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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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1 **Abstract (290/300)**

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

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

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

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

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

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

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

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6 26 periodontal status, and tooth loss. In future research, a cohort studies including the potential
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8 27 confounding factors and use of the major measures of work stress, are needed.
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12 29 **Keywords**

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14 30 systematic review, work stress, job stress, occupational stress, oral health, oral diseases
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6 31 **Strengths and limitations of this study**
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8 32 ► This is the first systematic review to evaluate and summarize the literature on the
9
10 33 association between work stress and oral conditions, including dental caries, periodontal
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12 34 status, and tooth loss.

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14 35 ► This systematic review provides a comprehensive insight into the quality of the included
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16 36 papers.

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18 37 ► The protocol of this systematic review was not registered.

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20 38 ► A meta-analysis could not be conducted because of the heterogeneity and the small
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22 39 number of included studies.
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40 INTRODUCTION

41 Oral diseases, such as dental caries and periodontal disease, still matter worldwide. The
42 Global Burden of Disease study has estimated that 2.3 billion individuals had untreated dental
43 caries, 796 million had severe periodontal disease, and 267 million had complete loss of
44 natural teeth in 2017.¹ Briefly, dental caries is the destruction of dental hard tissues in the
45 crowns and roots of the teeth.² Periodontal diseases are chronic inflammatory conditions with
46 disorders of the tissues surrounding and supporting the teeth.³ Tooth loss is mainly the
47 consequence of dental caries and periodontal disease.^{2,3} Because oral diseases result not only
48 in severe toothache, but also in eating, sleeping, and communication disabilities,^{4,5} poor oral
49 conditions can restrict work performance^{4,5} and bring about significant economic burden.⁶
50 Indeed, work productivity loss due to oral conditions is estimated at 187.61 billion US dollars
51 annually.⁶ The necessity of prevention of oral diseases for the working adults is highlighted.

52 Since the 1990s, rapid changes in the global economy and the diverse markets have
53 occurred,⁷ and psychological workplace stress has become more prevalent and severe,
54 especially among industrialized countries.⁷ Indeed, Kivimäki et al. reported 15% prevalence
55 of job strain measured using job-content and demand-control questionnaires from 13
56 European cohorts' data (1985–2006).⁸ Besides, work stress can have profound effects on
57 health. There is accumulating evidence of the risk of work stress on cancer, cardiovascular
58 diseases, diabetes, and depression.^{9,10} Béjean and Sultan-Taïeb estimated that the work-
59 related stress costs due to illnesses could be between €1,167 million and €1,975 million in
60 France in 2000.¹¹ Work stress has impacts on the workers' health and productivity.

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

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

71 **METHODS**

72 The reporting of this systematic review conforms to the Preferred Reporting Items for
73 Systematic Reviews and Meta-Analyses (PRISMA) guidelines.^{14,15} We also followed the
74 Conducting Systematic Reviews and Meta-Analyses of Observational Studies of Etiology
75 (COSMOS-E) guidance¹⁶ and the reporting of Meta-analysis Of Observational Studies in
76 Epidemiology (MOOSE).¹⁷

77 **Eligibility criteria**

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

82 **Information sources and searches**

83 On July 7, 2020, we identified potentially relevant published studies in PubMed (1966 to July
84 7, 2020) and Scopus (1966 to July 7, 2020) databases. We used the following script to obtain
85 a wide range of literatures: ("job strain" OR "effort reward") AND (dental OR oral); ("job
86 stress" OR "work stress" OR "occupational stress") AND (dental OR oral). In addition, we
87 manually hand-searched for potentially suitable studies through the reference lists of
88 identified articles and Google scholar. After the exclusion of duplicate articles, one author
89 (YuS) assessed the titles and abstracts according to the aforementioned criteria. Then, eligible

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6 90 studies were selected for the full-text review.
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8 91 **Data extraction**

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10 92 The author (YuS) extracted the following information from each eligible study: 1) name of
11 93 the first author; 2) study design; 3) study location (country); 4) number of participants and
12 94 work-related characteristics; 5) exposures and its measurements; 6) outcomes and its
13 95 measurements; 7) age range and proportion of women; 8) covariates included in the adjusted
14 96 models; and 9) the main results.
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20 97 **Quality assessment**

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22 98 We used the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies
23 99 to assess the quality of included studies.¹⁸ This tool includes 14 questions for evaluating the
24 100 internal validity of a study. For each question, the author (YuS) rated them as yes, no, or
25 101 other (including cannot determine, not reported, and not applicable). The overall quality
26 102 rating for the study was regarded as good if all the domains were assessed favorably.
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32 103 **Synthesis of results**

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34 104 A meta-analysis could not be conducted because of the heterogeneity and the small number
35 105 of included studies.
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38 106 **Patient and public involvement**

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40 107 No patient involved.
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44 109 **RESULTS**

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46 110 Figure 1 presents the flow diagram of information through the phases of the systematic
47 111 review. Of the 402 articles identified in PubMed and Scopus databases, 129 duplicated
48 112 articles were removed, the titles and abstract of 273 were screened, and 11 met the eligibility
49 113 criteria. Three more articles identified through reference lists and hand-search were added.
50 114 After full-text assessments of 14 articles, three were excluded (due to retraction [n=1]¹⁹ and
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6 115 use of composite outcomes including dental caries and periodontal status [n=2]).^{20,21} Finally,
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8 116 11 articles were included in this systematic review.^{22–32}
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117 **Study characteristics and results of individual studies**

118 Table 1 shows the 12 summaries from the 11 studies. One of eleven studies reported on dental
119 caries and periodontal status,²² eight reported on periodontal status,^{23–30} and two reported on
120 tooth loss.^{31,32} Three studies were conducted in Japan,^{26,30–32} two in India,^{28,29} and one each
121 in the UK,²⁴ the US,²⁵ Brazil,²² and Iraq.²⁷ One study did not report on the study location.²⁴
122 Among 11 studies, 9 studies were cross-sectional^{22,25–32} and the remaining 2 studies were
123 unclear; therefore, they were categorized as unknown.^{23,24} The sample size was varied from
124 10 to 1,426 among included studies. Four studies included participants who were not working
125 adults,^{24–27} two did not include women,^{22,31} and two did not report on sex.^{27,28}

