registries searched | 6, Supplemental Table 1 |
| 11 | Search software used, name and version, including special features used (eg, explosion) | NA |
| 12 | Use of hand searching (eg, reference lists of obtained articles) | 7, Supplemental Table 1 |
| 13 | List of citations located and those excluded, including justification | 6 |
| 14 | Method of addressing articles published in languages other than English | NA |
| 15 | Method of handling abstracts and unpublished studies | 7 |
| 16 | Description of any contact with authors | NA |
| Reporting of methods should include | | |
| 17 | Description of relevance or appropriateness of studies assembled for assessing the hypothesis to be tested | 6 |
| 18 | Rationale for the selection and coding of data (eg, sound clinical principles or convenience) | 7 |
| 19 | Documentation of how data were classified and coded (eg, multiple raters, blinding and interrater reliability) | 7 |
| 20 | Assessment of confounding (eg, comparability of cases and controls in studies where appropriate) | 7 |
| 21 | Assessment of study quality, including blinding of quality assessors, stratification or regression on possible predictors of study results | 7 |
| 22 | Assessment of heterogeneity | NA |
| 23 | Description of statistical methods (eg, complete description of fixed or random effects models, justification of whether the chosen models account for predictors of study results, dose-response models, or cumulative meta-analysis) in sufficient detail to be replicated | 7 |
| 24 | Provision of appropriate tables and graphics | Table 1, Table 2 |
| Reporting of results should include | | |
| 25 | Graphic summarizing individual study estimates and overall estimate | NA |
| 26 | Table giving descriptive information for each study included | Table 1 |
| 27 | Results of sensitivity testing (eg, subgroup analysis) | NA |
| 28 | Indication of statistical uncertainty of findings | NA |

| Item No | Recommendation | Reported on Page No |
|---|---|---|
| Reporting of discussion should include | | |
| 29 | Quantitative assessment of bias (eg, publication bias) | 11-12 |
| 30 | Justification for exclusion (eg, exclusion of non-English language citations) | 11-12 |
| 31 | Assessment of quality of included studies | 12-14 |
| Reporting of conclusions should include | | |
| 32 | Consideration of alternative explanations for observed results | 12-14 |
| 33 | Generalization of the conclusions (ie, appropriate for the data presented and within the domain of the literature review) | 12-14 |
| 34 | Guidelines for future research | 12-14 |
| 35 | Disclosure of funding source | 15 |

From: Stroup DF, Berlin JA, Morton SC, et al. Meta-analysis of Observational Studies in Epidemiology: A Proposal for Reporting. JAMA. 2000;283(15):2008–2012. doi:10.1001/jama.283.15.2008

Abbreviation: NA, not applicable

BMJ Open

# Work stress and oral conditions: A systematic review of observational studies



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**Title**

Work stress and oral conditions: A systematic review of observational studies

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**Abstract (300/300)**

**Objectives:** Although psychological stress is a risk factor for oral diseases, there seems to be no review on work stress. This study aimed to review the evidence on the association between work stress and oral conditions, including dental caries, periodontal status, and tooth loss.

**Design:** A systematic review of published observational studies.

**Data sources:** A systematic literature search was conducted in PubMed and Scopus databases on August 12, 2020.

**Study selection:** Articles were screened based on the following inclusion criteria: published after 1966; in English only; epidemiological studies on humans (except case studies, reviews, letters, commentaries, and editorials); and examined the association of work stress with dental caries, periodontal status, and tooth loss.

**Data extraction:** Data was extracted from eligible studies. A quality assessment was conducted using the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies.

**Results:** Of 402 articles identified, 11 met the inclusion criteria, and one study assessed the association of work stress with dental caries and periodontal status. Of 11 studies, one reported a nonsignificant association between work stress and dental caries; eight of nine studies reported a significant association between work stress and worse periodontal status; and one of two studies reported a significant association between work stress and tooth loss. Nine of eleven studies were cross-sectional, while the remaining two studies had unclear methodology. Only two studies were sufficiently adjusted for potential confounders. Eight studies assessed work stress but did not use the current major measures. Three studies were rated as fair, while eight studies had poor quality.

**Conclusions:** There is a lack of evidence on the association of work stress with dental caries and tooth loss. Eight studies suggested potential associations between periodontal status and

work stress. Cohort studies using the major work stress measures and adjusting for the potential confounders are needed.

**Keywords**

systematic review, work stress, job stress, occupational stress, oral health, oral diseases

**Strengths and limitations of this study**

► This is the first systematic review to evaluate and summarise the literature on the association between work stress and oral conditions, including dental caries, periodontal status, and tooth loss.

► This systematic review provides a comprehensive insight into the quality of the included papers.

► The systematic literature search, screening, and quality assessments were conducted by only one investigator.

► A meta-analysis could not be conducted because of the heterogeneity of work stress measures and outcome definitions.

## INTRODUCTION

Oral diseases, such as dental caries and periodontal disease, are a major health concern worldwide. The Global Burden of Disease study has estimated that 2.3 billion individuals had untreated dental caries, 796 million had severe periodontal disease, and 267 million had a complete loss of natural teeth in 2017.[1] Dental caries is the destruction of dental hard tissues in the crowns and roots of the teeth.[2] Periodontal diseases are chronic inflammatory conditions with disorders of the tissues surrounding and supporting the teeth.[3] Tooth loss is mainly the consequence of dental caries and periodontal disease.[2,3] Because oral diseases result in severe toothache and eating, sleeping, and communication disabilities,[4,5] poor oral conditions can restrict work performance[4,5] and create a significant economic burden.[6] Indeed, work productivity loss due to oral conditions is estimated at 187.61 billion US dollars annually.[6] The necessity of preventing oral diseases for working adults is highlighted.

Since the 1990s, rapid changes in the global economy and the diverse markets have occurred, and psychological workplace stress has become more prevalent and severe, especially among industrialised countries.[7] Indeed, Kivimäki et al. reported a 15% prevalence of job strain measured using job-content and demand-control questionnaires from 13 European cohorts' data (1985–2006).[8] Besides, work stress can have profound effects on health. There is accumulating evidence of the risk of work stress on cancer, cardiovascular diseases, diabetes, and depression.[9,10] Béjean and Sultan-Taïeb estimated that the work-related stress costs due to illnesses could range between €1,167 million and €1,975 million in France in 2000.[11] Work stress affects workers' health and productivity.

Psychological stress is recognised as a risk factor for dental caries and periodontal diseases. Psychological stress is related to oral diseases through immune system dysfunction, increased stress hormones, cariogenic bacterial counts, and poor oral health behaviours.[12,13] Work stress is strongly linked with psychological and physical health.[9,10] Previous systematic

reviews suggested potential associations of psychological stress with dental caries and periodontitis.[14,15] However, there seems to be no review on the association between work stress and oral diseases. Today, work stress has become an increasingly serious problem. Besides, the number of women in the workforce and dual-earner families have been increasing.[16] A wide range of populations can suffer the risk of oral diseases from exposure to work stress. Thus, the aim of this systematic review was to evaluate and summarise the literature on the association between work stress and oral conditions, including dental caries, periodontal status, and tooth loss. We set the following review question: Is work stress associated with dental caries, periodontal status, and tooth loss among working adults?

## METHODS

The reporting of this systematic review conforms to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[17,18] We also followed the Conducting Systematic Reviews and Meta-Analyses of Observational Studies of Etiology (COSMOS-E) guidance[19] and the reporting of Meta-analysis Of Observational Studies in Epidemiology (MOOSE).[20] The protocol of this systematic review was not registered.

### Eligibility criteria

Published studies were eligible if they: 1) were published in English; 2) were epidemiological studies on humans (except case studies, reviews, letters, commentaries, and editorials); and 3) examined the association of work stress with dental caries, periodontal status, and tooth loss.

### Information sources and searches

On August 12, 2020, we identified potentially relevant published studies in PubMed (1966 to August 12, 2020) and Scopus (1966 to August 12, 2020) databases. As PubMed and Scopus have only data back to 1966, we focused on articles published after 1966. We used

the following script to obtain a wide range of literature: ("job strain" OR "effort reward") AND (dental OR oral); ("job stress" OR "work stress" OR "occupational stress") AND (dental OR oral). The details of the search strategies for each database are shown in Supplemental Table 1. Besides, we manually hand-searched for potentially suitable studies through the reference lists of identified articles and Google scholar. After excluding duplicate articles, one author (YuS) assessed the titles and abstracts according to the aforementioned criteria. Then, eligible studies were selected for the full-text review.

**Data extraction**

One author (YuS) extracted the following information from each eligible study: 1) name of the first author; 2) study design; 3) study location (country); 4) number of participants and work-related characteristics; 5) exposure and its measurements; 6) outcome and its measurements; 7) age range and proportion of women; 8) covariates included in the adjusted models; and 9) the main results. The results were shown in Table 1.

**Quality assessment**

We used the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies to assess the quality of included studies.[21] This tool includes 14 questions for evaluating the internal validity of a study and these questions are documented in the footnote of Table 2. For each question, one author (YuS) rated them as yes, no, or other (including cannot determine, not reported, and not applicable). The overall quality rating for the study was regarded as good if all the domains were assessed favourably.

**Synthesis of results**

A meta-analysis could not be conducted because of the heterogeneity of work stress measures and outcome definitions.

**Patient and public involvement**

No patient involved.

## RESULTS

Figure 1 presents the flow diagram of information through the phases of the systematic review. Of the 402 articles identified in PubMed and Scopus databases, 129 duplicated articles were removed, the titles and abstracts of 273 were screened, and 11 met the eligibility criteria. Three more articles identified through reference lists and hand-search were added. One article was identified by a hand-search using Google Scholar,[22] one was a plagiarised article,[23] and the third was from a reference list.[24] After full-text assessments of 14 articles, three were excluded due to retraction (n=1)[25] and the use of composite outcomes including dental caries and periodontal status (n=2).[26,27] Finally, 11 articles were included in this systematic review.[22–24,28–35]

### Study characteristics of individual studies

Table 1 shows the 12 summaries from the 11 studies. One of eleven studies reported on dental caries and periodontal status,[28] eight reported on periodontal status,[22–24,29–33] and two reported on tooth loss.[34,35] Three studies were conducted in Japan,[31,33–35] two in India,[23,32] and one each in the UK,[29] the US,[30] Brazil,[28] and Iraq.[22] One study did not report on the study location.[29] The sample size varied from 18 to 1,426 among included studies. In one study, working status was not reported.[30] One study included employed and unemployed participants.[31] Two studies did not include women,[28,34] and three did not report on sex.[22,23,32]

Three studies assessed work stress using the current major measures (Job Demand-Control Model and Effort-Reward Imbalance Model).[28,34,35] Work stress was assessed using the Karasek job strain model,[28,34] the Effort-Reward Imbalance model,[35] the Brief Job Stress Questionnaire developed by referring to the demand-control-support model in Japan,[33] a self-reported job stress,[23] the Occupational Stress Indicator,[24,29] an occupational stress index by Srivastava and Singh,[32] the Life events scale,[22,31] and the Problems of Everyday Living Scale

by Pearlin and Schooler.[30]

Three studies presented only descriptive statistics.[22,30,32] Eight studies performed regression analyses;[23,24,28,29,31,33–35] but two of the eight studies did not report the types of a regression modeling used.[24,29] Only two studies sufficiently adjusted for potential confounders such as socioeconomic status and work-related variables.[28,35]

**Dental caries and work stress**

One study reported the cross-sectional association between work stress and dental caries, which included 164 paid male workers aged 35 to 44 years in Brazil.[28] Work stress was assessed according to the Karasek job strain model.[36] Dental caries status was assessed using the DMFS index (the number of decayed [D], missing [M], and filled [F] teeth surfaces per person). After adjusting for covariates, one-point increases in the work mental demand, work control, and work variety scores were associated with 0.19 (95% confidence interval [CI] = -0.91, 1.29), 0.87 (95% CI = -0.18, 1.91), and -0.06 (95% CI = -1.57, 1.45) increases in the DMFS index, respectively, in a multivariable regression analysis. Consequently, this study reported a nonsignificant association between work stress and dental caries.[28]

**Periodontal status and work stress**

Eight of nine studies reported a significant association between work stress and worse periodontal status.[22–24,28–33] The measurements of periodontal status varied across the included studies. The measurements included probing pocket depth,[22,24,32] clinical attachment level,[22,29,30] alveolar bone loss,[30] gingival index,[22] bleeding on probing,[22] the Community Periodontal Index and Treatment Needs protocol,[23] and a composite outcome, including these measures.[28,33] Eight studies assessed periodontal status based on oral examination with probe, but one study was based on only visual inspection by dentists.[33]

Among the nine studies, two studies had unclear methodology; therefore, they were categorised as unknown.[24,29] Freeman and Goss assessed work stress and periodontal status

over a 12-month period.[24] However, they did not clearly report when work stress and periodontal status variables were assessed and how they were used in the statistical models. Linden et al. followed-up patients for 5.5 years, but work stress was only assessed at the follow-up examination, not at the baseline survey.[29]

Among the remaining seven studies, after excluding the above two studies, three studies presented only descriptive statistics.[22,30,32] The remaining four papers reported significant associations following regression analyses.[23,28,31,33] However, Akhter et al. used general stress questions not specific to work stress and included nonworking adults.[31] Islam et al. used the Brief Job Stress Questionnaire derived from the demand-control-support model in Japan, and periodontal status was assessed based on the visual inspection by dentists.[33] Important potential confounders such as socioeconomic status and work-related variables, were not included. Ramji assessed work stress using a single job stress question and did not adjust for covariates in the statistical models.[23] Marcenes and Sheiham reported a significant association between periodontal status and work stress.[28] Periodontal status was assessed by the presence or absence of gums bleeding on probing or with pockets. The authors divided periodontal measures into groups based on "complete absence of teeth with gums bleeding on probing and with pockets," or "the presence of any tooth with gums bleeding on probing or pockets," and defined the latter as those with periodontal disease. After adjusting for covariates, one-point increases in work mental demand scores, work control scores, and work variety scores were associated with ORs of 1.22 (95%CI = 1.06, 1.37), 0.97 (95%CI = 0.88, 1.07), and 0.99 (95%CI = 0.85, 1.16), respectively, for having periodontal disease, in a logistic regression model.

