

PEER REVIEW HISTORY

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ARTICLE DETAILS

TITLE (PROVISIONAL)	Work stress and oral conditions: A systematic review of observational studies
AUTHORS	Sato, Yukihiko; Saijo, Yasuaki; Yoshioka, Eiji

VERSION 1 – REVIEW

REVIEWER	Peter Milgrom University of Washington USA
REVIEW RETURNED	26-Nov-2020

GENERAL COMMENTS	<p>This is a nicely done systematic review of studies of the relationship between work stress and oral conditions. My overall reaction is that the paper would be more meaningful if the authors discussed the actual magnitudes of the effects others have found rather than simply presenting the relative magnitudes. This might impact their argument that additional studies are merited. Some specific improvements are needed:</p> <ol style="list-style-type: none">1. The abstract could be improved by including the time period selected for the literature search and that the papers were in English only.2. Page 6, line 83. The authors should provide an explanation of why they chose 1966 as the cut off.3. Page 7, line 99. The authors should state the actual questions are in the table footnote.4. Page 8, line 127. The sentence beginning “Work stress assessed...” is unclear. Words may be missing.5. Page 9, line 158. Discussion is singular not plural. Line 159, literature is singular not plural.6. Page 11, line 179. The use of the word They is unclear.7. Page 12, line 190. The clause beginning “the definition of” is unclear. Line 214, the use of the word Them is unclear.8. The references contain multiple formatting errors and some references are incomplete. The references to books should include the publication location (see 7 for example). Some journal names are abbreviated while others are spelled out. Online references are incomplete (see 29 and 38 for example).
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REVIEWER	Guarnizo-Herreño, Carol UCL
REVIEW RETURNED	09-Dec-2020

GENERAL COMMENTS	<p>The topic of this paper is interesting, and it has important potential implications. However, to fully understand the rationale behind this review and some of its findings, certain things need clarification in the manuscript. Importantly, the Discussion section requires extensive revision, in my opinion. Specific comments according to each section are provided below for consideration of authors:</p> <p>Introduction</p> <ul style="list-style-type: none"> - Since previous reviews have examined the association between stress (in general) and oral health outcomes, I think the reader would benefit from a couple of sentences in the Introduction explaining why it is important to study one specific type of stress: work-related stress. I would recommend the authors to elaborate on this point and clearly state how this analysis builds upon previous reviews in this area. <p>Methods</p> <ul style="list-style-type: none"> - Please explain why single screening was preferred over the conventional double screening for study selection in this systematic review. On this issue, checking the following paper might be helpful: Waffenschmidt S, Knelangen M, Sieben W, Bühn S, Pieper D. Single screening versus conventional double screening for study selection in systematic reviews: a methodological systematic review. <i>BMC Med Res Methodol.</i> 2019; 19(1):132. - The heterogeneity among studies was one of the reasons given for not conducting a meta-analysis. Could you please briefly mention if differences across studies were mainly on the comparisons made, the outcomes considered, the exposures, all of these? <p>Results</p> <ul style="list-style-type: none"> - Figure 1: Perhaps it would be good to indicate in this figure that, after screening title and abstract of 273 studies, only 11 studies met the inclusion criteria. Then you can signpost the inclusion of the three additional studies identified through reference lists and hand-search. - Authors state that 'Four studies included participants who were not working adults'. However, one of those studies by Genco et al., (Ref #25) included adults aged 25 to 74 years, but it does not say whether they were working or not. Please revise the statement and amend if necessary, after checking each of the studies. - Please explain the difference between 'clinical examination' and 'visual inspection by dentists' when describing the methods used to assess periodontal status in the studies included in the review. <p>Discussion</p> <ul style="list-style-type: none"> - This section of the manuscript requires extensive revision, in my opinion. Most of the text included in the current Discussion section corresponds to more detailed information about results. Please see Docherty and Smith, <i>BMJ</i> 1999; 318: 1224-5 for how to structure a Discussion section. As a general rule, the first paragraph of the Discussion should briefly summarize the main
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	<p>findings. Then, the following paragraphs should address the weaknesses of the study design and measures, etc., discuss how the findings support or refute previous literature, potential explanations for findings, etc. The final paragraph should tie it all together –so what? Where next? What are the implications for practice?</p> <ul style="list-style-type: none"> - Findings of this review showed that eight of nine studies found a significant association between work stress and periodontal status. However, the first paragraph of the Discussion sections states that ‘Based on the findings of this review, evidence is lacking on the association of work stress with dental caries, periodontal status, and tooth loss’. Please explain why you included periodontal status in that statement. - Besides methodological issues, it would be interesting to discuss potential reasons for the lack of a significant association found between work stress and dental caries in the only study which assessed that outcome. - Authors mention that, due to the variety of measures used to assessed periodontal status in the studies, ‘it was difficult to estimate periodontal disease prevalence’. However, estimating such prevalence was not an objective of this analysis. Please revise and amend. <p>Please revise the use of English language throughout the text.</p>
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VERSION 1 – AUTHOR RESPONSE

Reviewer 1: Dr. Peter Milgrom

2-1. My overall reaction is that the paper would be more meaningful if the authors discussed the actual magnitudes of the effects others have found rather than simply presenting the relative magnitudes.