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

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

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6 140 examinations, but one study based on visual inspection by dentists.³⁰ The assessment of tooth
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8 141 loss was through oral examination³¹ or self-reported.³²
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10 142 Three studies presented only descriptive statistics.^{25,27,28} Eight studies performed
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12 143 regression analyses;^{22–24,26,29–32} but two studies of them did not report the types of a regression
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14 144 modeling used.^{23,24} Only two studies sufficiently adjusted for potential confounders such as
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16 145 socioeconomic status and work-related variables.^{22,32} One study reported a nonsignificant
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18 146 association between work stress and dental caries.²² Eight of nine studies reported a
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20 147 significant association between work stress and worse periodontal status.^{22–30} Two studies
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22 148 reported on association between work stress and tooth loss, but only one reported a significant
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24 149 association.^{31,32}
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26 150 **Study quality**

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28 151 Table 2 presents the results of the quality assessments for each study. Eight studies (73%)
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30 152 had poor quality while three (27%) were rated as fair. None of the studies addressed question
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32 153 6 (“For the analyses in this paper, were the exposure(s) of interest measured prior to the
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34 154 outcome(s) being measured?”); 7 (“Was the timeframe sufficient so that one could
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36 155 reasonably expect to see an association between exposure and outcome if it existed?”); and
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38 156 10 (“Was the exposure(s) assessed more than once over time?”); because all the studies were
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40 157 cross-sectional or the study design was unclear.
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42 158 **DISCUSSIONS**

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44 159 This is the first systematic review to evaluate and summarize the existing literatures on the
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46 160 associations between work stress and oral conditions. Based on the findings of this review,
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48 161 evidence is lacking on the association of work stress with dental caries, periodontal status,
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50 162 and tooth loss. As our findings showed, only one study reported on dental caries and
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52 163 periodontal status, eight reported on periodontal status, and two on tooth loss. The quality of
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54 164 the 11 studies were either fair (n=3) or poor (n=8). Only two studies sufficiently adjusted for
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6 165 potential confounders.^{22,32} One study reported a non-significant association between work
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8 166 stress and dental caries.²² Eight of nine studies reported the significant association between
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10 167 work stress and worse periodontal status.²²⁻³⁰ One of two studies reported a significant
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12 168 association between work stress and tooth loss.^{31,32} We could not conduct a meta-analysis
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14 169 due to the small number of included studies and varied outcomes and exposure variables. In
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16 170 particular, only 3 of 11 studies assessed work stress using the current major measures such
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18 171 as the Job Demand-Control Model and the Effort-Reward Imbalance Model.^{22,31,32}

172 **Dental caries and work stress**

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

186 **Periodontal status and works stress**

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

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6 190 definitions for periodontitis;^{34,35} but as previous studies pointed, the definition of periodontal
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8 191 disease has been numerous and lacked the consensus.³⁶ Thus, it was difficult to estimate
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10 192 periodontal disease prevalence.³⁷ None of the included studies used the accepted
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12 193 epidemiological definition of periodontal disease. In addition to the above limitation, how
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14 194 work stress was measured also varied across studies. Each measure assessed different
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16 195 dimensions of work stress.³⁸ Due to the heterogeneity of exposures and outcomes, we could
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18 196 not conduct a meta-analysis.

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20 197 The quality of most studies was poor. The study design was unclear in two.^{23,24}
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22 198 Freeman and Goss assessed work stress and periodontal status over a 12-month period.²³
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24 199 However, they did not clearly report when work stress and periodontal status variables were
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26 200 assessed and how they were used in the statistical models. Besides, the type of regression
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28 201 model could not be identified. Linden et al. followed-up patients for 5.5 years,²⁴ but work
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30 202 stress was only assessed at follow-up examination, not at baseline survey. In addition, the
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32 203 study included patients with moderate or established periodontitis, and the type of regression
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34 204 model could not be identified. Three studies presented only descriptive statistics.^{25,27,28} The
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36 205 remaining four papers reported significant associations following regression
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38 206 analyses.^{22,26,29,30} However, Akhter et al. did not use a questionnaire specific to work stress
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40 207 and included also nonworking adults.²⁶ Islam et al. used the Brief Job Stress Questionnaire
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42 208 developed by referring to the demand-control-support model in Japan and, periodontal status
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44 209 was assessed based on the visual inspection by dentists.³⁰ Important potential confounders
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46 210 such as socioeconomic status and work-related variables were not included. Ramji assessed
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48 211 work stress using a single job stress question and did not adjust for covariates in the statistical
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50 212 models.²⁹ Therefore, only one study was assessed as fair.^{22,30} Marcenes and Sheiham assessed
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52 213 the association between periodontal status and work stress.²² Periodontal status was assessed
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54 214 by the presence or absence of gums bleeding on probing, or with pockets. They divided them

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6 215 into groups based on "complete absence of teeth with gums bleeding on probing and with
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8 216 pockets," or "presence of any tooth with gums bleeding on probing or pockets," and defined
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10 217 the latter as those with periodontal disease. After adjusting for covariates, one-point increases
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12 218 in work mental demand scores, work control scores, and work variety scores were associated
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14 219 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,
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16 220 1.16) , respectively, for having periodontal disease, in a logistic regression model. A further
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18 221 cohort study, using the validated definitions of periodontal disease, including the potential
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20 222 confounding factors, and current major measurements of work stress should be performed.

223 **Tooth loss and work stress**

224 Two studies were identified on the association between work stress and tooth loss. One of
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26 225 the two reported a significant association between work stress and tooth loss.^{31,32} Hayashi et
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28 226 al. reported the association between work stress, assessed using the Karasek job strain model,
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30 227 and tooth loss.³¹ A total of 322 male workers employed at a manufacturing company were
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32 228 included. They dichotomized the number of tooth loss into ≤ 3 and ≥ 4 . After adjusting for
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34 229 covariates, high job demand and low control conditions were associated with high odds of
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36 230 having ≥ 4 teeth loss but not significant (OR = 1.2 [95% CI = 0.40, 3.42]). This study did not
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38 231 adjust for the important potential confounders. Sato et al. reported the association between
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40 232 work stress, assessed using the effort–reward imbalance model, and self-reported tooth loss.³²
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42 233 After adjusting for covariates including socioeconomic status and work-related variables, a
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44 234 high effort-reward imbalance ratio was significantly associated with a high prevalence of ≥ 1
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46 235 tooth loss (prevalence ratio = 1.20 [95% CI = 1.01, 1.42]). A further study should include a
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48 236 cohort design and potential confounding factors.