**Tooth loss and work stress**

Two studies on the association between work stress and tooth loss were identified. One of the two reported a significant association between work stress and tooth loss.[34,35] Hayashi et

al. reported the association between work stress, assessed using the Karasek job strain model, and tooth loss.[34] A total of 322 male workers employed at a manufacturing company were included. They dichotomised the number of tooth loss into ≤3 and ≥4. After adjusting for covariates, high job demand and low control conditions were associated with high odds of having ≥4 teeth loss but not significant (OR = 1.2 [95% CI = 0.40, 3.42]). This study did not adjust for the important potential confounders such as socioeconomic status and work-related variables. Sato et al. reported the association between work stress, assessed using the effort–reward imbalance model, and self-reported tooth loss.[35] After adjusting for covariates including socioeconomic status and work-related variables, a high effort-reward imbalance ratio was significantly associated with a high prevalence of ≥1 tooth loss (prevalence ratio = 1.20 [95% CI = 1.01, 1.42]).

**Study quality**

Table 2 presents the results of the quality assessments for each study. Eight studies (73%) had poor quality, while three (27%) were rated as fair. None of the studies addressed question 6 ("For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?"); 7 ("Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?"); and 10 ("Was the exposure(s) assessed more than once over time?"); because all the studies were cross-sectional or the study design was unclear.

## DISCUSSION

This is the first systematic review to evaluate and summarise the existing literature on the associations between work stress and oral conditions. As our findings showed, only one study reported on dental caries and periodontal status, nine on periodontal status, and two on tooth loss. Based on the findings of this review, the evidence is lacking on the association of work

stress with dental caries and tooth loss. Eight of nine studies reported the significant associations between multiple periodontal measures and work stress.

**Limitations of the review**

This systematic review has four limitations. First, the systematic literature search, screening, and quality assessments were conducted by only one investigator. A single screening could miss more studies than a double screening.[37] Second, only English language literature was included. Although a systematic review found no bias due to English-language restriction in systematic reviews,[38] this review might include bias. Third, there was no protocol for this systematic review. A priori systematic review protocol registration provides the rigor and trustworthiness of the reviews.[39] This might weaken the rigor and trustworthiness of our review. Finally, a meta-analysis could not be conducted owing to the heterogeneity of the included studies. Work stress was assessed using varied measures. Particularly, only a few studies used the current major measures of work stress. Indicators of periodontal status were also varied. No study used valid epidemiological definitions for periodontal disease as the outcome. The cut-off points differed between the two studies on tooth loss and work stress. Besides, there was only one study on dental caries and work stress. These limitations hindered us from performing a meta-analysis.

**Dental caries and work stress**

We found only one study on the cross-sectional association between work stress and dental caries.[28] The conclusion was that there was no significant association between work stress and dental caries. However, since the sample size was relatively small (n=164), there is the possibility of a false negative association. Besides, each subscale of the Karasek job strain model was simultaneously included in the statistical model. Generally, in the Karasek job strain model, the recommendation is to use four categories of job strain generated by the interaction of the subscales: High-strain jobs, active jobs, low-strain jobs, and passive jobs.[9]

Due to the above treatments of the subscales, it is possible that the association was underestimated. Additionally, as there was no cohort study, we could not assess the prospective associations. Considering the above limitations, it was difficult to determine whether work stress is associated with dental caries. A further study should include a cohort design and a relatively large sample size with appropriate work stress measures.

**Periodontal status and work stress**

Nine studies reported on the association between work stress and periodontal status.[22–24,28–33] However, the outcome measures were varied across the included studies. Although there are the accepted epidemiological definitions of periodontitis according to the European Workshop in Periodontology and the Centers for Disease Control/American Academy of Periodontology,[40,41] there was no study that used the definitions. It means that the included studies reported the associations between work stress and periodontal measures, not periodontal disease. In addition, the measurement of work stress was measured also varied across studies. Each measure assessed different dimensions of work stress.[42] Due to the heterogeneity of exposures and outcomes, we could not conduct a meta-analysis.

Of the nine studies, only one study adjusted for the potential confounders, such as socioeconomic status and work-related variables.[28] Besides, no cohort study was found. The failure to adjust for the confounders and consider the induction time weakens the research evidence. However, despite the above limitations, the consistent association between work stress and worse periodontal status is noteworthy. To verify the current results, a further cohort study using the validated definitions of periodontal disease and current measurements of work stress, in addition to adjusting for the potential confounders should be performed.

**Tooth loss and work stress**

Two studies on the association between work stress and tooth loss were identified. Hayashi's study included only male workers employed at one manufacturing company.[34] In contrast,

Sato's study included active workers sampled from a general population.[35] However, the response rate was relatively low (32%). The generalisability of both studies could be limited.

The two studies had different cut-off points of tooth loss. Hayashi's study used the cut-off point of more than 4 teeth lost. The cutoff point is higher than the mean number of teeth loss (at 25 to 34, 35 to 45, 46 to 54, and 55 to 64 years = 0.16, 0.58, 1.48, and 4.00, respectively) reported by the national statistical surveys.[43] This study targeted severe cases only. In Sato's study, the outcome was the loss of at least more than one tooth. However, this outcome relied on self-reported answers; therefore, self-reported bias might exist.

Both studies showed an increased risk of tooth loss, although only one of the two studies reported a significant association between work stress and tooth loss. However, due to the above limitations, it is difficult to derive any form of conclusion. In the future, a cohort study including general workers should be conducted to confirm these findings.

**Conclusions**

Based on the findings, this systematic review suggests a lack of evidence on the association of work stress with dental caries and tooth loss. Although eight of the nine studies reported significant associations between multiple periodontal measures and work stress, no study used valid epidemiological definitions of periodontal disease. For future research, well-designed cohort studies including potential confounding factors and the use of generally accepted measurements of work stress and periodontal disease are needed.

**Ethical Approval Statement**

Not applicable

**Contributors**

YuS contributed to the acquisition and the interpretation of data and drafting of the work. YaS and EY revised it critically for important intellectual content. All authors contributed to the conception 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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**Competing interests**

The authors declare no potential conflicts of interest with respect to the research, authorship, and publication of this article.

**Patient consent for publication**

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**Data availability statement**

Not applicable.

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## Tables

Table 1. Summary of included studies on work stress and oral conditions

| Author's name (year of publication) | Study design | Study location | Exposure (work stress) | Outcome | Number of participants | Mean age of the participants and proportion of women | Covariates | Main results |
|---|---|---|---|---|---|---|---|---|
| **Dental caries** | | | | | | | | |
| Marcenes and Sheiham (1992)[28] | Cross-sectional | Brazil | Karasek job strain model | DMFS index (number of decayed (D), missing (M), and Filled (F) teeth surfaces per persons) | 164 male paid workers aged from 35 to 44 years | Mean age = 41.2 (standard deviation = 2.2)<br>0% | Marital quality, toothbrushing frequency, sugar consumption, age, years of residence, type of toothpaste, frequency dental attendance, and socio-economic status | Work mental demand: Coefficients = 0.19 (95% CI = -0.91, 1.29)<br>Work control: Coefficients = 0.87 (95% CI = -0.18, 1.91)<br>Work variety: Coefficients = -0.06 (95% CI = -1.57, 1.45)<br>From a linear regression analysis |
| **Periodontal status** | | | | | | | | |
| Marcenes and Sheiham (1992)[28] | Cross-sectional | Brazil | Karasek job strain model | The presence or absence of teeth either with gums bleeding on probing or with pockets was used. The indicator was labelled as 'complete absence of teeth with gums bleeding on probing and with pockets', and 'presence of any tooth with gums bleeding on probing or pockets'. | 164 male paid workers aged from 35 to 44 years (16 workers were excluded from 164 participants due to missing values and edentulous) | Mean age = 41.2 (standard deviation = 2.2)<br>0% | Marital quality, toothbrushing frequency, sugar consumption, age, years of residence, type of toothpaste, frequency dental attendance, and socio-economic status | Work mental demand: Odds ratio = 1.22 (95% confidence interval = 1.06, 1.37)<br>Work control: Odds ratio = 0.97 (95% confidence interval = 0.88, 1.07)<br>Work variety: Odds ratio = 0.99 (95% confidence interval = 0.85, 1.16)<br>From a logistic regression analysis |
| Freeman and Goss (1993)[24] | Unknown | Not reported | Occupational Stress Indicator | Mean increases in pocket depth | 10 women and 8 men from the head office of a large company | Mean age = 39<br>55.6% | Unknown | Type A behaviour: Coefficients = 0.41 (p-value=0.003)<br>Work environment (organisation/climate): Coefficients = -0.34 (p-value = 0.007)<br>(statistical model was not reported) |
| Linden et al. (1996)[29] | Unknown | UK | Occupational Stress Indicator assessed at the second examination | Changes in clinical attachment level after an interval of 5.5 (SD 0.6) years. | 23 employed regular dental attendees aged between 20 and 50 years who had moderate or | Mean age = 41.1 (standard deviation = 7.3)<br>43.5% | Age and social class of the household | Job satisfaction: Coefficients = -0.014 (p-value < 0.01)<br>Type A: Coefficients = 0.026 (p-value < 0.05) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | established periodontitis (13 men and 10 women) | | | Locus of control: Coefficients = -0.035 (p-value ≥ 0.05) (statistical model was not reported) |
| Genco et al. (1999)[30] | Cross-sectional | US | Problems of Everyday Living Scale of Pearlin and Schooler | Severity of Attachment Loss Healthy (0 to 1 mm clinical attachment level), low (1.1 to 2.0 mm), moderate (2.1 to 3.0 mm), high (3.1 to 4.0 mm) and severe (4.1 to 8.0 mm)<br>Severity of Alveolar Bone Loss Healthy (0.4 to 1.9 mm alveolar crestal height), low (2.0 to 2.9 mm), moderate (3.0 to 3.9 mm), and severe (≥4.0 mm) | 1,426 inhabitants aged 25 to 74 years (741 women and 685 men) *working status was unknown | Mean age = 48.9 (standard deviation = 13.9)<br>52.0% | Age, gender, and levels of smoking. | Job strain score among Attachment Loss categories (mean ± standard error)<br>Healthy: 2.12 ± 0.05<br>Low: 2.09 ± 0.02<br>Moderate: 2.16 ± 0.02<br>High: 2.09 ± 0.05<br>Severe: 2.22 ± 0.05<br>(nonsignificant)<br>From analysis of covariance<br><br>Job strain score among Alveolar Bone Loss categories (mean ± standard error)<br>Healthy: 2.12 ± 0.02<br>Low: 2.10 ± 0.03<br>Moderate: 2.09 ± 0.04<br>Severe: 2.19 ± 0.04<br>(nonsignificant)<br>From analysis of covariance |
| Akhter et al. (2005)[31] | Cross-sectional | Japan | Life events scale (yes or no) | Mean clinical attachment loss <1.5 mm were assigned to a non-diseased group and those with mean clinical attachment loss ≥1.5 mm were assigned to a diseased group | 1,089 employed and unemployed residents ranging in age from 18 to 96 years of a farming village in the northernmost island of Japan (531 men and 558 women) | Mean age = 55.0 (standard deviation = 1.7)<br>51.2% | Age, gender, employment status, smoking behaviour, stress within 1 month, self-health-related stress, family health-related stress, frequency of dental attendance, hyperlipidaemia, and diabetes mellitus | Job stress (reference: No): Odds ratio = 1.71 (95% confidence interval = 1.10, 2.67) from a logistic regression analysis |
| Talib Bandar (2009)[22] | Cross-sectional | Iraq | Life events scale (yes or no) | Gingival Index, probing pocket depth, bleeding on probing, and clinical attachment level | 64 working dental patients of both genders with ages ranging from 23 to 65 years | Mean age and sex were not reported. | None | The mean gingival index yes = 1.851 and no = 1.586 (p-value > 0.05)<br><br>Total mean percentage of sites with probing pocket depth ≥ 4 mm<br>yes = 6.277% and no = 4.762% (p-values <0.05) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Total mean Bleeding On Probing<br>yes = 41.534% and no = 32.137% (p-value > 0.05)<br><br>The mean of the clinical attachment level<br>yes = 2.837 and no = 2.275 (p-value > 0.05)<br>(all p-values from t-test) |
| Mahendra et al. (2011)[32] | Cross-sectional | India | An occupational stress index of Srivastava, A. K. and Singh, A. P. | Control group (n=30): probing pocket depth (PPD) ≤ 3 mm<br>Test group 1 (n=40): at least four sites with probing pocket depth > 4mm and ≤ 6 mm<br>Test group 2 (n=30): at least four sites with probing pocket depth > 6mm | 110 police personnel aged 35-48 years with moderate or established periodontitis | Mean age (standard deviation); control group: 40.23 (3.46); test group 1: 40.42 (3.54); test group 2: 41.18 (3.78)<br>Sex was not reported. | None | Mean Occupational Stress Index Score (standard deviation)<br>Control: 79.53 (23.57)<br>Test group 1: 133.68 (33.23)<br>Test group 2: 158.13 (32.44)<br>p-value <0.001<br>(p-values from ANOVA with the Scheffe Test) |
| Ramji, (2011)[23] | Cross-sectional | India | Self-reported job stress (having or not) | Community Periodontal Index and Treatment Needs protocol<br>(a tooth scored 3 or 4 indicating increased pocket depth of over 2 mm indicates presence of periodontitis) | 198 industrial labour full time workers from a small scale sector (SS) and 68 from a large scale sector (LS) between the age of 18-64 years | Age groups (SS [n=130], LS [n=68])<br>15-19 years: 0%, 1%<br>20-29 years: 38%, 60%<br>30-44 years: 45%, 20%<br>45-64 years: 17%, 19%<br>Sex was not reported. | None | Having self-reported job stress: Odds ratio = 7.5 (95% confidence interval = 3.7, 15.02) from a logistic regression analysis |
| Islam et al. (2019)[33] | Cross-sectional | Japan | Brief Job Stress Questionnaire developed by referring the demand-control-support model in Japan<br>(low stress, High stress-High coping, | No inflammation of the gingiva or redness and/or swelling of the interdental papilla without gingival recession was classified as non-periodontitis, and any redness and/or swelling in the gingiva with gingival recession and/or tooth mobility was classified as periodontitis, based on visual inspection by dentists | 738 workers of a Japanese crane manufacturing company (92 were women) | Mean age = 40.7 (standard deviation = 10.5)<br>12.5% | Age, gender, daily flossing, regular dental checkup, body mass index, sleeping duration, current smoker, daily alcohol drinking, monthly overtime work, and worker type | High stress-High coping: Odds ratio = 0.30 (95% confidence interval = 0.14, 0.66)<br>High stress-Low coping: Odds ratio = 2.79 (95% confidence interval = 1.05, 7.43)<br>(reference: low stress)<br>from a logistic regression analysis |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | and High stress-low coping)<br>*coping was assessed using a questionnaire developed by a Japanese company | | | | | |
| **Tooth loss** | | | | | | | | |
| Hayashi et al. (2001)[34] | Cross-sectional | Japan | Karasek job strain model (high job demand and low control and other categories) | Tooth loss via oral examination (≥4 teeth lost and 3≤ teeth lost) | 252 male workers employed at a manufacturing company aged 20–59 years | Mean age = 38.7 (standard deviation = 11.0)<br>0% | Age, type A behaviour, alexythymia, depression, job satisfaction, and life satisfaction | High job demand and low control (reference: other categories): Odds ratio = 1.2 (95% confidence interval = 0.40, 3.42) from a logistic regression analysis |
| Sato et al. (2020)[35] | Cross-sectional | Japan | Effort-Reward Imbalance model (having or not) | Self-reported tooth loss<br>Having tooth loss or not (= no experience of tooth loss) | 1,195 employees aged 25–50 years old who work 20 h per week or more (women = 569) | Median age = 37 (1st and 3rd quartiles = 31 and 43)<br>48% | Age, sex, marital status, annual household income, years of education, employment status, occupation, working hours per week, job position, company size, body mass index, and smoking status | High effort-reward imbalance ratio: Prevalence ratio = 1.20 (95% confidence interval = 1.01, 1.42) from Poisson regression models with a robust error variance |