Response:

We agree with your comment. We have revised the discussion section thoroughly (Lines 209-282, pages 11-14).

2-2. The abstract could be improved by including the time period selected for the literature search and that the papers were in English only.

Response:

We have clarified the time period and the language restriction in the abstract.

(Lines 8-9, page 2)

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

2-3. Page 6, line 83. The authors should provide an explanation of why they chose 1966 as the cut off.

Response:

We have added an explanation for the choice of the period.

(Lines 89-90, page 6)

As PubMed and Scopus have only data back to 1966, we focused on articles published after 1966.

2-4. Page 7, line 99. The authors should state the actual questions are in the table footnote.

Response:

We have indicated that each document was placed in the footnote of Table 2.

(Lines 109-110, page 7)

Each document of the question was shown in the footnote of Table 2.

2-5. Page 8, line 127. The sentence beginning "Work stress assessed..." is unclear. Words may be missing.

Response:

We apologize for the incorrect grammar. We have revised this sentence. Our manuscript has been rechecked by an English native speaker.

(Lines 134-139, page 8)

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

2-6. Page 9, line 158. Discussion is singular not plural. Line 159, literature is singular not plural.

Response:

We have revised these terms.

(Lines 209-211, page 11)

DISCUSSION

This is the first systematic review to evaluate and summarise the existing literature on the associations between work stress and oral conditions.

2-7. Page 11, line 179. The use of the word They is unclear.

Response:

We have clarified it.

(Lines 233-234, page 12)

The conclusion was that there was no significant association between work stress and dental caries.

2-8. Page 12, line 190. The clause beginning “the definition of” is unclear.

Response:

We have revised this sentence.

(Lines 246-251, page 13)

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.

2-9. Line 214, the use of the word Them is unclear.

Response:

We have clarified it.

(Lines 178-181, page 10)

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.

2-10. The references contain multiple formatting errors and some references are incomplete. The references to books should include the publication location (see 7 for example). Some journal names are abbreviated while others are spelled out. Online references are incomplete (see 29 and 38 for example).

Response:

Thank you for your comment. We have rechecked and updated all the references.

Reviewer 2: Dr. Carol Guarnizo-Herreño

Introduction

3-1. Since previous reviews have examined the association between stress (in general) and oral health outcomes, I think the reader would benefit from a couple of sentences in the Introduction explaining why it is important to study one specific type of stress: work-related stress. I would recommend the authors to elaborate on this point and clearly state how this analysis builds upon previous reviews in this area.

Response:

We have added an explanation about the importance of work-stress and why it should be studied.

(Lines 68-71, page 6)

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.

Methods

3-2. Please explain why single screening was preferred over the conventional double screening for study selection in this systematic review. On this issue, checking the following paper might be helpful: Waffenschmidt S, Knelang M, Sieben W, Bühn S, Pieper D. Single screening versus conventional double screening for study selection in systematic reviews: a methodological systematic review. *BMC Med Res Methodol.* 2019; 19(1):132.

Response:

Due to limited resources, the articles were reviewed by one investigator. We agree that single screening creates bias and have described this limitation in the discussion section.

(Lines 217-219, page 12)

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

3-3. The heterogeneity among studies was one of the reasons given for not conducting a meta-analyses. Could you please briefly mention if differences across studies were mainly on the comparisons made, the outcomes considered, the exposures, all of these?

Response:

We have added the reasons. Besides, we have discussed this limitation in the discussion section.

(Line 39-40, page 4)

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

(Lines 111-113, page 7)

Synthesis of results

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

(Lines 224-230, page 12)

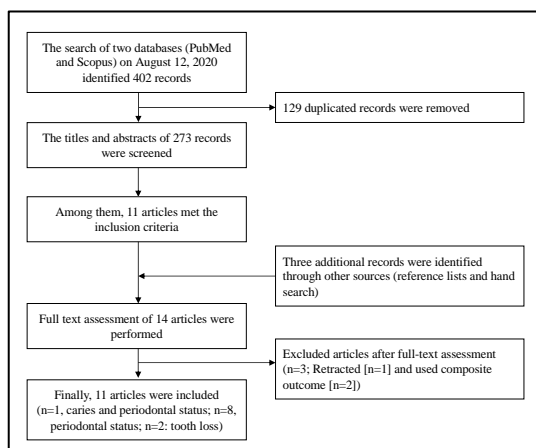
Finally, a meta-analysis could not be conducted owing to the heterogeneity of the included studies. Work stress was assessed using varied measures. Particularly, only a few studies used the current major measures of work stress. Indicators of periodontal status were also varied. No study used valid epidemiological 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.