237 **Conclusions**

238 Based on the findings, this systematic review suggests a lack of evidence on the association
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54 239 of work stress with dental caries, periodontal status, and tooth loss. For future research, well-

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6 240 designed cohort studies including potential confounding factors and the use of generally
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8 241 accepted measurements of work stress are needed.
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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.

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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 Type A behavior: Coefficients = 0.41 (p-value=0.003)
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	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)

1					established periodontitis				Locus of control: Coefficients = -
2					(13 men and 10				0,035 (p-value ≥ 0.05)
3					women)				(statistical model was not
4									reported)
5									Job strain score among
6									Attachment Loss categories
7									(mean ± standard error)
8				Severity of Attachment Loss					Healthy: 2.12 ± 0.05
9				Healthy (0 to 1 mm clinical					Low: 2.09 ± 0.02
10				attachment level), low (1.1 to 2.0					Moderate: 2.16 ± 0.02
11				mm), moderate (2.1 to 3.0 mm),					High: 2.09 ± 0.05
12	Genco et al.	Cross-	US	Problems of	1,426 inhabitants aged	Mean age =			Severe: 2.22 ± 0.05
13	(1999) ²⁵	sectional		Everyday Living	25 to 74 years (741	48.9 (standard		Age, gender, and levels of	From analysis of covariance
14				Scale of Pearlin and	women and 685 men)	deviation =			
15				Schooler		13.9)			
16				Severity of Alveolar Bone Loss		52.0%			Job strain score among Alveolar
17				Healthy (0.4 to 1.9 mm alveolar					Bone Loss categories (mean ±
18				crestal height), low (2.0 to 2.9 mm),					standard error)
19				moderate (3.0 to 3.9 mm), and					Healthy: 2.12 ± 0.02
20				severe (≥4.0 mm)					Low: 2.10 ± 0.03
21									Moderate: 2.09 ± 0.04
22									Severe: 2.19 ± 0.04
23									From analysis of covariance
24					1,089 residents ranging			Age, gender, employment	
25	Akhter et al.	Cross-	Japan	Life events scale	in age from 18 to	Mean age =		status, smoking behavior,	Job stress (reference: No): Odds
26	(2005) ²⁶	sectional		(yes or no)	96years of a farming	55.0 (standard		stress within 1 month, self-	ratio = 1.71 (95% confidence
27					village in the	deviation = 1.7)		health-related stress, family	interval = 1.10, 2.67) from a
28					northernmost island of	51.2%		health-related stress,	logistic regression analysis
29					Japan (531 men and			frequency of dental	
30					558 women)			attendance, hyperlipidemia,	
31								and diabetes mellitus	
32									The mean gingival index
33									yes = 1.851 and no = 1.586 (p-
34									value > 0.05)
35	Talib Bandar	Cross-	Iraq	Life events scale	64 patients of both				Total mean percentage of sites
36	(2009) ²⁷	sectional		(yes or no)	genders with ages	Not reported	None		with probing pocket depth ≥ 4
37					ranging from 23 to 65				mm
38					years				yes = 6.277% and no = 4.762%
39									(p-values <0.05)
40									Total mean Bleeding On Probing
41									yes = 41.534% and no =
42									32.137% (p-value > 0.05)
43									The mean of the clinical

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									attachment level yes = 2.837 and no = 2.275 (p-value > 0.05) (p-values from t-test) 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)
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 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 was around 40 years. Sex was not reported.	None		
Ramji, (2011) ²⁹	Cross-sectional	India	Self-reported job stress from one question (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 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]) 15-19 years 0%, 1% 20-29 years 38%, 60% 30-44 years 45%, 20% 45-64 years 17%, 19% 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 (low stress, High stress-High coping, and High stress-low coping) *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) 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	

1				Karasek job strain model					
2	Hayashi et al.	Cross-sectional	Japan	(high job demand and low control and other categories)	Tooth loss via oral examination (≥ 4 teeth lost and $3 \leq$ teeth lost)	252 male workers employed at a manufacturing company aged 20–59 years	Mean age = 38.7 (standard deviation = 11.0) 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)
3	(2001) ³¹								
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8	Sato et al.	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)	Median age = 37 (1st and 3rd quartiles = 31 and 43) 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
9	(2020) ³²								
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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

1 exposure, or exposure measured as continuous variable)?

2
3 Q9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?

4
5 Q10. Was the exposure(s) assessed more than once over time?

6
7 Q11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?

8
9 Q12. Were the outcome assessors blinded to the exposure status of participants?

10
11 Q13. Was loss to follow-up after baseline 20% or less?

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

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

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The search of two databases (PubMed and Scopus) on July 7, 2020 identified 402 records

129 duplicated records were removed

The titles and abstracts of 273 records were screened

Three additional records were identified through other sources (reference lists and hand search)

Full text assessment of 14 articles were performed

Excluded articles after full-text assessment (n=3; Retracted [n=1] and used composite outcome [n=2])

Finally, 11 articles were included (n=1, caries and periodontal status; n=8, periodontal status; n=2, tooth loss)



PRISMA 2009 Checklist

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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

Page 1 of 2

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
Page 1 of 2			
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			
For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml			



PRISMA 2009 Checklist

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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
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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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Page 2 of 2

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BMJ Open

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

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-046532.R1
Article Type:	Original research
Date Submitted by the Author:	24-Mar-2021
Complete List of Authors:	Sato, Yukihiro; Asahikawa Medical University, Division of Public Health and Epidemiology, Department of Social Medicine Saijo, Yasuaki; Asahikawa Medical University, Division of Public Health and Epidemiology, Department of Social Medicine Yoshioka, Eiji ; Asahikawa Medical University, Division of Public Health and Epidemiology, Department of Social Medicine
Primary Subject Heading:	Occupational and environmental medicine
Secondary Subject Heading:	Dentistry and oral medicine
Keywords:	OCCUPATIONAL & INDUSTRIAL MEDICINE, SOCIAL MEDICINE, EPIDEMIOLOGY

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Title

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

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2,881 words

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1 **Abstract (300/300)**

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

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

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

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

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

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

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

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6 26 work stress. Cohort studies using the major work stress measures and adjusting for the
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8 27 potential confounders are needed.
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12 29 **Keywords**

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14 30 systematic review, work stress, job stress, occupational stress, oral health, oral diseases
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For peer review only

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6 31 **Strengths and limitations of this study**
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8 32 ► This is the first systematic review to evaluate and summarise the literature on the
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10 33 association between work stress and oral conditions, including dental caries, periodontal
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12 34 status, and tooth loss.