Table 2. Quality assessment of included studies

| | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 | Q12 | Q13 | Q14 | Quality Rating (Good, Fair, or Poor) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Marcenes and Sheiham (1992)[28] | Yes | Yes | NR | Yes | Yes | No | No | Yes | Yes | No | Yes | Yes | NA | Yes | Fair |
| Freeman and Goss (1993)[24] | Yes | Yes | NR | No | Yes | No | No | Yes | Yes | No | Yes | Yes | NA | No | Poor |
| Linden et al. (1996)[29] | Yes | Yes | NR | Yes | Yes | No | No | Yes | Yes | No | Yes | Yes | NA | No | Poor |
| Genco et al. (1999)[30] | Yes | Yes | NR | No | Yes | No | No | Yes | No | No | Yes | Yes | NA | No | Poor |
| Akhter et al. (2005)[31] | Yes | Yes | NR | No | Yes | No | No | NA | No | No | Yes | Yes | NA | No | Poor |
| Talib Bandar (2009)[22] | Yes | Yes | NR | No | No | No | No | NA | No | No | Yes | Yes | NA | No | Poor |
| Mahendra et al. (2011)[32] | Yes | Yes | NR | Yes | Yes | No | No | NA | Yes | No | Yes | Yes | NA | No | Poor |
| Ramji (2011)[23] | Yes | Yes | No | Yes | Yes | No | No | NA | No | No | Yes | Yes | NA | No | Poor |
| Islam et al. (2019)[33] | Yes | Yes | NR | Yes | Yes | No | No | NA | No | No | Yes | Yes | NA | No | Poor |
| Hayashi et al. (2001)[34] | Yes | Yes | Yes | Yes | Yes | No | No | NA | Yes | No | Yes | Yes | NA | No | Fair |
| Sato et al. (2020)[35] | Yes | Yes | No | Yes | Yes | No | No | NA | Yes | No | Yes | No | NA | Yes | Fair |

Abbreviation: CD, cannot determine; NA, not applicable; NR, not reported

Q1. Was the research question or objective in this paper clearly stated?

Q2. Was the study population clearly specified and defined?

Q3. Was the participation rate of eligible persons at least 50%?

Q4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?

Q5. Was a sample size justification, power description, or variance and effect estimates provided?

Q6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?

Q7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?

Q8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of

exposure, or exposure measured as continuous variable)?

Q9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?

Q10. Was the exposure(s) assessed more than once over time?

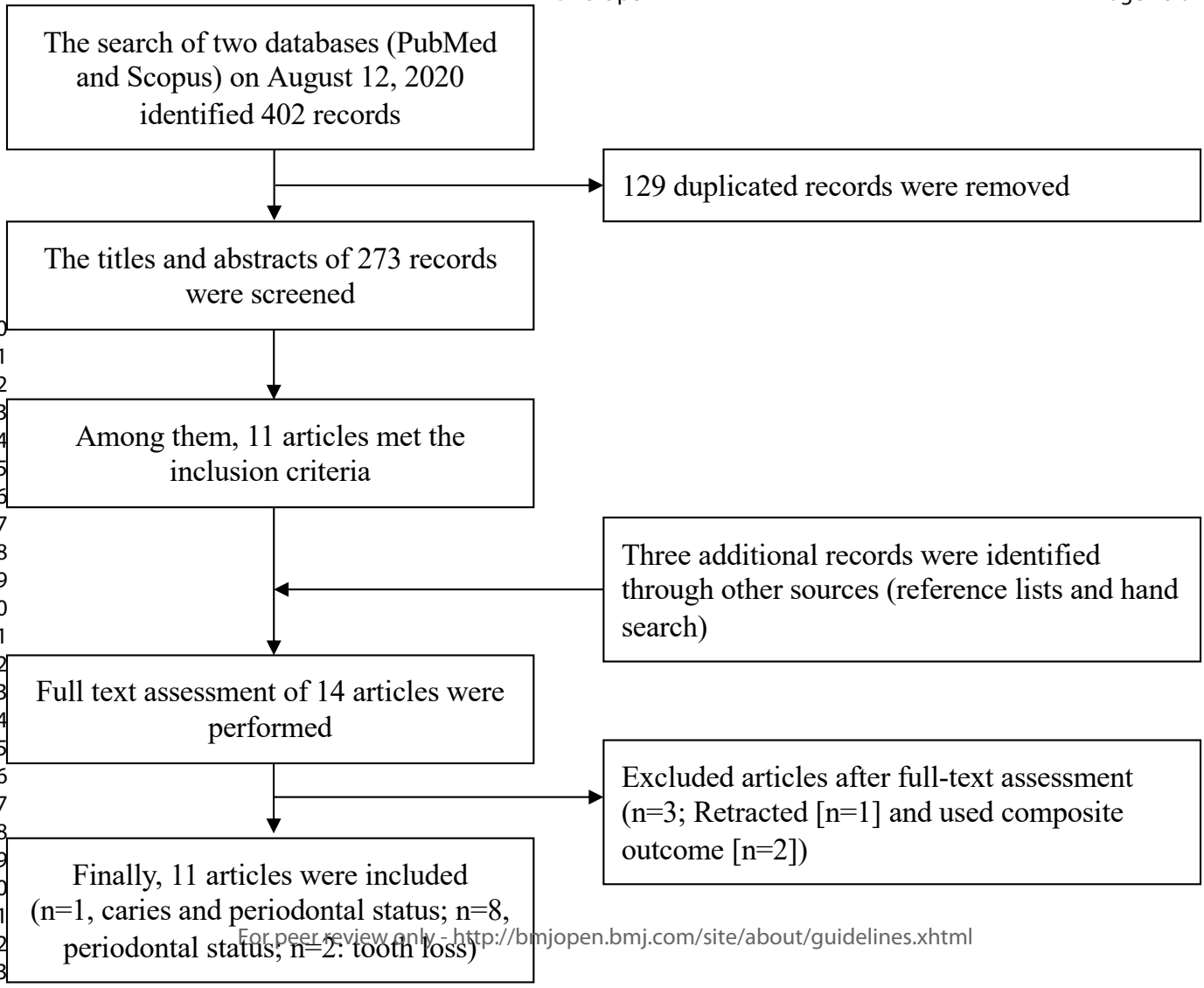
Q11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?

Q12. Were the outcome assessors blinded to the exposure status of participants?

Q13. Was loss to follow-up after baseline 20% or less?

Q14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?

Figure 1. Flow of search strategy and selection of studies for a systematic review.



Supplemental Table 1. The precise search strategies for each database.

| Database | Date | Combination of terms used | Limitation | Result |
|---|---|---|---|---|
| PubMed | August 12, 2020 | ("job strain" OR "effort reward") AND (dental OR oral) | English | 22 |
| PubMed | August 12, 2020 | ("job stress" OR "work stress" OR "occupational stress") AND (dental OR oral) | English | 143 |
| Scopus | August 12, 2020 | ("job strain" OR "effort reward") AND (dental OR oral) | English | 20 |
| Scopus | August 12, 2020 | ("job stress" OR "work stress" OR "occupational stress") AND (dental OR oral) | English | 217 |

# MOOSE Checklist for Meta-analyses of Observational Studies

| Item No | Recommendation | Reported on Page No |
|---|---|---|
| Reporting of background should include | | |
| 1 | Problem definition | 5-6 |
| 2 | Hypothesis statement | 6 |
| 3 | Description of study outcome(s) | 6 |
| 4 | Type of exposure or intervention used | 6 |
| 5 | Type of study designs used | 6 |
| 6 | Study population | 6 |
| Reporting of search strategy should include | | |
| 7 | Qualifications of searchers (eg, librarians and investigators) | 7 |
| 8 | Search strategy, including time period included in the synthesis and key words | 6-7, Supplemental Table 1 |
| 9 | Effort to include all available studies, including contact with authors | 7 |
| 10 | Databases and registries searched | 6, Supplemental Table 1 |
| 11 | Search software used, name and version, including special features used (eg, explosion) | NA |
| 12 | Use of hand searching (eg, reference lists of obtained articles) | 7, Supplemental Table 1 |
| 13 | List of citations located and those excluded, including justification | 6 |
| 14 | Method of addressing articles published in languages other than English | NA |
| 15 | Method of handling abstracts and unpublished studies | 7 |
| 16 | Description of any contact with authors | NA |
| Reporting of methods should include | | |
| 17 | Description of relevance or appropriateness of studies assembled for assessing the hypothesis to be tested | 6 |
| 18 | Rationale for the selection and coding of data (eg, sound clinical principles or convenience) | 7 |
| 19 | Documentation of how data were classified and coded (eg, multiple raters, blinding and interrater reliability) | 7 |
| 20 | Assessment of confounding (eg, comparability of cases and controls in studies where appropriate) | 7 |
| 21 | Assessment of study quality, including blinding of quality assessors, stratification or regression on possible predictors of study results | 7 |
| 22 | Assessment of heterogeneity | NA |
| 23 | Description of statistical methods (eg, complete description of fixed or random effects models, justification of whether the chosen models account for predictors of study results, dose-response models, or cumulative meta-analysis) in sufficient detail to be replicated | 7 |
| 24 | Provision of appropriate tables and graphics | Table 1, Table 2 |
| Reporting of results should include | | |
| 25 | Graphic summarizing individual study estimates and overall estimate | NA |
| 26 | Table giving descriptive information for each study included | Table 1 |
| 27 | Results of sensitivity testing (eg, subgroup analysis) | NA |
| 28 | Indication of statistical uncertainty of findings | NA |

| Item No | Recommendation | Reported on Page No |
|---|---|---|
| Reporting of discussion should include | | |
| 29 | Quantitative assessment of bias (eg, publication bias) | 11-12 |
| 30 | Justification for exclusion (eg, exclusion of non-English language citations) | 11-12 |
| 31 | Assessment of quality of included studies | 12-14 |
| Reporting of conclusions should include | | |
| 32 | Consideration of alternative explanations for observed results | 12-14 |
| 33 | Generalization of the conclusions (ie, appropriate for the data presented and within the domain of the literature review) | 12-14 |
| 34 | Guidelines for future research | 12-14 |
| 35 | Disclosure of funding source | 15 |

From: Stroup DF, Berlin JA, Morton SC, et al. Meta-analysis of Observational Studies in Epidemiology: A Proposal for Reporting. JAMA. 2000;283(15):2008–2012. doi:10.1001/jama.283.15.2008

Abbreviation: NA, not applicable

BMJ Open

# Work stress and oral conditions: A systematic review of observational studies



| | |
|---|---|
| Journal: | *BMJ Open* |
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| | |

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**Title**

Work stress and oral conditions: A systematic review of observational studies

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**Abstract (300/300)**

**Objectives:** Although psychological stress is a risk factor for oral diseases, there seems to be no review on work stress. This study aimed to review the evidence on the association between work stress and oral conditions, including dental caries, periodontal status, and tooth loss.

**Design:** A systematic review of published observational studies.

**Data sources:** A systematic literature search was conducted in PubMed and Scopus databases on August 12, 2020.

**Study selection:** Articles were screened based on the following inclusion criteria: published after 1966; in English only; epidemiological studies on humans (except case studies, reviews, letters, commentaries, and editorials); and examined the association of work stress with dental caries, periodontal status, and tooth loss.

**Data extraction:** Data was extracted from eligible studies. A quality assessment was conducted using the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies.

**Results:** Of 402 articles identified, 11 met the inclusion criteria, and one study assessed the association of work stress with dental caries and periodontal status. Of 11 studies, one reported a nonsignificant association between work stress and dental caries; eight of nine studies reported a significant association between work stress and worse periodontal status; and one of two studies reported a significant association between work stress and tooth loss. Nine of eleven studies were cross-sectional, while the remaining two studies had unclear methodology. Only two studies were sufficiently adjusted for potential confounders. Eight studies assessed work stress but did not use the current major measures. Three studies were rated as fair, while eight studies had poor quality.

**Conclusions:** There is a lack of evidence on the association of work stress with dental caries and tooth loss. Eight studies suggested potential associations between periodontal status and

work stress. Cohort studies using the major work stress measures and adjusting for the potential confounders are needed.

**Keywords**

systematic review, work stress, job stress, occupational stress, oral health, oral diseases

**Strengths and limitations of this study**

► This is the first systematic review to evaluate and summarise the literature on the association between work stress and oral conditions, including dental caries, periodontal status, and tooth loss.

► This systematic review provides a comprehensive insight into the quality of the included papers.

► The systematic literature search, screening, and quality assessments were conducted by only one investigator.

► A meta-analysis could not be conducted because of the heterogeneity of work stress measures and outcome definitions.