Results

3-4. Figure 1: Perhaps it would be good to indicate in this figure that, after screening title and abstract of 273 studies, only 11 studies met the inclusion criteria. Then you can signpost the inclusion of the three additional studies identified through reference lists and hand-search.

Response:

We have modified Figure 1 following your comment.



3-5. Authors state that 'Four studies included participants who were not working adults'. However, one of those studies by Genco et al., (Ref #25) included adults aged 25 to 74 years, but it does not say

whether they were working or not. Please revise the statement and amend if necessary, after checking each of the studies.

Response:

As you pointed out, the correct expression is “working status was unknown.” We have revised Table 1 and confirmed the details of all the articles again.

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) 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) ²⁵	Cross-sectional	Brazil	Karasek job strain model	The presence or absence of teeth either with gums bleeding on probing or with pockets	164 male paid workers aged from 35 to 44 years (16 workers were excluded from 164 participants due	Mean age = 41.2 (standard deviation = 2.2) 0%	Marital quality, toothbrushing frequency, sugar consumption, age, years of residence, type of toothpaste,	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)

				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'.	to missing values and edentulous)		frequency dental attendance, and socio-economic status	Work variety: Odds ratio = 0.99 (95% confidence interval = 0.85, 1.16) 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 55.6%	Unknown	Type A behaviour: Coefficients = 0.41 (p-value=0.003) Work environment (organisation/climate): Coefficients = -0.34 (p-value = 0.007) (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 establish	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) Locus of control: Coefficients = -0.035 (p-

					ed periodont itis (13 men and 10 women)			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 Attachm ent Loss Healthy (0 to 1 mm clinical attachm ent level), low (1.1 to 2.0 mm), moderat e (2.1 to 3.0 mm), high (3.1 to 4.0 mm) and severe (4.1 to 8.0 mm)	1,426 inhabitan ts aged 25 to 74 years (741 women and 685 men) *working status was unknown	Mean age = 48.9 (standar d deviatio n = 13.9) 52.0%	Age, gender, and levels of smoking.	Job strain score among Attachment Loss categories (mean \pm standard error) Healthy: 2.12 \pm 0.05 Low: 2.09 \pm 0.02 Moderate: 2.16 \pm 0.02 High: 2.09 \pm 0.05 Severe: 2.22 \pm 0.05 (nonsignificant) From analysis of covariance Job strain score among Alveolar Bone Loss categories (mean \pm standard error) Healthy: 2.12 \pm 0.02 Low: 2.10 \pm 0.03 Moderate: 2.09 \pm 0.04 Severe: 2.19 \pm 0.04 (nonsignificant) From analysis of covariance
Akhter et al. (2005) ²⁹	Cross- sectional	Japan	Life events scale	Mean clinical attachm ent loss	1,089 employe d and unemplo	Mean age = 55.0 (standar	Age, gender, employe nt status,	Job stress (reference: No): Odds ratio = 1.71

			(yes or no)	<1.5 mm were assigned to a non-disease group and those with mean clinical attachment loss ≥ 1.5 mm were assigned to a disease group	64 residents ranging in age from 18 to 96 years of a farming village in the northern most island of Japan (531 men and 558 women)	Standard deviation = 1.7) 51.2%	smoking behaviour, stress within 1 month, self-health-related stress, family health-related stress, frequency of dental attendance, hyperlipidaemia, and diabetes mellitus	(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) 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 yes = 2.837 and no = 2.275 (p-value > 0.05)

(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 Test group 1 (n=40): at least four sites with probing pocket depth > 4mm and ≤ 6 mm 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) Sex was not reported	None	Mean Occupational Stress Index Score (standard deviation) Control: 79.53 (23.57) Test group 1: 133.68 (33.23) Test group 2: 158.13 (32.44) p-value <0.001 (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 (a tooth scored 3 or 4 indicating increased pocket depth of over 2 mm indicates presence of	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]) 15-19 years: 0%, 1% 20-29 years: 38%, 60% 30-44 years: 45%, 20% 45-64 years: 17%, 19% Sex was not	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 (low stress, High stress-High coping, and High stress-low coping) *coping was assessed using a questionnaire developed by a Japanese company	periodontitis) 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) 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) High stress-Low coping: Odds ratio = 2.79 (95% confidence interval = 1.05, 7.43) (reference: low stress) from a logistic regression analysis	
Tooth loss									
Hayashi et al. (2001) ³⁴	Cross-sectional	Japan	Karasek job strain model (high job demand and low control and other	Tooth loss via oral examination (≥ 4 teeth lost and	252 male workers employed at a manufacturing company	Mean age = 38.7 (standard deviation =	Age, type A behaviour, alexythymia, depression, job satisfaction, and life	High job demand and low control (reference: other categories): Odds ratio = 1.2 (95% confidence	