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14 35 ► This systematic review provides a comprehensive insight into the quality of the included
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16 36 papers.

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18 37 ► The systematic literature search, screening, and quality assessments were conducted by
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20 38 only one investigator.

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22 39 ► A meta-analysis could not be conducted because of the heterogeneity of work stress
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24 40 measures and outcome definitions.
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41 INTRODUCTION

42 Oral diseases, such as dental caries and periodontal disease, are a major health concern
43 worldwide. The Global Burden of Disease study has estimated that 2.3 billion individuals
44 had untreated dental caries, 796 million had severe periodontal disease, and 267 million had
45 a complete loss of natural teeth in 2017.¹ Dental caries is the destruction of dental hard tissues
46 in the crowns and roots of the teeth.² Periodontal diseases are chronic inflammatory
47 conditions with disorders of the tissues surrounding and supporting the teeth.³ Tooth loss is
48 mainly the consequence of dental caries and periodontal disease.^{2,3} Because oral diseases
49 result in severe toothache and eating, sleeping, and communication disabilities,^{4,5} poor oral
50 conditions can restrict work performance^{4,5} and create a significant economic burden.⁶ Indeed,
51 work productivity loss due to oral conditions is estimated at 187.61 billion US dollars
52 annually.⁶ The necessity of preventing oral diseases for working adults is highlighted.

53 Since the 1990s, rapid changes in the global economy and the diverse markets have
54 occurred, and psychological workplace stress has become more prevalent and severe,
55 especially among industrialised countries.⁷ Indeed, Kivimäki et al. reported a 15% prevalence
56 of job strain measured using job-content and demand-control questionnaires from 13
57 European cohorts' data (1985–2006).⁸ Besides, work stress can have profound effects on
58 health. There is accumulating evidence of the risk of work stress on cancer, cardiovascular
59 diseases, diabetes, and depression.^{9,10} Béjean and Sultan-Taïeb estimated that the work-
60 related stress costs due to illnesses could range between €1,167 million and €1,975 million
61 in France in 2000.¹¹ Work stress affects workers' health and productivity.

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

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6 66 reviews suggested potential associations of psychological stress with dental caries and
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8 67 periodontitis.^{14,15} However, there seems to be no review on the association between work
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10 68 stress and oral diseases. Today, work stress has become an increasingly serious problem.
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12 69 Besides, the number of women in the workforce and dual-earner families have been
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14 70 increasing.¹⁶ A wide range of populations can suffer the risk of oral diseases from exposure
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16 71 to work stress. Thus, the aim of this systematic review was to evaluate and summarise the
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18 72 literature on the association between work stress and oral conditions, including dental caries,
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20 73 periodontal status, and tooth loss. We set the following review question: Is work stress
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22 74 associated with dental caries, periodontal status, and tooth loss among working adults?
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76 **METHODS**

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28 77 The reporting of this systematic review conforms to the Preferred Reporting Items for
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30 78 Systematic Reviews and Meta-Analyses (PRISMA) guidelines.^{17,18} We also followed the
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32 79 Conducting Systematic Reviews and Meta-Analyses of Observational Studies of Etiology
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34 80 (COSMOS-E) guidance¹⁹ and the reporting of Meta-analysis Of Observational Studies in
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36 81 Epidemiology (MOOSE).²⁰ The protocol of this systematic review was not registered.

38 **Eligibility criteria**

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40 83 Published studies were eligible if they: 1) were published in English; 2) were epidemiological
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42 84 studies on humans (except case studies, reviews, letters, commentaries, and editorials); and
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44 85 3) examined the association of work stress with dental caries, periodontal status, and tooth
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46 86 loss.

48 **Information sources and searches**

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50 88 On August 12, 2020, we identified potentially relevant published studies in PubMed (1966
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52 89 to August 12, 2020) and Scopus (1966 to August 12, 2020) databases. As PubMed and
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54 90 Scopus have only data back to 1966, we focused on articles published after 1966. We used
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6 91 the following script to obtain a wide range of literature: ("job strain" OR "effort reward")
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8 92 AND (dental OR oral); ("job stress" OR "work stress" OR "occupational stress") AND
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10 93 (dental OR oral). The details of the search strategies for each database are shown in
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12 94 Supplemental Table 1. Besides, we manually hand-searched for potentially suitable studies
13
14 95 through the reference lists of identified articles and Google scholar. After excluding duplicate
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16 96 articles, one author (YuS) assessed the titles and abstracts according to the aforementioned
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18 97 criteria. Then, eligible studies were selected for the full-text review.

98 **Data extraction**

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

104 **Quality assessment**

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

111 **Synthesis of results**

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

114 **Patient and public involvement**

115 No patient involved.

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117 RESULTS

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

125 Study characteristics of individual studies

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

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

140 Three studies presented only descriptive statistics.^{28,30,31} Eight studies performed

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6 141 regression analyses;^{25–27,29,32–35} but two of the eight studies did not report the types of a
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8 142 regression modeling used.^{26,27} Only two studies sufficiently adjusted for potential
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10 143 confounders such as socioeconomic status and work-related variables.^{25,35}

144 **Dental caries and work stress**

145 One study reported the cross-sectional association between work stress and dental caries,
146 which included 164 paid male workers aged 35 to 44 years in Brazil.²⁵ Work stress was
147 assessed according to the Karasek job strain model.³⁶ Dental caries status was assessed using
148 the DMFS index (the number of decayed [D], missing [M], and filled [F] teeth surfaces per
149 person). After adjusting for covariates, one-point increases in the work mental demand, work
150 control, and work variety scores were associated with 0.19 (95% confidence interval [CI] =
151 -0.91, 1.29), 0.87 (95% CI = -0.18, 1.91), and -0.06 (95% CI = -1.57, 1.45) increases in the
152 DMFS index, respectively, in a multivariable regression analysis. Consequently, this study
153 reported a nonsignificant association between work stress and dental caries.²⁵