## INTRODUCTION

Oral diseases, such as dental caries and periodontal disease, are a major health concern worldwide. The Global Burden of Disease study has estimated that 2.3 billion individuals had untreated dental caries, 796 million had severe periodontal disease, and 267 million had a complete loss of natural teeth in 2017.[1] Dental caries is the destruction of dental hard tissues in the crowns and roots of the teeth.[2] Periodontal diseases are chronic inflammatory conditions with disorders of the tissues surrounding and supporting the teeth.[3] Tooth loss is mainly the consequence of dental caries and periodontal disease.[2,3] Because oral diseases result in severe toothache and eating, sleeping, and communication disabilities,[4,5] poor oral conditions can restrict work performance[4,5] and create a significant economic burden.[6] Indeed, work productivity loss due to oral conditions is estimated at 187.61 billion US dollars annually.[6] The necessity of preventing oral diseases for working adults is highlighted.

Since the 1990s, rapid changes in the global economy and the diverse markets have occurred, and psychological workplace stress has become more prevalent and severe, especially among industrialised countries.[7] Indeed, Kivimäki et al. reported a 15% prevalence of job strain measured using job-content and demand-control questionnaires from 13 European cohorts' data (1985–2006).[8] Besides, work stress can have profound effects on health. There is accumulating evidence of the risk of work stress on cancer, cardiovascular diseases, diabetes, and depression.[9,10] Béjean and Sultan-Taïeb estimated that the work-related stress costs due to illnesses could range between €1,167 million and €1,975 million in France in 2000.[11] Work stress affects workers' health and productivity.

Psychological stress is recognised as a risk factor for dental caries and periodontal diseases. Psychological stress is related to oral diseases through immune system dysfunction, increased stress hormones, cariogenic bacterial counts, and poor oral health behaviours.[12,13] Work stress is strongly linked with psychological and physical health.[9,10] Previous systematic

reviews suggested potential associations of psychological stress with dental caries and periodontitis.[14,15] However, there seems to be no review on the association between work stress and oral diseases. Today, work stress has become an increasingly serious problem. Besides, the number of women in the workforce and dual-earner families have been increasing.[16] A wide range of populations can suffer the risk of oral diseases from exposure to work stress. Thus, the aim of this systematic review was to evaluate and summarise the literature on the association between work stress and oral conditions, including dental caries, periodontal status, and tooth loss. We set the following review question: Is work stress associated with dental caries, periodontal status, and tooth loss among working adults?

## METHODS

The reporting of this systematic review conforms to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[17,18] We also followed the Conducting Systematic Reviews and Meta-Analyses of Observational Studies of Etiology (COSMOS-E) guidance[19] and the reporting of Meta-analysis Of Observational Studies in Epidemiology (MOOSE).[20] The protocol of this systematic review was not registered.

### Eligibility criteria

Published studies were eligible if they: 1) were published in English; 2) were epidemiological studies on humans (except case studies, reviews, letters, commentaries, and editorials); and 3) examined the association of work stress with dental caries, periodontal status, and tooth loss.

### Information sources and searches

On August 12, 2020, we identified potentially relevant published studies in PubMed (1966 to August 12, 2020) and Scopus (1966 to August 12, 2020) databases. As PubMed and Scopus have only data back to 1966, we focused on articles published after 1966. We used

the following script to obtain a wide range of literature: ("job strain" OR "effort reward") AND (dental OR oral); ("job stress" OR "work stress" OR "occupational stress") AND (dental OR oral). The details of the search strategies for each database are shown in Supplemental Table 1. Besides, we manually hand-searched for potentially suitable studies through the reference lists of identified articles and Google scholar. After excluding duplicate articles, one author (YuS) assessed the titles and abstracts according to the aforementioned criteria. Then, eligible studies were selected for the full-text review.

**Data extraction**

One author (YuS) extracted the following information from each eligible study: 1) name of the first author; 2) study design; 3) study location (country); 4) number of participants and work-related characteristics; 5) exposure and its measurements; 6) outcome and its measurements; 7) age range and proportion of women; 8) covariates included in the adjusted models; and 9) the main results. The results were shown in Table 1.

**Quality assessment**

We used the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies to assess the quality of included studies.[21] This tool includes 14 questions for evaluating the internal validity of a study and these questions are documented in the footnote of Table 2. For each question, one author (YuS) rated them as yes, no, or other (including cannot determine, not reported, and not applicable). The overall quality rating for the study was regarded as good if all the domains were assessed favourably.

**Synthesis of results**

A meta-analysis could not be conducted because of the heterogeneity of work stress measures and outcome definitions.

**Patient and public involvement**

No patient involved.

## RESULTS

Figure 1 presents the flow diagram of information through the phases of the systematic review. Of the 402 articles identified in PubMed and Scopus databases, 129 duplicated articles were removed, the titles and abstracts of 273 were screened, and 11 met the eligibility criteria. Three more articles identified through reference lists and hand-search were added. One article was identified by a hand-search using Google Scholar,[22] one was from a reference list,[23] and the third was an article[24] plagiarised by a retraction paper. Because the article[24] which was plagiarised by the retracted one was published officially and has not been retracted, it was included in our references. After full-text assessments of 14 articles, three were excluded due to retraction (n=1) and the use of composite outcomes including dental caries and periodontal status (n=2).[25,26] Finally, 11 articles were included in this systematic review.[22–24,27–34]

### Study characteristics of individual studies

Table 1 shows the 12 summaries from the 11 studies. One of eleven studies reported on dental caries and periodontal status,[27] eight reported on periodontal status,[22–24,28–32] and two reported on tooth loss.[33,34] Three studies were conducted in Japan,[30,32–34] two in India,[24,31] and one each in the UK,[28] the US,[29] Brazil,[27] and Iraq.[22] One study did not report on the study location.[28] The sample size varied from 18 to 1,426 among included studies. In one study, working status was not reported.[29] One study included employed and unemployed participants.[30] Two studies did not include women,[27,33] and three did not report on sex.[22,24,31]

Three studies assessed work stress using the current major measures (Job Demand-Control Model and Effort-Reward Imbalance Model).[27,33,34] Work stress was assessed using the Karasek job strain model,[27,33] the Effort-Reward Imbalance model,[34] the Brief Job Stress Questionnaire developed by referring to the demand-control-support model in Japan,[32] a self-

reported job stress,[24] the Occupational Stress Indicator,[23,28] an occupational stress index by Srivastava and Singh,[31] the Life events scale,[22,30] and the Problems of Everyday Living Scale by Pearlin and Schooler.[29]

Three studies presented only descriptive statistics.[22,29,31] Eight studies performed regression analyses;[23,24,27,28,30,32–34] but two of the eight studies did not report the types of a regression modeling used.[23,28] Only two studies sufficiently adjusted for potential confounders such as socioeconomic status and work-related variables.[27,34]

**Dental caries and work stress**

One study reported the cross-sectional association between work stress and dental caries, which included 164 paid male workers aged 35 to 44 years in Brazil.[27] Work stress was assessed according to the Karasek job strain model.[35] Dental caries status was assessed using the DMFS index (the number of decayed [D], missing [M], and filled [F] teeth surfaces per person). After adjusting for covariates, one-point increases in the work mental demand, work control, and work variety scores were associated with 0.19 (95% confidence interval [CI] = -0.91, 1.29), 0.87 (95% CI = -0.18, 1.91), and -0.06 (95% CI = -1.57, 1.45) increases in the DMFS index, respectively, in a multivariable regression analysis. Consequently, this study reported a nonsignificant association between work stress and dental caries.[27]

**Periodontal status and work stress**

Eight of nine studies reported a significant association between work stress and worse periodontal status.[22–24,27–32] The measurements of periodontal status varied across the included studies. The measurements included probing pocket depth,[22,23,31] clinical attachment level,[22,28,29] alveolar bone loss,[29] gingival index,[22] bleeding on probing,[22] the Community Periodontal Index and Treatment Needs protocol,[24] and a composite outcome, including these measures.[27,32] Eight studies assessed periodontal status based on oral examination with probe, but one study was based on only visual inspection by dentists.[32]

Among the nine studies, two studies had unclear methodology; therefore, they were categorised as unknown.[23,28] Freeman and Goss assessed work stress and periodontal status over a 12-month period.[23] However, they did not clearly report when work stress and periodontal status variables were assessed and how they were used in the statistical models. Linden et al. followed-up patients for 5.5 years, but work stress was only assessed at the follow-up examination, not at the baseline survey.[28]

Among the remaining seven studies, after excluding the above two studies, three studies presented only descriptive statistics.[22,29,31] The remaining four papers reported significant associations following regression analyses.[24,27,30,32] However, Akhter et al. used general stress questions not specific to work stress and included nonworking adults.[30] Islam et al. used the Brief Job Stress Questionnaire derived from the demand-control-support model in Japan, and periodontal status was assessed based on the visual inspection by dentists.[32] Important potential confounders such as socioeconomic status and work-related variables, were not included. Ramji assessed work stress using a single job stress question and did not adjust for covariates in the statistical models.[24] Marcenes and Sheiham reported a significant association between periodontal status and work stress.[27] Periodontal status was assessed by the presence or absence of gums bleeding on probing or with pockets. The authors divided periodontal measures into groups based on "complete absence of teeth with gums bleeding on probing and with pockets," or "the presence of any tooth with gums bleeding on probing or pockets," and defined the latter as those with periodontal disease. After adjusting for covariates, one-point increases in work mental demand scores, work control scores, and work variety scores were associated with ORs of 1.22 (95%CI = 1.06, 1.37), 0.97 (95%CI = 0.88, 1.07), and 0.99 (95%CI = 0.85, 1.16), respectively, for having periodontal disease, in a logistic regression model.

**Tooth loss and work stress**

Two studies on the association between work stress and tooth loss were identified. One of the two reported a significant association between work stress and tooth loss.[33,34] Hayashi et al. reported the association between work stress, assessed using the Karasek job strain model, and tooth loss.[33] A total of 322 male workers employed at a manufacturing company were included. They dichotomised the number of tooth loss into ≤3 and ≥4. After adjusting for covariates, high job demand and low control conditions were associated with high odds of having ≥4 teeth loss but not significant (OR = 1.2 [95% CI = 0.40, 3.42]). This study did not adjust for the important potential confounders such as socioeconomic status and work-related variables. Sato et al. reported the association between work stress, assessed using the effort–reward imbalance model, and self-reported tooth loss.[34] After adjusting for covariates including socioeconomic status and work-related variables, a high effort-reward imbalance ratio was significantly associated with a high prevalence of ≥1 tooth loss (prevalence ratio = 1.20 [95% CI = 1.01, 1.42]).

**Study quality**

Table 2 presents the results of the quality assessments for each study. Eight studies (73%) had poor quality, while three (27%) were rated as fair. None of the studies addressed question 6 ("For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?"); 7 ("Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?"); and 10 ("Was the exposure(s) assessed more than once over time?"); because all the studies were cross-sectional or the study design was unclear.

## DISCUSSION

This is the first systematic review to evaluate and summarise the existing literature on the associations between work stress and oral conditions. As our findings showed, only one study

reported on dental caries and periodontal status, nine on periodontal status, and two on tooth loss. Based on the findings of this review, the evidence is lacking on the association of work stress with dental caries and tooth loss. Eight of nine studies reported the significant associations between multiple periodontal measures and work stress.

**Limitations of the review**

This systematic review has four limitations. First, the systematic literature search, screening, and quality assessments were conducted by only one investigator. A single screening could miss more studies than a double screening.[36] Second, only English language literature was included. Although a systematic review found no bias due to English-language restriction in systematic reviews,[37] this review might include bias. Third, there was no protocol for this systematic review. A priori systematic review protocol registration provides the rigor and trustworthiness of the reviews.[38] This might weaken the rigor and trustworthiness of our review. Finally, a meta-analysis could not be conducted owing to the heterogeneity of the included studies. Work stress was assessed using varied measures. Particularly, only a few studies used the current major measures of work stress. Indicators of periodontal status were also varied. No study used valid epidemiological definitions for periodontal disease as the outcome. The cut-off points differed between the two studies on tooth loss and work stress. Besides, there was only one study on dental caries and work stress. These limitations hindered us from performing a meta-analysis.

**Dental caries and work stress**

We found only one study on the cross-sectional association between work stress and dental caries.[27] The conclusion was that there was no significant association between work stress and dental caries. However, since the sample size was relatively small (n=164), there is the possibility of a false negative association. Besides, each subscale of the Karasek job strain model was simultaneously included in the statistical model. Generally, in the Karasek job

strain model, the recommendation is to use four categories of job strain generated by the interaction of the subscales: High-strain jobs, active jobs, low-strain jobs, and passive jobs.[9] Due to the above treatments of the subscales, it is possible that the association was underestimated. Additionally, as there was no cohort study, we could not assess the prospective associations. Considering the above limitations, it was difficult to determine whether work stress is associated with dental caries. A further study should include a cohort design and a relatively large sample size with appropriate work stress measures.

**Periodontal status and work stress**

Nine studies reported on the association between work stress and periodontal status.[22–24,27–32] However, the outcome measures were varied across the included studies. Although there are the accepted epidemiological definitions of periodontitis according to the European Workshop in Periodontology and the Centers for Disease Control/American Academy of Periodontology,[39,40] there was no study that used the definitions. It means that the included studies reported the associations between work stress and periodontal measures, not periodontal disease. In addition, the measurement of work stress was measured also varied across studies. Each measure assessed different dimensions of work stress.[41] Due to the heterogeneity of exposures and outcomes, we could not conduct a meta-analysis.

Of the nine studies, only one study adjusted for the potential confounders, such as socioeconomic status and work-related variables.[27] Besides, no cohort study was found. The failure to adjust for the confounders and consider the induction time weakens the research evidence. However, despite the above limitations, the consistent association between work stress and worse periodontal status is noteworthy. To verify the current results, a further cohort study using the validated definitions of periodontal disease and current measurements of work stress, in addition to adjusting for the potential confounders should be performed.

**Tooth loss and work stress**

Two studies on the association between work stress and tooth loss were identified. Hayashi's study included only male workers employed at one manufacturing company.[33] In contrast, Sato's study included active workers sampled from a general population.[34] However, the response rate was relatively low (32%). The generalisability of both studies could be limited.

The two studies had different cut-off points of tooth loss. Hayashi's study used the cut-off point of more than 4 teeth lost. The cutoff point is higher than the mean number of teeth loss (at 25 to 34, 35 to 45, 46 to 54, and 55 to 64 years = 0.16, 0.58, 1.48, and 4.00, respectively) reported by the national statistical surveys.[42] This study targeted severe cases only. In Sato's study, the outcome was the loss of at least more than one tooth. However, this outcome relied on self-reported answers; therefore, self-reported bias might exist.

Both studies showed an increased risk of tooth loss, although only one of the two studies reported a significant association between work stress and tooth loss. However, due to the above limitations, it is difficult to derive any form of conclusion. In the future, a cohort study including general workers should be conducted to confirm these findings.