Sato et al. (2020) ³⁵	Cross-sectional	Japan	Effort-Reward Imbalance model (having or not)	Self-reported tooth loss 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)	11.0% Median age = 37 (1st and 3rd quartiles = 31 and 43) 48%	satisfaction	interval = 0.40, 3.42) from a logistic regression analysis 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
								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

3-6. Please explain the difference between ‘clinical examination’ and ‘visual inspection by dentists’ when describing the methods used to assess periodontal status in the studies included in the review.

Response:

We have clarified the difference.

(Lines 160-161, page 9)

Eight studies assessed periodontal status based on oral examination with probe, but one study was based on only visual inspection by dentists.³³

Discussion

3-7. This section of the manuscript requires extensive revision, in my opinion. Most of the text included in the current Discussion section corresponds to more detailed information about results. Please see Docherty and Smith, BMJ 1999; 318: 1224-5 for how to structure a Discussion section. As a general rule, the first paragraph of the Discussion should briefly summarize the main findings. Then, the following paragraphs should address the weaknesses of the study design and measures, etc.,

discuss how the findings support or refute previous literature, potential explanations for findings, etc. The final paragraph should tie it all together –so what? Where next? What are the implications for practice?

Response:

We agree with your comment. We have amended the results and discussion sections based on the paper you recommended.

(Lines 117-199, pages 8-11)

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]).

(Lines 209-282, page 11-14)

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.

3-8. Findings of this review showed that eight of nine studies found a significant association between work stress and periodontal status. However, the first paragraph of the Discussion sections states that 'Based on the findings of this review, evidence is lacking on the association of work stress with dental caries, periodontal status, and tooth loss'. Please explain why you included periodontal status in that statement.

Response:

We agree with your comment. We have modified the discussion and conclusion sections to convey accurate meaning.

(Lines 24-27, pages 2-3)

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.

(Lines 276-282, page 14)

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.

3-9. Besides methodological issues, it would be interesting to discuss potential reasons for the lack of a significant association found between work stress and dental caries in the only study which assessed that outcome.

Response:

As you have recommended, we have added the potential reasons for the lack of a significant association between work stress and dental caries.

(Lines 235-240, page 12)

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.

3-10. Authors mention that, due to the variety of measures used to assessed periodontal status in the studies, 'it was difficult to estimate periodontal disease prevalence'. However, estimating such prevalence was not an objective of this analysis. Please revise and amend.

Response:

We agree with your comment. We have deleted this sentence.

3-11. Please revise the use of English language throughout the text.

Response:

We apologize for the incorrect grammar and use of the English language. Our manuscript has been rechecked by an English native speaker.

VERSION 2 – REVIEW

REVIEWER	Milgrom, Peter University of Washington, Oral Health Sciences
REVIEW RETURNED	26-Mar-2021

GENERAL COMMENTS	The authors have done an excellent job of responding to the prior reviews. Please address the following: Page 7 under data extraction, line 99 should read "one author" rather than "The author". There is a similar problem in line 107. The sentence that begins at the end of line 109 makes no sense as written and needs to be revised.
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REVIEWER	Guarnizo-Herreño, Carol UCL
REVIEW RETURNED	30-Mar-2021
GENERAL COMMENTS	The authors have answered my earlier comments in a very satisfactory manner. I have no further concerns.

VERSION 2 – AUTHOR RESPONSE

Reviewer 1

2-1. Page 7 under data extraction, line 99 should read "one author" rather than "The author". There is a similar problem in line 107.

Response:

We thank you for your comments. We have changed to "one author" from "the author."

(Line 99, page 7)

One author (YuS) extracted the following information from each eligible study:

(Line 108 to 109, page 7)

For each question, one author (YuS) rated them as yes, no, or other (including cannot determine, not reported, and not applicable)

2-2. The sentence that begins at the end of line 109 makes no sense as written and needs to be revised.

Response:

We have modified this sentence.

(Lines 106 to 107, page 7)

This tool includes 14 questions for evaluating the internal validity of a study and these questions are documented in the footnote of Table 2.