154 **Periodontal status and work stress**

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

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

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6 166 Linden et al. followed-up patients for 5.5 years, but work stress was only assessed at the
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8 167 follow-up examination, not at the baseline survey.²⁷
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10 168 Among the remaining seven studies, after excluding the above two studies, three
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12 169 studies presented only descriptive statistics.^{28,30,31} The remaining four papers reported
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14 170 significant associations following regression analyses.^{25,29,32,33} However, Akhter et al. used
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16 171 general stress questions not specific to work stress and included nonworking adults.²⁹ Islam
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18 172 et al. used the Brief Job Stress Questionnaire derived from the demand-control-support model
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20 173 in Japan, and periodontal status was assessed based on the visual inspection by dentists.³³
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22 174 Important potential confounders such as socioeconomic status and work-related variables,
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24 175 were not included. Ramji assessed work stress using a single job stress question and did not
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26 176 adjust for covariates in the statistical models.³² Marcenes and Sheiham reported a significant
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28 177 association between periodontal status and work stress.²⁵ Periodontal status was assessed by
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30 178 the presence or absence of gums bleeding on probing or with pockets. The authors divided
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32 179 periodontal measures into groups based on “complete absence of teeth with gums bleeding
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34 180 on probing and with pockets,” or “the presence of any tooth with gums bleeding on probing
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36 181 or pockets,” and defined the latter as those with periodontal disease. After adjusting for
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38 182 covariates, one-point increases in work mental demand scores, work control scores, and work
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40 183 variety scores were associated with ORs of 1.22 (95%CI = 1.06, 1.37), 0.97 (95%CI = 0.88,
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42 184 1.07), and 0.99 (95%CI = 0.85, 1.16), respectively, for having periodontal disease, in a
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44 185 logistic regression model.

45 46 186 **Tooth loss and work stress**

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48 187 Two studies on the association between work stress and tooth loss were identified. One of
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50 188 the two reported a significant association between work stress and tooth loss.^{34,35} Hayashi et
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52 189 al. reported the association between work stress, assessed using the Karasek job strain model,
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54 190 and tooth loss.³⁴ A total of 322 male workers employed at a manufacturing company were
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6 191 included. They dichotomised the number of tooth loss into ≤ 3 and ≥ 4 . After adjusting for
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8 192 covariates, high job demand and low control conditions were associated with high odds of
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10 193 having ≥ 4 teeth loss but not significant (OR = 1.2 [95% CI = 0.40, 3.42]). This study did not
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12 194 adjust for the important potential confounders such as socioeconomic status and work-related
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14 195 variables. Sato et al. reported the association between work stress, assessed using the effort-
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16 196 reward imbalance model, and self-reported tooth loss.³⁵ After adjusting for covariates
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18 197 including socioeconomic status and work-related variables, a high effort-reward imbalance
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20 198 ratio was significantly associated with a high prevalence of ≥ 1 tooth loss (prevalence ratio =
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22 199 1.20 [95% CI = 1.01, 1.42]).

24 200 **Study quality**

26 201 Table 2 presents the results of the quality assessments for each study. Eight studies (73%)
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28 202 had poor quality, while three (27%) were rated as fair. None of the studies addressed question
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30 203 6 (“For the analyses in this paper, were the exposure(s) of interest measured prior to the
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32 204 outcome(s) being measured?”); 7 (“Was the timeframe sufficient so that one could
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34 205 reasonably expect to see an association between exposure and outcome if it existed?”); and
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36 206 10 (“Was the exposure(s) assessed more than once over time?”); because all the studies were
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38 207 cross-sectional or the study design was unclear.

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42 209 **DISCUSSION**

44 210 This is the first systematic review to evaluate and summarise the existing literature on the
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46 211 associations between work stress and oral conditions. As our findings showed, only one study
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48 212 reported on dental caries and periodontal status, nine on periodontal status, and two on tooth
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50 213 loss. Based on the findings of this review, the evidence is lacking on the association of work
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52 214 stress with dental caries and tooth loss. Eight of nine studies reported the significant
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54 215 associations between multiple periodontal measures and work stress.

216 **Limitations of the review**

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

231 **Dental caries and work stress**

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

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6 241 prospective associations. Considering the above limitations, it was difficult to determine
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8 242 whether work stress is associated with dental caries. A further study should include a cohort
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10 243 design and a relatively large sample size with appropriate work stress measures.

11 244 **Periodontal status and work stress**

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14 245 Nine studies reported on the association between work stress and periodontal status.²⁵⁻³³
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16 246 However, the outcome measures were varied across the included studies. Although there are
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18 247 the accepted epidemiological definitions of periodontitis according to the European
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20 248 Workshop in Periodontology and the Centers for Disease Control/American Academy of
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22 249 Periodontology,^{40,41} there was no study that used the definitions. It means that the included
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24 250 studies reported the associations between work stress and periodontal measures, not
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26 251 periodontal disease. In addition, the measurement of work stress was measured also varied
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28 252 across studies. Each measure assessed different dimensions of work stress.⁴² Due to the
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30 253 heterogeneity of exposures and outcomes, we could not conduct a meta-analysis.

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32 254 Of the nine studies, only one study adjusted for the potential confounders, such as
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34 255 socioeconomic status and work-related variables.²⁵ Besides, no cohort study was found. The
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36 256 failure to adjust for the confounders and consider the induction time weakens the research
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38 257 evidence. However, despite the above limitations, the consistent association between work
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40 258 stress and worse periodontal status is noteworthy. To verify the current results, a further
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42 259 cohort study using the validated definitions of periodontal disease and current measurements
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44 260 of work stress, in addition to adjusting for the potential confounders should be performed.

45 261 **Tooth loss and work stress**

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48 262 Two studies on the association between work stress and tooth loss were identified. Hayashi's
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50 263 study included only male workers employed at one manufacturing company.³⁴ In contrast,
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52 264 Sato's study included active workers sampled from a general population.³⁵ However, the
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54 265 response rate was relatively low (32%). The generalisability of both studies could be limited.

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6 266 The two studies had different cut-off points of tooth loss. Hayashi's study used the
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8 267 cut-off point of more than 4 teeth lost. The cutoff point is higher than the mean number of
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10 268 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,
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12 269 respectively) reported by the national statistical surveys.⁴³ This study targeted severe cases
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14 270 only. In Sato's study, the outcome was the loss of at least more than one tooth. However, this
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16 271 outcome relied on self-reported answers; therefore, self-reported bias might exist.

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18 272 Both studies showed an increased risk of tooth loss, although only one of the two
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20 273 studies reported a significant association between work stress and tooth loss. However, due
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22 274 to the above limitations, it is difficult to derive any form of conclusion. In the future, a cohort
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24 275 study including general workers should be conducted to confirm these findings.