**Conclusions**

Based on the findings, this systematic review suggests a lack of evidence on the association of work stress with dental caries and tooth loss. Although eight of the nine studies reported significant associations between multiple periodontal measures and work stress, no study used valid epidemiological definitions of periodontal disease. For future research, well-designed cohort studies including potential confounding factors and the use of generally accepted measurements of work stress and periodontal disease are needed.

**Ethical Approval Statement**

Not applicable

**Contributors**

YuS contributed to the acquisition and the interpretation of data and drafting of the work. YaS and EY revised it critically for important intellectual content. All authors contributed to the conception 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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**Competing interests**

The authors declare no potential conflicts of interest with respect to the research, authorship, and publication of this article.

**Patient consent for publication**

Not required.

**Provenance and peer review**

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**Data availability statement**

Not applicable.

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## Tables

Table 1. Summary of included studies on work stress and oral conditions

| Author's name (year of publication) | Study design | Study location | Exposure (work stress) | Outcome | Number of participants | Mean age of the participants and proportion of women | Covariates | Main results |
|---|---|---|---|---|---|---|---|---|
| **Dental caries** | | | | | | | | |
| Marcenes and Sheiham (1992)[27] | Cross-sectional | Brazil | Karasek job strain model | DMFS index (number of decayed (D), missing (M), and Filled (F) teeth surfaces per persons) | 164 male paid workers aged from 35 to 44 years | Mean age = 41.2 (standard deviation = 2.2)<br>0% | Marital quality, toothbrushing frequency, sugar consumption, age, years of residence, type of toothpaste, frequency dental attendance, and socio-economic status | Work mental demand: Coefficients = 0.19 (95% CI = -0.91, 1.29)<br>Work control: Coefficients = 0.87 (95% CI = -0.18, 1.91)<br>Work variety: Coefficients = -0.06 (95% CI = -1.57, 1.45)<br>From a linear regression analysis |
| **Periodontal status** | | | | | | | | |
| Marcenes and Sheiham (1992)[27] | Cross-sectional | Brazil | Karasek job strain model | The presence or absence of teeth either with gums bleeding on probing or with pockets was used. The indicator was labelled as 'complete absence of teeth with gums bleeding on probing and with pockets', and 'presence of any tooth with gums bleeding on probing or pockets'. | 164 male paid workers aged from 35 to 44 years (16 workers were excluded from 164 participants due to missing values and edentulous) | Mean age = 41.2 (standard deviation = 2.2)<br>0% | Marital quality, toothbrushing frequency, sugar consumption, age, years of residence, type of toothpaste, frequency dental attendance, and socio-economic status | Work mental demand: Odds ratio = 1.22 (95% confidence interval = 1.06, 1.37)<br>Work control: Odds ratio = 0.97 (95% confidence interval = 0.88, 1.07)<br>Work variety: Odds ratio = 0.99 (95% confidence interval = 0.85, 1.16)<br>From a logistic regression analysis |
| Freeman and Goss (1993)[23] | Unknown | Not reported | Occupational Stress Indicator | Mean increases in pocket depth | 10 women and 8 men from the head office of a large company | Mean age = 39<br>55.6% | Unknown | Type A behaviour: Coefficients = 0.41 (p-value=0.003)<br>Work environment (organisation/climate): Coefficients = -0.34 (p-value = 0.007)<br>(statistical model was not reported) |
| Linden et al. (1996)[28] | Unknown | UK | Occupational Stress Indicator assessed at the second examination | Changes in clinical attachment level after an interval of 5.5 (SD 0.6) years. | 23 employed regular dental attendees aged between 20 and 50 years who had moderate or | Mean age = 41.1 (standard deviation = 7.3)<br>43.5% | Age and social class of the household | Job satisfaction: Coefficients = -0.014 (p-value < 0.01)<br>Type A: Coefficients = 0.026 (p-value < 0.05) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | established periodontitis (13 men and 10 women) | | | Locus of control: Coefficients = -0.035 (p-value ≥ 0.05) (statistical model was not reported) |
| Genco et al. (1999)[29] | Cross-sectional | US | Problems of Everyday Living Scale of Pearlin and Schooler | Severity of Attachment Loss Healthy (0 to 1 mm clinical attachment level), low (1.1 to 2.0 mm), moderate (2.1 to 3.0 mm), high (3.1 to 4.0 mm) and severe (4.1 to 8.0 mm)<br>Severity of Alveolar Bone Loss Healthy (0.4 to 1.9 mm alveolar crestal height), low (2.0 to 2.9 mm), moderate (3.0 to 3.9 mm), and severe (≥4.0 mm) | 1,426 inhabitants aged 25 to 74 years (741 women and 685 men) *working status was unknown | Mean age = 48.9 (standard deviation = 13.9)<br>52.0% | Age, gender, and levels of smoking. | Job strain score among Attachment Loss categories (mean ± standard error)<br>Healthy: 2.12 ± 0.05<br>Low: 2.09 ± 0.02<br>Moderate: 2.16 ± 0.02<br>High: 2.09 ± 0.05<br>Severe: 2.22 ± 0.05<br>(nonsignificant)<br>From analysis of covariance<br><br>Job strain score among Alveolar Bone Loss categories (mean ± standard error)<br>Healthy: 2.12 ± 0.02<br>Low: 2.10 ± 0.03<br>Moderate: 2.09 ± 0.04<br>Severe: 2.19 ± 0.04<br>(nonsignificant)<br>From analysis of covariance |
| Akhter et al. (2005)[30] | Cross-sectional | Japan | Life events scale (yes or no) | Mean clinical attachment loss <1.5 mm were assigned to a non-diseased group and those with mean clinical attachment loss ≥1.5 mm were assigned to a diseased group | 1,089 employed and unemployed residents ranging in age from 18 to 96 years of a farming village in the northernmost island of Japan (531 men and 558 women) | Mean age = 55.0 (standard deviation = 1.7)<br>51.2% | Age, gender, employment status, smoking behaviour, stress within 1 month, self-health-related stress, family health-related stress, frequency of dental attendance, hyperlipidaemia, and diabetes mellitus | Job stress (reference: No): Odds ratio = 1.71 (95% confidence interval = 1.10, 2.67) from a logistic regression analysis |
| Talib Bandar (2009)[22] | Cross-sectional | Iraq | Life events scale (yes or no) | Gingival Index, probing pocket depth, bleeding on probing, and clinical attachment level | 64 working dental patients of both genders with ages ranging from 23 to 65 years | Mean age and sex were not reported. | None | The mean gingival index yes = 1.851 and no = 1.586 (p-value > 0.05)<br><br>Total mean percentage of sites with probing pocket depth ≥ 4 mm<br>yes = 6.277% and no = 4.762% (p-values <0.05) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Total mean Bleeding On Probing<br>yes = 41.534% and no = 32.137% (p-value > 0.05)<br><br>The mean of the clinical attachment level<br>yes = 2.837 and no = 2.275 (p-value > 0.05)<br>(all p-values from t-test) |
| Mahendra et al. (2011)[31] | Cross-sectional | India | An occupational stress index of Srivastava, A. K. and Singh, A. P. | Control group (n=30): probing pocket depth (PPD) ≤ 3 mm<br>Test group 1 (n=40): at least four sites with probing pocket depth > 4mm and ≤ 6 mm<br>Test group 2 (n=30): at least four sites with probing pocket depth > 6mm | 110 police personnel aged 35-48 years with moderate or established periodontitis | Mean age (standard deviation); control group: 40.23 (3.46); test group 1: 40.42 (3.54); test group 2: 41.18 (3.78)<br>Sex was not reported. | None | Mean Occupational Stress Index Score (standard deviation)<br>Control: 79.53 (23.57)<br>Test group 1: 133.68 (33.23)<br>Test group 2: 158.13 (32.44)<br>p-value <0.001<br>(p-values from ANOVA with the Scheffe Test) |
| Ramji, (2011)[24] | Cross-sectional | India | Self-reported job stress (having or not) | Community Periodontal Index and Treatment Needs protocol<br>(a tooth scored 3 or 4 indicating increased pocket depth of over 2 mm indicates presence of periodontitis) | 198 industrial labour full time workers from a small scale sector (SS) and 68 from a large scale sector (LS) between the age of 18-64 years | Age groups (SS [n=130], LS [n=68])<br>15-19 years: 0%, 1%<br>20-29 years: 38%, 60%<br>30-44 years: 45%, 20%<br>45-64 years: 17%, 19%<br>Sex was not reported. | None | Having self-reported job stress: Odds ratio = 7.5 (95% confidence interval = 3.7, 15.02) from a logistic regression analysis |
| Islam et al. (2019)[32] | Cross-sectional | Japan | Brief Job Stress Questionnaire developed by referring the demand-control-support model in Japan<br>(low stress, High stress-High coping, | No inflammation of the gingiva or redness and/or swelling of the interdental papilla without gingival recession was classified as non-periodontitis, and any redness and/or swelling in the gingiva with gingival recession and/or tooth mobility was classified as periodontitis, based on visual inspection by dentists | 738 workers of a Japanese crane manufacturing company (92 were women) | Mean age = 40.7 (standard deviation = 10.5)<br>12.5% | Age, gender, daily flossing, regular dental checkup, body mass index, sleeping duration, current smoker, daily alcohol drinking, monthly overtime work, and worker type | High stress-High coping: Odds ratio = 0.30 (95% confidence interval = 0.14, 0.66)<br>High stress-Low coping: Odds ratio = 2.79 (95% confidence interval = 1.05, 7.43)<br>(reference: low stress)<br>from a logistic regression analysis |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | and High stress-low coping)<br>*coping was assessed using a questionnaire developed by a Japanese company | | | | | |
| **Tooth loss** | | | | | | | | |
| Hayashi et al. (2001)[33] | Cross-sectional | Japan | Karasek job strain model (high job demand and low control and other categories) | Tooth loss via oral examination (≥4 teeth lost and 3≤ teeth lost) | 252 male workers employed at a manufacturing company aged 20–59 years | Mean age = 38.7 (standard deviation = 11.0)<br>0% | Age, type A behaviour, alexythymia, depression, job satisfaction, and life satisfaction | High job demand and low control (reference: other categories): Odds ratio = 1.2 (95% confidence interval = 0.40, 3.42) from a logistic regression analysis |
| Sato et al. (2020)[34] | Cross-sectional | Japan | Effort-Reward Imbalance model (having or not) | Self-reported tooth loss<br>Having tooth loss or not (= no experience of tooth loss) | 1,195 employees aged 25–50 years old who work 20 h per week or more (women = 569) | Median age = 37 (1st and 3rd quartiles = 31 and 43)<br>48% | Age, sex, marital status, annual household income, years of education, employment status, occupation, working hours per week, job position, company size, body mass index, and smoking status | High effort-reward imbalance ratio: Prevalence ratio = 1.20 (95% confidence interval = 1.01, 1.42) from Poisson regression models with a robust error variance |

Table 2. Quality assessment of included studies

| | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 | Q12 | Q13 | Q14 | Quality Rating (Good, Fair, or Poor) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Marcenes and Sheiham (1992)[27] | Yes | Yes | NR | Yes | Yes | No | No | Yes | Yes | No | Yes | Yes | NA | Yes | Fair |
| Freeman and Goss (1993)[23] | Yes | Yes | NR | No | Yes | No | No | Yes | Yes | No | Yes | Yes | NA | No | Poor |
| Linden et al. (1996)[28] | Yes | Yes | NR | Yes | Yes | No | No | Yes | Yes | No | Yes | Yes | NA | No | Poor |
| Genco et al. (1999)[29] | Yes | Yes | NR | No | Yes | No | No | Yes | No | No | Yes | Yes | NA | No | Poor |
| Akhter et al. (2005)[30] | Yes | Yes | NR | No | Yes | No | No | NA | No | No | Yes | Yes | NA | No | Poor |
| Talib Bandar (2009)[22] | Yes | Yes | NR | No | No | No | No | NA | No | No | Yes | Yes | NA | No | Poor |
| Mahendra et al. (2011)[31] | Yes | Yes | NR | Yes | Yes | No | No | NA | Yes | No | Yes | Yes | NA | No | Poor |
| Ramji (2011)[24] | Yes | Yes | No | Yes | Yes | No | No | NA | No | No | Yes | Yes | NA | No | Poor |
| Islam et al. (2019)[32] | Yes | Yes | NR | Yes | Yes | No | No | NA | No | No | Yes | Yes | NA | No | Poor |
| Hayashi et al. (2001)[33] | Yes | Yes | Yes | Yes | Yes | No | No | NA | Yes | No | Yes | Yes | NA | No | Fair |
| Sato et al. (2020)[34] | Yes | Yes | No | Yes | Yes | No | No | NA | Yes | No | Yes | No | NA | Yes | Fair |

Abbreviation: CD, cannot determine; NA, not applicable; NR, not reported

Q1. Was the research question or objective in this paper clearly stated?

Q2. Was the study population clearly specified and defined?

Q3. Was the participation rate of eligible persons at least 50%?

Q4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?

Q5. Was a sample size justification, power description, or variance and effect estimates provided?

Q6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?

Q7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?

Q8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of

exposure, or exposure measured as continuous variable)?

Q9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?

Q10. Was the exposure(s) assessed more than once over time?