26 276 **Conclusions**

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28 277 Based on the findings, this systematic review suggests a lack of evidence on the association
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30 278 of work stress with dental caries and tooth loss. Although eight of the nine studies reported
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32 279 significant associations between multiple periodontal measures and work stress, no study
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34 280 used valid epidemiological definitions of periodontal disease. For future research, well-
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36 281 designed cohort studies including potential confounding factors and the use of generally
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38 282 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) 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 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) 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 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)
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	Job satisfaction: Coefficients = -0.014 (p-value < 0.01) Type A: Coefficients = 0.026 (p-value < 0.05)
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) 43.5%	Age and social class of the household	

established periodontitis
(13 men and 10 women)

Locus of control: Coefficients =
-0.035 (p-value \geq 0.05)
(statistical model was not
reported)

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

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)
52.0%

Age, gender, and levels of
smoking.

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 (\geq 4.0 mm)

Problems of
Everyday Living
Scale of Pearlin and
Schooler

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)
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

Mean clinical attachment loss
<1.5 mm were assigned to a non-
diseased group and those with
mean clinical attachment loss \geq 1.5
mm were assigned to a diseased
group

Life events scale
(yes or no)

Job stress (reference: No): Odds
ratio = 1.71 (95% confidence
interval = 1.10, 2.67) from a
logistic regression analysis

The mean gingival index
yes = 1.851 and no = 1.586 (p-
value > 0.05)

64 working dental
patients of both genders
with ages ranging from
23 to 65 years

Mean age and sex
were not reported.

None

Gingival Index, probing pocket
depth, bleeding on probing, and
clinical attachment level

Life events scale
(yes or no)

Total mean percentage of sites
with probing pocket depth \geq 4
mm
yes = 6.277% and no = 4.762%
(p-values <0.05)

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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)

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)

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. 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 reported.	None
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 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	15-19 years: 0%, 1% 20-29 years: 38%, 60% 30-44 years: 45%, 20% 45-64 years: 17%, 19% Sex was not reported.	None
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,	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

1 and High stress-low
2 coping)
3 *coping was
4 assessed using a
5 questionnaire
6 developed by a
7 Japanese company

8 **Tooth loss**

9									
10	Hayashi et al.	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 $3 \leq$ teeth lost)	252 male workers employed at a manufacturing company aged 20–59 years	Mean age = 38.7 (standard deviation = 11.0) 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
11	(2001) ³⁴								
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16	Sato et al.	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)	Median age = 37 (1st and 3rd quartiles = 31 and 43) 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
17	(2020) ³⁵								
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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

1 exposure, or exposure measured as continuous variable)?

2
3 Q9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?

4
5 Q10. Was the exposure(s) assessed more than once over time?

6
7 Q11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?

8
9 Q12. Were the outcome assessors blinded to the exposure status of participants?

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

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13 Q14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and
14 outcome(s)?
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1 Figure 1. Flow of search strategy and selection of studies for a systematic review.
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1 The search of two databases (PubMed
2 and Scopus) on August 12, 2020
3 identified 402 records

4
5 129 duplicated records were removed

6
7 The titles and abstracts of 273 records
8 were screened
9

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12
13 Among them, 11 articles met the
14 inclusion criteria
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18 Three additional records were identified
19 through other sources (reference lists and hand
20 search)
21

22
23 Full text assessment of 14 articles were
24 performed
25

26
27 Excluded articles after full-text assessment
28 (n=3; Retracted [n=1] and used composite
29 outcome [n=2])
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31 Finally, 11 articles were included
32 (n=1, caries and periodontal status; n=8,
33 periodontal status, n=2: tooth loss)
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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

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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:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-046532.R2
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Primary Subject Heading:	Occupational and environmental medicine
Secondary Subject Heading:	Dentistry and oral medicine
Keywords:	OCCUPATIONAL & INDUSTRIAL MEDICINE, SOCIAL MEDICINE, EPIDEMIOLOGY

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Title

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

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1 **Abstract (300/300)**

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

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

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

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

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

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

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

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6 26 work stress. Cohort studies using the major work stress measures and adjusting for the
7
8 27 potential confounders are needed.
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10 28

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12 29 **Keywords**

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14 30 systematic review, work stress, job stress, occupational stress, oral health, oral diseases
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6 31 **Strengths and limitations of this study**
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8 32 ► This is the first systematic review to evaluate and summarise the literature on the
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10 33 association between work stress and oral conditions, including dental caries, periodontal
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12 34 status, and tooth loss.

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14 35 ► This systematic review provides a comprehensive insight into the quality of the included
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16 36 papers.

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18 37 ► The systematic literature search, screening, and quality assessments were conducted by
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20 38 only one investigator.

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22 39 ► A meta-analysis could not be conducted because of the heterogeneity of work stress
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24 40 measures and outcome definitions.
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41 INTRODUCTION

42 Oral diseases, such as dental caries and periodontal disease, are a major health concern
43 worldwide. The Global Burden of Disease study has estimated that 2.3 billion individuals
44 had untreated dental caries, 796 million had severe periodontal disease, and 267 million had
45 a complete loss of natural teeth in 2017.¹ Dental caries is the destruction of dental hard tissues
46 in the crowns and roots of the teeth.² Periodontal diseases are chronic inflammatory
47 conditions with disorders of the tissues surrounding and supporting the teeth.³ Tooth loss is
48 mainly the consequence of dental caries and periodontal disease.^{2,3} Because oral diseases
49 result in severe toothache and eating, sleeping, and communication disabilities,^{4,5} poor oral
50 conditions can restrict work performance^{4,5} and create a significant economic burden.⁶ Indeed,
51 work productivity loss due to oral conditions is estimated at 187.61 billion US dollars
52 annually.⁶ The necessity of preventing oral diseases for working adults is highlighted.

53 Since the 1990s, rapid changes in the global economy and the diverse markets have
54 occurred, and psychological workplace stress has become more prevalent and severe,
55 especially among industrialised countries.⁷ Indeed, Kivimäki et al. reported a 15% prevalence
56 of job strain measured using job-content and demand-control questionnaires from 13
57 European cohorts' data (1985–2006).⁸ Besides, work stress can have profound effects on
58 health. There is accumulating evidence of the risk of work stress on cancer, cardiovascular
59 diseases, diabetes, and depression.^{9,10} Béjean and Sultan-Taïeb estimated that the work-
60 related stress costs due to illnesses could range between €1,167 million and €1,975 million
61 in France in 2000.¹¹ Work stress affects workers' health and productivity.