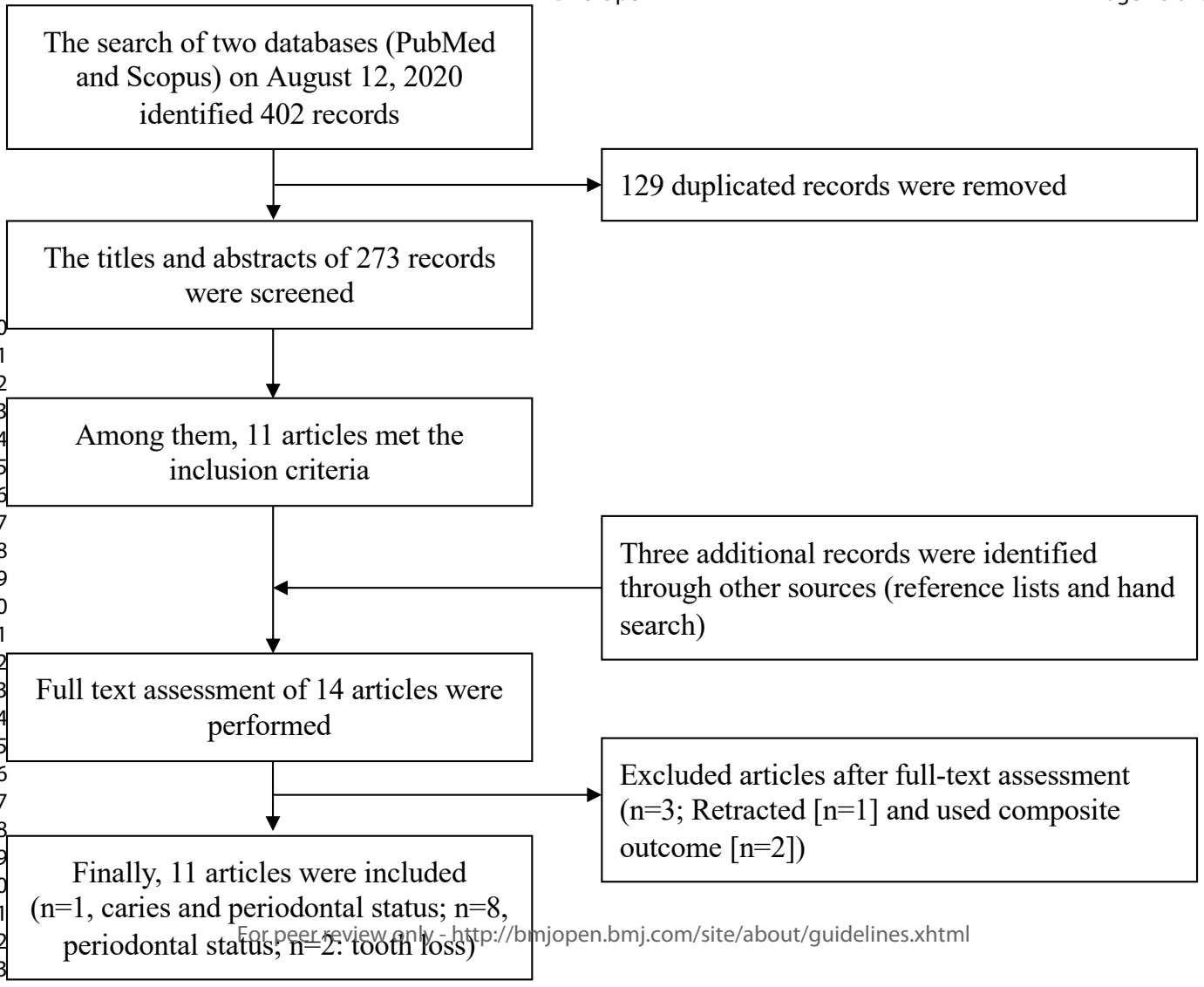
Q11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?

Q12. Were the outcome assessors blinded to the exposure status of participants?

Q13. Was loss to follow-up after baseline 20% or less?

Q14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?

Figure 1. Flow of search strategy and selection of studies for a systematic review.



Supplemental Table 1. The precise search strategies for each database.

| Database | Date | Combination of terms used | Limitation | Result |
|---|---|---|---|---|
| PubMed | August 12, 2020 | ("job strain" OR "effort reward") AND (dental OR oral) | English | 22 |
| PubMed | August 12, 2020 | ("job stress" OR "work stress" OR "occupational stress") AND (dental OR oral) | English | 143 |
| Scopus | August 12, 2020 | ("job strain" OR "effort reward") AND (dental OR oral) | English | 20 |
| Scopus | August 12, 2020 | ("job stress" OR "work stress" OR "occupational stress") AND (dental OR oral) | English | 217 |

# PRISMA 2009 Checklist

| Section/topic | # | Checklist item | Reported on page # |
|---|---|---|---|
| **TITLE** | | | |
| Title | 1 | Identify the report as a systematic review, meta-analysis, or both. | p1 |
| **ABSTRACT** | | | |
| Structured summary | 2 | Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number. | p2, 3 |
| **INTRODUCTION** | | | |
| Rationale | 3 | Describe the rationale for the review in the context of what is already known. | p5, 6 |
| Objectives | 4 | Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS). | p6 |
| **METHODS** | | | |
| Protocol and registration | 5 | Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number. | Not applicable |
| Eligibility criteria | 6 | Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale. | p6 |
| Information sources | 7 | Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched. | p6 |
| Search | 8 | Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated. | p6, 7 |
| Study selection | 9 | State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis). | p6, 7 |
| Data collection process | 10 | Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators. | p7 |
| Data items | 11 | List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made. | p7 |
| Risk of bias in individual studies | 12 | Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis. | p7 |
| Summary measures | 13 | State the principal summary measures (e.g., risk ratio, difference in means). | Not applicable |

# PRISMA 2009 Checklist

| | | | |
|---|---|---|---|
| Synthesis of results | 14 | Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., $I^2$) for each meta-analysis. | Not applicable |



| Section/topic | # | Checklist item | Reported on page # |
|---|---|---|---|
| Risk of bias across studies | 15 | Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies). | Not applicable |
| Additional analyses | 16 | Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified. | Not applicable |
| **RESULTS** | | | |
| Study selection | 17 | Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram. | p8 |
| Study characteristics | 18 | For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations. | p8, 9 |
| Risk of bias within studies | 19 | Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12). | p11 |
| Results of individual studies | 20 | For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot. | p8-11 |
| Synthesis of results | 21 | Present results of each meta-analysis done, including confidence intervals and measures of consistency. | Not applicable |
| Risk of bias across studies | 22 | Present results of any assessment of risk of bias across studies (see Item 15). | Not applicable |
| Additional analysis | 23 | Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]). | Not applicable |
| **DISCUSSION** | | | |
| Summary of evidence | 24 | Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers). | p11, 12 |
| Limitations | 25 | Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias). | p12 |
| Conclusions | 26 | Provide a general interpretation of the results in the context of other evidence, and implications for future research. | p14 |
| **FUNDING** | | | |

# PRISMA 2009 Checklist

| | | | |
|---|---|---|---|
| Funding | 27 | Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review. | p15 |

*From:* Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

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BMJ Open

# Work stress and oral conditions: A systematic review of observational studies



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**Title**

Work stress and oral conditions: A systematic review of observational studies

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**Abstract (300/300)**

**Objectives:** Although psychological stress is a risk factor for oral diseases, there seems to be no review on work stress. This study aimed to review the evidence on the association between work stress and oral conditions, including dental caries, periodontal status, and tooth loss.

**Design:** A systematic review of published observational studies.

**Data sources:** A systematic literature search was conducted in PubMed and Scopus databases on August 12, 2020.

**Study selection:** Articles were screened based on the following inclusion criteria: published after 1966; in English only; epidemiological studies on humans (except case studies, reviews, letters, commentaries, and editorials); and examined the association of work stress with dental caries, periodontal status, and tooth loss.

**Data extraction:** Data was extracted from eligible studies. A quality assessment was conducted using the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies.

**Results:** Of 402 articles identified, 11 met the inclusion criteria, and one study assessed the association of work stress with dental caries and periodontal status. Of 11 studies, one reported a nonsignificant association between work stress and dental caries; eight of nine studies reported a significant association between work stress and worse periodontal status; and one of two studies reported a significant association between work stress and tooth loss. Nine of eleven studies were cross-sectional, while the remaining two studies had unclear methodology. Only two studies were sufficiently adjusted for potential confounders. Eight studies assessed work stress but did not use the current major measures. Three studies were rated as fair, while eight studies had poor quality.

**Conclusions:** There is a lack of evidence on the association of work stress with dental caries and tooth loss. Eight studies suggested potential associations between periodontal status and

work stress. Cohort studies using the major work stress measures and adjusting for the potential confounders are needed.

**Keywords**

systematic review, work stress, job stress, occupational stress, oral health, oral diseases

**Strengths and limitations of this study**

► This is the first systematic review to evaluate and summarise the literature on the association between work stress and oral conditions, including dental caries, periodontal status, and tooth loss.

► This systematic review provides a comprehensive insight into the quality of the included papers.

► The systematic literature search, screening, and quality assessments were conducted by only one investigator.

► A meta-analysis could not be conducted because of the heterogeneity of work stress measures and outcome definitions.

## INTRODUCTION

Oral diseases, such as dental caries and periodontal disease, are a major health concern worldwide. The Global Burden of Disease study has estimated that 2.3 billion individuals had untreated dental caries, 796 million had severe periodontal disease, and 267 million had a complete loss of natural teeth in 2017.[1] Dental caries is the destruction of dental hard tissues in the crowns and roots of the teeth.[2] Periodontal diseases are chronic inflammatory conditions with disorders of the tissues surrounding and supporting the teeth.[3] Tooth loss is mainly the consequence of dental caries and periodontal disease.[2,3] Because oral diseases result in severe toothache and eating, sleeping, and communication disabilities,[4,5] poor oral conditions can restrict work performance[4,5] and create a significant economic burden.[6] Indeed, work productivity loss due to oral conditions is estimated at 187.61 billion US dollars annually.[6] The necessity of preventing oral diseases for working adults is highlighted.

Since the 1990s, rapid changes in the global economy and the diverse markets have occurred, and psychological workplace stress has become more prevalent and severe, especially among industrialised countries.[7] Indeed, Kivimäki et al. reported a 15% prevalence of job strain measured using job-content and demand-control questionnaires from 13 European cohorts' data (1985–2006).[8] Besides, work stress can have profound effects on health. There is accumulating evidence of the risk of work stress on cancer, cardiovascular diseases, diabetes, and depression.[9,10] Béjean and Sultan-Taïeb estimated that the work-related stress costs due to illnesses could range between €1,167 million and €1,975 million in France in 2000.[11] Work stress affects workers' health and productivity.

Psychological stress is recognised as a risk factor for dental caries and periodontal diseases. Psychological stress is related to oral diseases through immune system dysfunction, increased stress hormones, cariogenic bacterial counts, and poor oral health behaviours.[12,13] Work stress is strongly linked with psychological and physical health.[9,10] Previous systematic

reviews suggested potential associations of psychological stress with dental caries and periodontitis.[14,15] However, there seems to be no review on the association between work stress and oral diseases. Today, work stress has become an increasingly serious problem. Besides, the number of women in the workforce and dual-earner families have been increasing.[16] A wide range of populations can suffer the risk of oral diseases from exposure to work stress. Thus, the aim of this systematic review was to evaluate and summarise the literature on the association between work stress and oral conditions, including dental caries, periodontal status, and tooth loss. We set the following review question: Is work stress associated with dental caries, periodontal status, and tooth loss among working adults?

## METHODS

The reporting of this systematic review conforms to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[17,18] We also followed the Conducting Systematic Reviews and Meta-Analyses of Observational Studies of Etiology (COSMOS-E) guidance[19] and the reporting of Meta-analysis Of Observational Studies in Epidemiology (MOOSE).[20] The protocol of this systematic review was not registered.

### Eligibility criteria

Published studies were eligible if they: 1) were published in English; 2) were epidemiological studies on humans (except case studies, reviews, letters, commentaries, and editorials); and 3) examined the association of work stress with dental caries, periodontal status, and tooth loss.

### Information sources and searches

On August 12, 2020, we identified potentially relevant published studies in PubMed (1966 to August 12, 2020) and Scopus (1966 to August 12, 2020) databases. As PubMed and Scopus have only data back to 1966, we focused on articles published after 1966. We used

the following script to obtain a wide range of literature: ("job strain" OR "effort reward") AND (dental OR oral); ("job stress" OR "work stress" OR "occupational stress") AND (dental OR oral). The details of the search strategies for each database are shown in Supplemental Table 1. Besides, we manually hand-searched for potentially suitable studies through the reference lists of identified articles and Google scholar. After excluding duplicate articles, one author (YuS) assessed the titles and abstracts according to the aforementioned criteria. Then, eligible studies were selected for the full-text review.

**Data extraction**

One author (YuS) extracted the following information from each eligible study: 1) name of the first author; 2) study design; 3) study location (country); 4) number of participants and work-related characteristics; 5) exposure and its measurements; 6) outcome and its measurements; 7) age range and proportion of women; 8) covariates included in the adjusted models; and 9) the main results. The results were shown in Table 1.

**Quality assessment**

We used the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies to assess the quality of included studies.[21] This tool includes 14 questions for evaluating the internal validity of a study and these questions are documented in the footnote of Table 2. For each question, one author (YuS) rated them as yes, no, or other (including cannot determine, not reported, and not applicable). The overall quality rating for the study was regarded as good if all the domains were assessed favourably.

**Synthesis of results**

A meta-analysis could not be conducted because of the heterogeneity of work stress measures and outcome definitions.

**Patient and public involvement**

No patient involved.

## RESULTS

Figure 1 presents the flow diagram of information through the phases of the systematic review. Of the 402 articles identified in PubMed and Scopus databases, 129 duplicated articles were removed, the titles and abstracts of 273 were screened, and 11 met the eligibility criteria. Three more articles identified through reference lists and hand-search were added. One article was identified by a hand-search using Google Scholar,[22] one was from a reference list,[23] and the third was an article[24] plagiarised by a retraction paper. Because the article[24] which was plagiarised by the retracted one was published officially and has not been retracted, it was included in our references. After full-text assessments of 14 articles, three were excluded due to retraction (n=1) and the use of composite outcomes including dental caries and periodontal status (n=2).[25,26] Finally, 11 articles were included in this systematic review.[22–24,27–34]

### Study characteristics of individual studies

Table 1 shows the 12 summaries from the 11 studies. One of eleven studies reported on dental caries and periodontal status,[27] eight reported on periodontal status,[22–24,28–32] and two reported on tooth loss.[33,34] Three studies were conducted in Japan,[30,32–34] two in India,[24,31] and one each in the UK,[28] the US,[29] Brazil,[27] and Iraq.[22] One study did not report on the study location.[28] The sample size varied from 18 to 1,426 among included studies. In one study, working status was not reported.[29] One study included employed and unemployed participants.[30] Two studies did not include women,[27,33] and three did not report on sex.[22,24,31]

Three studies assessed work stress using the current major measures (Job Demand-Control Model and Effort-Reward Imbalance Model).[27,33,34] Work stress was assessed using the Karasek job strain model,[27,33] the Effort-Reward Imbalance model,[34] the Brief Job Stress Questionnaire developed by referring to the demand-control-support model in Japan,[32] a self-

reported job stress,[24] the Occupational Stress Indicator,[23,28] an occupational stress index by Srivastava and Singh,[31] the Life events scale,[22,30] and the Problems of Everyday Living Scale by Pearlin and Schooler.[29]

Three studies presented only descriptive statistics.[22,29,31] Eight studies performed regression analyses;[23,24,27,28,30,32–34] but two of the eight studies did not report the types of a regression modeling used.[23,28] Only two studies sufficiently adjusted for potential confounders such as socioeconomic status and work-related variables.[27,34]

**Dental caries and work stress**

One study reported the cross-sectional association between work stress and dental caries, which included 164 paid male workers aged 35 to 44 years in Brazil.[27] Work stress was assessed according to the Karasek job strain model.[35] Dental caries status was assessed using the DMFS index (the number of decayed [D], missing [M], and filled [F] teeth surfaces per person). After adjusting for covariates, one-point increases in the work mental demand, work control, and work variety scores were associated with 0.19 (95% confidence interval [CI] = -0.91, 1.29), 0.87 (95% CI = -0.18, 1.91), and -0.06 (95% CI = -1.57, 1.45) increases in the DMFS index, respectively, in a multivariable regression analysis. Consequently, this study reported a nonsignificant association between work stress and dental caries.[27]

**Periodontal status and work stress**

Eight of nine studies reported a significant association between work stress and worse periodontal status.[22–24,27–32] The measurements of periodontal status varied across the included studies. The measurements included probing pocket depth,[22,23,31] clinical attachment level,[22,28,29] alveolar bone loss,[29] gingival index,[22] bleeding on probing,[22] the Community Periodontal Index and Treatment Needs protocol,[24] and a composite outcome, including these measures.[27,32] Eight studies assessed periodontal status based on oral examination with probe, but one study was based on only visual inspection by dentists.[32]

Among the nine studies, two studies had unclear methodology; therefore, they were categorised as unknown.[23,28] Freeman and Goss assessed work stress and periodontal status over a 12-month period.[23] However, they did not clearly report when work stress and periodontal status variables were assessed and how they were used in the statistical models. Linden et al. followed-up patients for 5.5 years, but work stress was only assessed at the follow-up examination, not at the baseline survey.[28]

Among the remaining seven studies, after excluding the above two studies, three studies presented only descriptive statistics.[22,29,31] The remaining four papers reported significant associations following regression analyses.[24,27,30,32] However, Akhter et al. used general stress questions not specific to work stress and included nonworking adults.[30] Islam et al. used the Brief Job Stress Questionnaire derived from the demand-control-support model in Japan, and periodontal status was assessed based on the visual inspection by dentists.[32] Important potential confounders such as socioeconomic status and work-related variables, were not included. Ramji assessed work stress using a single job stress question and did not adjust for covariates in the statistical models.[24] Marcenes and Sheiham reported a significant association between periodontal status and work stress.[27] Periodontal status was assessed by the presence or absence of gums bleeding on probing or with pockets. The authors divided periodontal measures into groups based on "complete absence of teeth with gums bleeding on probing and with pockets," or "the presence of any tooth with gums bleeding on probing or pockets," and defined the latter as those with periodontal disease. After adjusting for covariates, one-point increases in work mental demand scores, work control scores, and work variety scores were associated with ORs of 1.22 (95%CI = 1.06, 1.37), 0.97 (95%CI = 0.88, 1.07), and 0.99 (95%CI = 0.85, 1.16), respectively, for having periodontal disease, in a logistic regression model.

**Tooth loss and work stress**

Two studies on the association between work stress and tooth loss were identified. One of the two reported a significant association between work stress and tooth loss.[33,34] Hayashi et al. reported the association between work stress, assessed using the Karasek job strain model, and tooth loss.[33] A total of 322 male workers employed at a manufacturing company were included. They dichotomised the number of tooth loss into ≤3 and ≥4. After adjusting for covariates, high job demand and low control conditions were associated with high odds of having ≥4 teeth loss but not significant (OR = 1.2 [95% CI = 0.40, 3.42]). This study did not adjust for the important potential confounders such as socioeconomic status and work-related variables. Sato et al. reported the association between work stress, assessed using the effort–reward imbalance model, and self-reported tooth loss.[34] After adjusting for covariates including socioeconomic status and work-related variables, a high effort-reward imbalance ratio was significantly associated with a high prevalence of ≥1 tooth loss (prevalence ratio = 1.20 [95% CI = 1.01, 1.42]).

**Study quality**

Table 2 presents the results of the quality assessments for each study. Eight studies (73%) had poor quality, while three (27%) were rated as fair. None of the studies addressed question 6 ("For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?"); 7 ("Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?"); and 10 ("Was the exposure(s) assessed more than once over time?"); because all the studies were cross-sectional or the study design was unclear.

## DISCUSSION

This is the first systematic review to evaluate and summarise the existing literature on the associations between work stress and oral conditions. As our findings showed, only one study

reported on dental caries and periodontal status, nine on periodontal status, and two on tooth loss. Based on the findings of this review, the evidence is lacking on the association of work stress with dental caries and tooth loss. Eight of nine studies reported the significant associations between multiple periodontal measures and work stress.

**Limitations of the review**

This systematic review has four limitations. First, the systematic literature search, screening, and quality assessments were conducted by only one investigator. A single screening could miss more studies than a double screening.[36] Second, only English language literature was included. Although a systematic review found no bias due to English-language restriction in systematic reviews,[37] this review might include bias. Third, there was no protocol for this systematic review. A priori systematic review protocol registration provides the rigor and trustworthiness of the reviews.[38] This might weaken the rigor and trustworthiness of our review. Finally, a meta-analysis could not be conducted owing to the heterogeneity of the included studies. Work stress was assessed using varied measures. Particularly, only a few studies used the current major measures of work stress. Indicators of periodontal status were also varied. No study used valid epidemiological definitions for periodontal disease as the outcome. The cut-off points differed between the two studies on tooth loss and work stress. Besides, there was only one study on dental caries and work stress. These limitations hindered us from performing a meta-analysis.

**Dental caries and work stress**

We found only one study on the cross-sectional association between work stress and dental caries.[27] The conclusion was that there was no significant association between work stress and dental caries. However, since the sample size was relatively small (n=164), there is the possibility of a false negative association. Besides, each subscale of the Karasek job strain model was simultaneously included in the statistical model. Generally, in the Karasek job

strain model, the recommendation is to use four categories of job strain generated by the interaction of the subscales: High-strain jobs, active jobs, low-strain jobs, and passive jobs.[9] Due to the above treatments of the subscales, it is possible that the association was underestimated. Additionally, as there was no cohort study, we could not assess the prospective associations. Considering the above limitations, it was difficult to determine whether work stress is associated with dental caries. A further study should include a cohort design and a relatively large sample size with appropriate work stress measures.

**Periodontal status and work stress**

Nine studies reported on the association between work stress and periodontal status.[22–24,27–32] However, the outcome measures were varied across the included studies. Although there are the accepted epidemiological definitions of periodontitis according to the European Workshop in Periodontology and the Centers for Disease Control/American Academy of Periodontology,[39,40] there was no study that used the definitions. It means that the included studies reported the associations between work stress and periodontal measures, not periodontal disease. In addition, the measurement of work stress was measured also varied across studies. Each measure assessed different dimensions of work stress.[41] Due to the heterogeneity of exposures and outcomes, we could not conduct a meta-analysis.

Of the nine studies, only one study adjusted for the potential confounders, such as socioeconomic status and work-related variables.[27] Besides, no cohort study was found. The failure to adjust for the confounders and consider the induction time weakens the research evidence. However, despite the above limitations, the consistent association between work stress and worse periodontal status is noteworthy. To verify the current results, a further cohort study using the validated definitions of periodontal disease and current measurements of work stress, in addition to adjusting for the potential confounders should be performed.

**Tooth loss and work stress**

Two studies on the association between work stress and tooth loss were identified. Hayashi's study included only male workers employed at one manufacturing company.[33] In contrast, Sato's study included active workers sampled from a general population.[34] However, the response rate was relatively low (32%). The generalisability of both studies could be limited.

The two studies had different cut-off points of tooth loss. Hayashi's study used the cut-off point of more than 4 teeth lost. The cutoff point is higher than the mean number of teeth loss (at 25 to 34, 35 to 45, 46 to 54, and 55 to 64 years = 0.16, 0.58, 1.48, and 4.00, respectively) reported by the national statistical surveys.[42] This study targeted severe cases only. In Sato's study, the outcome was the loss of at least more than one tooth. However, this outcome relied on self-reported answers; therefore, self-reported bias might exist.

Both studies showed an increased risk of tooth loss, although only one of the two studies reported a significant association between work stress and tooth loss. However, due to the above limitations, it is difficult to derive any form of conclusion. In the future, a cohort study including general workers should be conducted to confirm these findings.

**Conclusions**

Based on the findings, this systematic review suggests a lack of evidence on the association of work stress with dental caries and tooth loss. Although eight of the nine studies reported significant associations between multiple periodontal measures and work stress, no study used valid epidemiological definitions of periodontal disease. For future research, well-designed cohort studies including potential confounding factors and the use of generally accepted measurements of work stress and periodontal disease are needed.

**Ethical Approval Statement**

Not applicable

**Contributors**

YuS contributed to the acquisition and the interpretation of data and drafting of the work. YaS and EY revised it critically for important intellectual content. All authors contributed to the conception 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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**Competing interests**

The authors declare no potential conflicts of interest with respect to the research, authorship, and publication of this article.

**Patient consent for publication**

Not required.

**Provenance and peer review**

Not commissioned; externally peer-reviewed.

**Data availability statement**

Not applicable.

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## Tables

Table 1. Summary of included studies on work stress and oral conditions

| Author's name (year of publication) | Study design | Study location | Exposure (work stress) | Outcome | Number of participants | Mean age of the participants and proportion of women | Covariates | Main results |
|---|---|---|---|---|---|---|---|---|
| **Dental caries** | | | | | | | | |
| Marcenes and Sheiham (1992)[27] | Cross-sectional | Brazil | Karasek job strain model | DMFS index (number of decayed (D), missing (M), and Filled (F) teeth surfaces per persons) | 164 male paid workers aged from 35 to 44 years | Mean age = 41.2 (standard deviation = 2.2)<br>0% | Marital quality, toothbrushing frequency, sugar consumption, age, years of residence, type of toothpaste, frequency dental attendance, and socio-economic status | Work mental demand: Coefficients = 0.19 (95% CI = -0.91, 1.29)<br>Work control: Coefficients = 0.87 (95% CI = -0.18, 1.91)<br>Work variety: Coefficients = -0.06 (95% CI = -1.57, 1.45)<br>From a linear regression analysis |
| **Periodontal status** | | | | | | | | |
| Marcenes and Sheiham (1992)[27] | Cross-sectional | Brazil | Karasek job strain model | The presence or absence of teeth either with gums bleeding on probing or with pockets was used. The indicator was labelled as 'complete absence of teeth with gums bleeding on probing and with pockets', and 'presence of any tooth with gums bleeding on probing or pockets'. | 164 male paid workers aged from 35 to 44 years (16 workers were excluded from 164 participants due to missing values and edentulous) | Mean age = 41.2 (standard deviation = 2.2)<br>0% | Marital quality, toothbrushing frequency, sugar consumption, age, years of residence, type of toothpaste, frequency dental attendance, and socio-economic status | Work mental demand: Odds ratio = 1.22 (95% confidence interval = 1.06, 1.37)<br>Work control: Odds ratio = 0.97 (95% confidence interval = 0.88, 1.07)<br>Work variety: Odds ratio = 0.99 (95% confidence interval = 0.85, 1.16)<br>From a logistic regression analysis |
| Freeman and Goss (1993)[23] | Unknown | Not reported | Occupational Stress Indicator | Mean increases in pocket depth | 10 women and 8 men from the head office of a large company | Mean age = 39<br>55.6% | Unknown | Type A behaviour: Coefficients = 0.41 (p-value=0.003)<br>Work environment (organisation/climate): Coefficients = -0.34 (p-value = 0.007)<br>(statistical model was not reported) |
| Linden et al. (1996)[28] | Unknown | UK | Occupational Stress Indicator assessed at the second examination | Changes in clinical attachment level after an interval of 5.5 (SD 0.6) years. | 23 employed regular dental attendees aged between 20 and 50 years who had moderate or | Mean age = 41.1 (standard deviation = 7.3)<br>43.5% | Age and social class of the household | Job satisfaction: Coefficients = -0.014 (p-value < 0.01)<br>Type A: Coefficients = 0.026 (p-value < 0.05) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | established periodontitis (13 men and 10 women) | | | Locus of control: Coefficients = -0.035 (p-value ≥ 0.05) (statistical model was not reported) |
| Genco et al. (1999)[29] | Cross-sectional | US | Problems of Everyday Living Scale of Pearlin and Schooler | Severity of Attachment Loss Healthy (0 to 1 mm clinical attachment level), low (1.1 to 2.0 mm), moderate (2.1 to 3.0 mm), high (3.1 to 4.0 mm) and severe (4.1 to 8.0 mm)<br>Severity of Alveolar Bone Loss Healthy (0.4 to 1.9 mm alveolar crestal height), low (2.0 to 2.9 mm), moderate (3.0 to 3.9 mm), and severe (≥4.0 mm) | 1,426 inhabitants aged 25 to 74 years (741 women and 685 men) *working status was unknown | Mean age = 48.9 (standard deviation = 13.9)<br>52.0% | Age, gender, and levels of smoking. | Job strain score among Attachment Loss categories (mean ± standard error)<br>Healthy: 2.12 ± 0.05<br>Low: 2.09 ± 0.02<br>Moderate: 2.16 ± 0.02<br>High: 2.09 ± 0.05<br>Severe: 2.22 ± 0.05<br>(nonsignificant)<br>From analysis of covariance<br><br>Job strain score among Alveolar Bone Loss categories (mean ± standard error)<br>Healthy: 2.12 ± 0.02<br>Low: 2.10 ± 0.03<br>Moderate: 2.09 ± 0.04<br>Severe: 2.19 ± 0.04<br>(nonsignificant)<br>From analysis of covariance |
| Akhter et al. (2005)[30] | Cross-sectional | Japan | Life events scale (yes or no) | Mean clinical attachment loss <1.5 mm were assigned to a non-diseased group and those with mean clinical attachment loss ≥1.5 mm were assigned to a diseased group | 1,089 employed and unemployed residents ranging in age from 18 to 96 years of a farming village in the northernmost island of Japan (531 men and 558 women) | Mean age = 55.0 (standard deviation = 1.7)<br>51.2% | Age, gender, employment status, smoking behaviour, stress within 1 month, self-health-related stress, family health-related stress, frequency of dental attendance, hyperlipidaemia, and diabetes mellitus | Job stress (reference: No): Odds ratio = 1.71 (95% confidence interval = 1.10, 2.67) from a logistic regression analysis |
| Talib Bandar (2009)[22] | Cross-sectional | Iraq | Life events scale (yes or no) | Gingival Index, probing pocket depth, bleeding on probing, and clinical attachment level | 64 working dental patients of both genders with ages ranging from 23 to 65 years | Mean age and sex were not reported. | None | The mean gingival index yes = 1.851 and no = 1.586 (p-value > 0.05)<br><br>Total mean percentage of sites with probing pocket depth ≥ 4 mm<br>yes = 6.277% and no = 4.762% (p-values <0.05) |