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

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6 66 reviews suggested potential associations of psychological stress with dental caries and
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8 67 periodontitis.^{14,15} However, there seems to be no review on the association between work
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10 68 stress and oral diseases. Today, work stress has become an increasingly serious problem.
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12 69 Besides, the number of women in the workforce and dual-earner families have been
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14 70 increasing.¹⁶ A wide range of populations can suffer the risk of oral diseases from exposure
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16 71 to work stress. Thus, the aim of this systematic review was to evaluate and summarise the
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18 72 literature on the association between work stress and oral conditions, including dental caries,
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20 73 periodontal status, and tooth loss. We set the following review question: Is work stress
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22 74 associated with dental caries, periodontal status, and tooth loss among working adults?
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26 76 **METHODS**

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28 77 The reporting of this systematic review conforms to the Preferred Reporting Items for
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30 78 Systematic Reviews and Meta-Analyses (PRISMA) guidelines.^{17,18} We also followed the
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32 79 Conducting Systematic Reviews and Meta-Analyses of Observational Studies of Etiology
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34 80 (COSMOS-E) guidance¹⁹ and the reporting of Meta-analysis Of Observational Studies in
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36 81 Epidemiology (MOOSE).²⁰ The protocol of this systematic review was not registered.

38 82 **Eligibility criteria**

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40 83 Published studies were eligible if they: 1) were published in English; 2) were epidemiological
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42 84 studies on humans (except case studies, reviews, letters, commentaries, and editorials); and
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44 85 3) examined the association of work stress with dental caries, periodontal status, and tooth
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46 86 loss.

48 87 **Information sources and searches**

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50 88 On August 12, 2020, we identified potentially relevant published studies in PubMed (1966
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52 89 to August 12, 2020) and Scopus (1966 to August 12, 2020) databases. As PubMed and
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54 90 Scopus have only data back to 1966, we focused on articles published after 1966. We used
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6 91 the following script to obtain a wide range of literature: ("job strain" OR "effort reward")
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8 92 AND (dental OR oral); ("job stress" OR "work stress" OR "occupational stress") AND
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10 93 (dental OR oral). The details of the search strategies for each database are shown in
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12 94 Supplemental Table 1. Besides, we manually hand-searched for potentially suitable studies
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14 95 through the reference lists of identified articles and Google scholar. After excluding duplicate
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16 96 articles, one author (YuS) assessed the titles and abstracts according to the aforementioned
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18 97 criteria. Then, eligible studies were selected for the full-text review.

98 **Data extraction**

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

104 **Quality assessment**

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

111 **Synthesis of results**

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

114 **Patient and public involvement**

115 No patient involved.

116

117 **RESULTS**

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

127 **Study characteristics of individual studies**

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

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

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6 141 by Pearlin and Schooler.³⁰

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8 142 Three studies presented only descriptive statistics.^{22,30,32} Eight studies performed
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10 143 regression analyses,^{23,24,28,29,31,33–35} but two of the eight studies did not report the types of a
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12 144 regression modeling used.^{24,29} Only two studies sufficiently adjusted for potential
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14 145 confounders such as socioeconomic status and work-related variables.^{28,35}

16 146 **Dental caries and work stress**

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18 147 One study reported the cross-sectional association between work stress and dental caries,
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20 148 which included 164 paid male workers aged 35 to 44 years in Brazil.²⁸ Work stress was
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22 149 assessed according to the Karasek job strain model.³⁶ Dental caries status was assessed using
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24 150 the DMFS index (the number of decayed [D], missing [M], and filled [F] teeth surfaces per
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26 151 person). After adjusting for covariates, one-point increases in the work mental demand, work
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28 152 control, and work variety scores were associated with 0.19 (95% confidence interval [CI] =
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30 153 -0.91, 1.29), 0.87 (95% CI = -0.18, 1.91), and -0.06 (95% CI = -1.57, 1.45) increases in the
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32 154 DMFS index, respectively, in a multivariable regression analysis. Consequently, this study
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34 155 reported a nonsignificant association between work stress and dental caries.²⁸

36 156 **Periodontal status and work stress**

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38 157 Eight of nine studies reported a significant association between work stress and worse
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40 158 periodontal status.^{22–24,28–33} The measurements of periodontal status varied across the
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42 159 included studies. The measurements included probing pocket depth,^{22,24,32} clinical attachment
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44 160 level,^{22,29,30} alveolar bone loss,³⁰ gingival index,²² bleeding on probing,²² the Community
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46 161 Periodontal Index and Treatment Needs protocol,²³ and a composite outcome, including these
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48 162 measures.^{28,33} Eight studies assessed periodontal status based on oral examination with probe,
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50 163 but one study was based on only visual inspection by dentists.³³

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52 164 Among the nine studies, two studies had unclear methodology; therefore, they were
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54 165 categorised as unknown.^{24,29} Freeman and Goss assessed work stress and periodontal status

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6 166 over a 12-month period.²⁴ However, they did not clearly report when work stress and
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8 167 periodontal status variables were assessed and how they were used in the statistical models.
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10 168 Linden et al. followed-up patients for 5.5 years, but work stress was only assessed at the
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12 169 follow-up examination, not at the baseline survey.²⁹
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14 170 Among the remaining seven studies, after excluding the above two studies, three
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16 171 studies presented only descriptive statistics.^{22,30,32} The remaining four papers reported
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18 172 significant associations following regression analyses.^{23,28,31,33} However, Akhter et al. used
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20 173 general stress questions not specific to work stress and included nonworking adults.³¹ Islam
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22 174 et al. used the Brief Job Stress Questionnaire derived from the demand-control-support model
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24 175 in Japan, and periodontal status was assessed based on the visual inspection by dentists.³³
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26 176 Important potential confounders such as socioeconomic status and work-related variables,
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28 177 were not included. Ramji assessed work stress using a single job stress question and did not
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30 178 adjust for covariates in the statistical models.²³ Marcenes and Sheiham reported a significant
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32 179 association between periodontal status and work stress.²⁸ Periodontal status was assessed by
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34 180 the presence or absence of gums bleeding on probing or with pockets. The authors divided
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36 181 periodontal measures into groups based on “complete absence of teeth with gums bleeding
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38 182 on probing and with pockets,” or “the presence of any tooth with gums bleeding on probing
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40 183 or pockets,” and defined the latter as those with periodontal disease. After adjusting for
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42 184 covariates, one-point increases in work mental demand scores, work control scores, and work
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44 185 variety scores were associated with ORs of 1.22 (95%CI = 1.06, 1.37), 0.97 (95%CI = 0.88,
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46 186 1.07), and 0.99 (95%CI = 0.85, 1.16), respectively, for having periodontal disease, in a
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48 187 logistic regression model.
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50 188 **Tooth loss and work stress**