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|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Total mean Bleeding On Probing<br>yes = 41.534% and no = 32.137% (p-value > 0.05)<br><br>The mean of the clinical attachment level<br>yes = 2.837 and no = 2.275 (p-value > 0.05)<br>(all p-values from t-test) |
| Mahendra et al. (2011)[31] | Cross-sectional | India | An occupational stress index of Srivastava, A. K. and Singh, A. P. | Control group (n=30): probing pocket depth (PPD) ≤ 3 mm<br>Test group 1 (n=40): at least four sites with probing pocket depth > 4mm and ≤ 6 mm<br>Test group 2 (n=30): at least four sites with probing pocket depth > 6mm | 110 police personnel aged 35-48 years with moderate or established periodontitis | Mean age (standard deviation); control group: 40.23 (3.46); test group 1: 40.42 (3.54); test group 2: 41.18 (3.78)<br>Sex was not reported. | None | Mean Occupational Stress Index Score (standard deviation)<br>Control: 79.53 (23.57)<br>Test group 1: 133.68 (33.23)<br>Test group 2: 158.13 (32.44)<br>p-value <0.001<br>(p-values from ANOVA with the Scheffe Test) |
| Ramji, (2011)[24] | Cross-sectional | India | Self-reported job stress (having or not) | Community Periodontal Index and Treatment Needs protocol<br>(a tooth scored 3 or 4 indicating increased pocket depth of over 2 mm indicates presence of periodontitis) | 198 industrial labour full time workers from a small scale sector (SS) and 68 from a large scale sector (LS) between the age of 18-64 years | Age groups (SS [n=130], LS [n=68])<br>15-19 years: 0%, 1%<br>20-29 years: 38%, 60%<br>30-44 years: 45%, 20%<br>45-64 years: 17%, 19%<br>Sex was not reported. | None | Having self-reported job stress: Odds ratio = 7.5 (95% confidence interval = 3.7, 15.02) from a logistic regression analysis |
| Islam et al. (2019)[32] | Cross-sectional | Japan | Brief Job Stress Questionnaire developed by referring the demand-control-support model in Japan<br>(low stress, High stress-High coping, | No inflammation of the gingiva or redness and/or swelling of the interdental papilla without gingival recession was classified as non-periodontitis, and any redness and/or swelling in the gingiva with gingival recession and/or tooth mobility was classified as periodontitis, based on visual inspection by dentists | 738 workers of a Japanese crane manufacturing company (92 were women) | Mean age = 40.7 (standard deviation = 10.5)<br>12.5% | Age, gender, daily flossing, regular dental checkup, body mass index, sleeping duration, current smoker, daily alcohol drinking, monthly overtime work, and worker type | High stress-High coping: Odds ratio = 0.30 (95% confidence interval = 0.14, 0.66)<br>High stress-Low coping: Odds ratio = 2.79 (95% confidence interval = 1.05, 7.43)<br>(reference: low stress)<br>from a logistic regression analysis |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | and High stress-low coping)<br>*coping was assessed using a questionnaire developed by a Japanese company | | | | | |
| **Tooth loss** | | | | | | | | |
| Hayashi et al. (2001)[33] | Cross-sectional | Japan | Karasek job strain model (high job demand and low control and other categories) | Tooth loss via oral examination (≥4 teeth lost and 3≤ teeth lost) | 252 male workers employed at a manufacturing company aged 20–59 years | Mean age = 38.7 (standard deviation = 11.0)<br>0% | Age, type A behaviour, alexythymia, depression, job satisfaction, and life satisfaction | High job demand and low control (reference: other categories): Odds ratio = 1.2 (95% confidence interval = 0.40, 3.42) from a logistic regression analysis |
| Sato et al. (2020)[34] | Cross-sectional | Japan | Effort-Reward Imbalance model (having or not) | Self-reported tooth loss<br>Having tooth loss or not (= no experience of tooth loss) | 1,195 employees aged 25–50 years old who work 20 h per week or more (women = 569) | Median age = 37 (1st and 3rd quartiles = 31 and 43)<br>48% | Age, sex, marital status, annual household income, years of education, employment status, occupation, working hours per week, job position, company size, body mass index, and smoking status | High effort-reward imbalance ratio: Prevalence ratio = 1.20 (95% confidence interval = 1.01, 1.42) from Poisson regression models with a robust error variance |

Table 2. Quality assessment of included studies

| | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 | Q12 | Q13 | Q14 | Quality Rating (Good, Fair, or Poor) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Marcenes and Sheiham (1992)[27] | Yes | Yes | NR | Yes | Yes | No | No | Yes | Yes | No | Yes | Yes | NA | Yes | Fair |
| Freeman and Goss (1993)[23] | Yes | Yes | NR | No | Yes | No | No | Yes | Yes | No | Yes | Yes | NA | No | Poor |
| Linden et al. (1996)[28] | Yes | Yes | NR | Yes | Yes | No | No | Yes | Yes | No | Yes | Yes | NA | No | Poor |
| Genco et al. (1999)[29] | Yes | Yes | NR | No | Yes | No | No | Yes | No | No | Yes | Yes | NA | No | Poor |
| Akhter et al. (2005)[30] | Yes | Yes | NR | No | Yes | No | No | NA | No | No | Yes | Yes | NA | No | Poor |
| Talib Bandar (2009)[22] | Yes | Yes | NR | No | No | No | No | NA | No | No | Yes | Yes | NA | No | Poor |
| Mahendra et al. (2011)[31] | Yes | Yes | NR | Yes | Yes | No | No | NA | Yes | No | Yes | Yes | NA | No | Poor |
| Ramji (2011)[24] | Yes | Yes | No | Yes | Yes | No | No | NA | No | No | Yes | Yes | NA | No | Poor |
| Islam et al. (2019)[32] | Yes | Yes | NR | Yes | Yes | No | No | NA | No | No | Yes | Yes | NA | No | Poor |
| Hayashi et al. (2001)[33] | Yes | Yes | Yes | Yes | Yes | No | No | NA | Yes | No | Yes | Yes | NA | No | Fair |
| Sato et al. (2020)[34] | Yes | Yes | No | Yes | Yes | No | No | NA | Yes | No | Yes | No | NA | Yes | Fair |

Abbreviation: CD, cannot determine; NA, not applicable; NR, not reported

Q1. Was the research question or objective in this paper clearly stated?

Q2. Was the study population clearly specified and defined?

Q3. Was the participation rate of eligible persons at least 50%?

Q4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?

Q5. Was a sample size justification, power description, or variance and effect estimates provided?

Q6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?

Q7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?

Q8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of

exposure, or exposure measured as continuous variable)?

Q9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?

Q10. Was the exposure(s) assessed more than once over time?

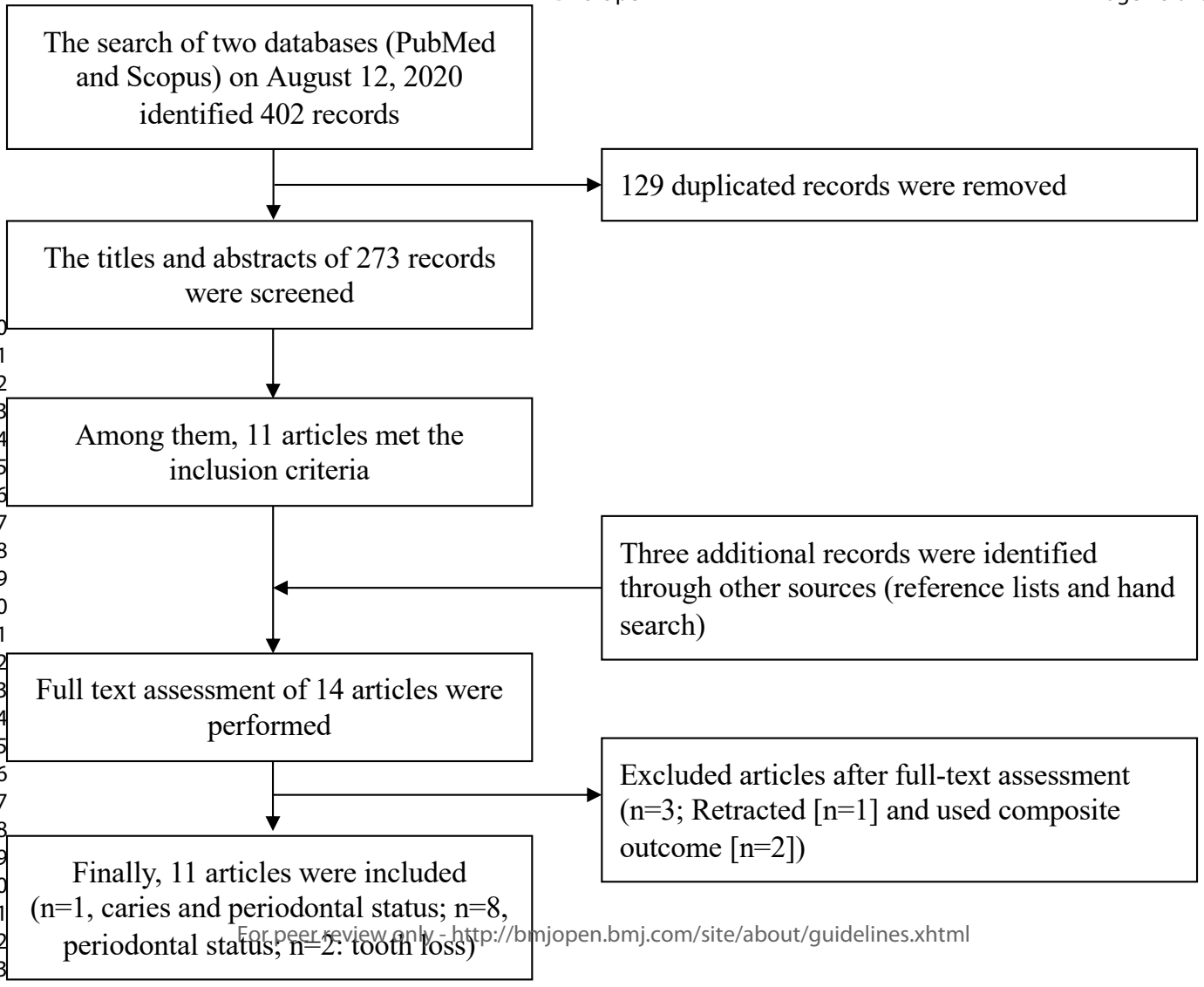
Q11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?

Q12. Were the outcome assessors blinded to the exposure status of participants?

Q13. Was loss to follow-up after baseline 20% or less?

Q14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?

Figure 1. Flow of search strategy and selection of studies for a systematic review.



Supplemental Table 1. The precise search strategies for each database.

| Database | Date | Combination of terms used | Limitation | Result |
|---|---|---|---|---|
| PubMed | August 12, 2020 | ("job strain" OR "effort reward") AND (dental OR oral) | English | 22 |
| PubMed | August 12, 2020 | ("job stress" OR "work stress" OR "occupational stress") AND (dental OR oral) | English | 143 |
| Scopus | August 12, 2020 | ("job strain" OR "effort reward") AND (dental OR oral) | English | 20 |
| Scopus | August 12, 2020 | ("job stress" OR "work stress" OR "occupational stress") AND (dental OR oral) | English | 217 |

# PRISMA 2009 Checklist

| Section/topic | # | Checklist item | Reported on page # |
|---|---|---|---|
| **TITLE** | | | |
| Title | 1 | Identify the report as a systematic review, meta-analysis, or both. | p1 |
| **ABSTRACT** | | | |
| Structured summary | 2 | Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number. | p2, 3 |
| **INTRODUCTION** | | | |
| Rationale | 3 | Describe the rationale for the review in the context of what is already known. | p5, 6 |
| Objectives | 4 | Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS). | p6 |
| **METHODS** | | | |
| Protocol and registration | 5 | Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number. | Not applicable |
| Eligibility criteria | 6 | Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale. | p6 |
| Information sources | 7 | Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched. | p6, 7 |
| Search | 8 | Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated. | p6, 7 |
| Study selection | 9 | State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis). | p6, 7 |
| Data collection process | 10 | Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators. | p7 |
| Data items | 11 | List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made. | p7 |
| Risk of bias in individual studies | 12 | Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis. | p7 |
| Summary measures | 13 | State the principal summary measures (e.g., risk ratio, difference in means). | p7 |
| Synthesis of results | 14 | Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., $I^2$) for each meta-analysis. | Not applicable |

# PRISMA 2009 Checklist

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| Section/topic | # | Checklist item | Reported on page # |
|---|---|---|---|
| Risk of bias across studies | 15 | Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies). | Not applicable * |
| Additional analyses | 16 | Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified. | Not applicable * |
| **RESULTS** | | | |
| Study selection | 17 | Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram. | p8 |
| Study characteristics | 18 | For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations. | p8, 9 |
| Risk of bias within studies | 19 | Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12). | p11 |
| Results of individual studies | 20 | For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot. | p8-11 |
| Synthesis of results | 21 | Present results of each meta-analysis done, including confidence intervals and measures of consistency. | Not applicable * |
| Risk of bias across studies | 22 | Present results of any assessment of risk of bias across studies (see Item 15). | Not applicable * |
| Additional analysis | 23 | Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]). | Not applicable * |
| **DISCUSSION** | | | |
| Summary of evidence | 24 | Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers). | p11, 12 |

# PRISMA 2009 Checklist

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|---|---|---|---|
| Limitations | 25 | Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias). | p12 |
| Conclusions | 26 | Provide a general interpretation of the results in the context of other evidence, and implications for future research. | p14 |
| **FUNDING** | | | |
| Funding | 27 | Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review. | p15 |

*Because a meta-analysis was not conducted, these sections were not applicable.

*From:* Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

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