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52 189 Two studies on the association between work stress and tooth loss were identified. One of
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54 190 the two reported a significant association between work stress and tooth loss.^{34,35} Hayashi et
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6 191 al. reported the association between work stress, assessed using the Karasek job strain model,
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8 192 and tooth loss.³⁴ A total of 322 male workers employed at a manufacturing company were
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10 193 included. They dichotomised the number of tooth loss into ≤ 3 and ≥ 4 . After adjusting for
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12 194 covariates, high job demand and low control conditions were associated with high odds of
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14 195 having ≥ 4 teeth loss but not significant (OR = 1.2 [95% CI = 0.40, 3.42]). This study did not
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16 196 adjust for the important potential confounders such as socioeconomic status and work-related
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18 197 variables. Sato et al. reported the association between work stress, assessed using the effort–
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20 198 reward imbalance model, and self-reported tooth loss.³⁵ After adjusting for covariates
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22 199 including socioeconomic status and work-related variables, a high effort-reward imbalance
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24 200 ratio was significantly associated with a high prevalence of ≥ 1 tooth loss (prevalence ratio =
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26 201 1.20 [95% CI = 1.01, 1.42]).

202 **Study quality**

203 Table 2 presents the results of the quality assessments for each study. Eight studies (73%)
204 had poor quality, while three (27%) were rated as fair. None of the studies addressed question
205 6 (“For the analyses in this paper, were the exposure(s) of interest measured prior to the
206 outcome(s) being measured?”); 7 (“Was the timeframe sufficient so that one could
207 reasonably expect to see an association between exposure and outcome if it existed?”); and
208 10 (“Was the exposure(s) assessed more than once over time?”); because all the studies were
209 cross-sectional or the study design was unclear.

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211 **DISCUSSION**

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

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6 216 stress with dental caries and tooth loss. Eight of nine studies reported the significant
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8 217 associations between multiple periodontal measures and work stress.
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10 218 **Limitations of the review**

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12 219 This systematic review has four limitations. First, the systematic literature search, screening,
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14 220 and quality assessments were conducted by only one investigator. A single screening could
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16 221 miss more studies than a double screening.³⁷ Second, only English language literature was
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18 222 included. Although a systematic review found no bias due to English-language restriction in
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20 223 systematic reviews,³⁸ this review might include bias. Third, there was no protocol for this
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22 224 systematic review. A priori systematic review protocol registration provides the rigor and
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24 225 trustworthiness of the reviews.³⁹ This might weaken the rigor and trustworthiness of our
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26 226 review. Finally, a meta-analysis could not be conducted owing to the heterogeneity of the
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28 227 included studies. Work stress was assessed using varied measures. Particularly, only a few
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30 228 studies used the current major measures of work stress. Indicators of periodontal status were
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32 229 also varied. No study used valid epidemiological definitions for periodontal disease as the
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34 230 outcome. The cut-off points differed between the two studies on tooth loss and work stress.
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36 231 Besides, there was only one study on dental caries and work stress. These limitations
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38 232 hindered us from performing a meta-analysis.

40 233 **Dental caries and work stress**

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42 234 We found only one study on the cross-sectional association between work stress and dental
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44 235 caries.²⁸ The conclusion was that there was no significant association between work stress
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46 236 and dental caries. However, since the sample size was relatively small (n=164), there is the
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48 237 possibility of a false negative association. Besides, each subscale of the Karasek job strain
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50 238 model was simultaneously included in the statistical model. Generally, in the Karasek job
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52 239 strain model, the recommendation is to use four categories of job strain generated by the
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54 240 interaction of the subscales: High-strain jobs, active jobs, low-strain jobs, and passive jobs.⁹
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6 241 Due to the above treatments of the subscales, it is possible that the association was
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8 242 underestimated. Additionally, as there was no cohort study, we could not assess the
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10 243 prospective associations. Considering the above limitations, it was difficult to determine
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12 244 whether work stress is associated with dental caries. A further study should include a cohort
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14 245 design and a relatively large sample size with appropriate work stress measures.

16 246 **Periodontal status and work stress**

18 247 Nine studies reported on the association between work stress and periodontal status.^{22–24,28–}
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20 248 ³³ However, the outcome measures were varied across the included studies. Although there
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22 249 are the accepted epidemiological definitions of periodontitis according to the European
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24 250 Workshop in Periodontology and the Centers for Disease Control/American Academy of
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26 251 Periodontology,^{40,41} there was no study that used the definitions. It means that the included
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28 252 studies reported the associations between work stress and periodontal measures, not
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30 253 periodontal disease. In addition, the measurement of work stress was measured also varied
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32 254 across studies. Each measure assessed different dimensions of work stress.⁴² Due to the
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34 255 heterogeneity of exposures and outcomes, we could not conduct a meta-analysis.

36 256 Of the nine studies, only one study adjusted for the potential confounders, such as
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38 257 socioeconomic status and work-related variables.²⁸ Besides, no cohort study was found. The
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40 258 failure to adjust for the confounders and consider the induction time weakens the research
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42 259 evidence. However, despite the above limitations, the consistent association between work
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44 260 stress and worse periodontal status is noteworthy. To verify the current results, a further
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46 261 cohort study using the validated definitions of periodontal disease and current measurements
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48 262 of work stress, in addition to adjusting for the potential confounders should be performed.

50 263 **Tooth loss and work stress**

52 264 Two studies on the association between work stress and tooth loss were identified. Hayashi's
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54 265 study included only male workers employed at one manufacturing company.³⁴ In contrast,

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6 266 Sato's study included active workers sampled from a general population.³⁵ However, the
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8 267 response rate was relatively low (32%). The generalisability of both studies could be limited.
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10 268 The two studies had different cut-off points of tooth loss. Hayashi's study used the
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12 269 cut-off point of more than 4 teeth lost. The cutoff point is higher than the mean number of
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14 270 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,
15
16 271 respectively) reported by the national statistical surveys.⁴³ This study targeted severe cases
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18 272 only. In Sato's study, the outcome was the loss of at least more than one tooth. However, this
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20 273 outcome relied on self-reported answers; therefore, self-reported bias might exist.

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22 274 Both studies showed an increased risk of tooth loss, although only one of the two
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24 275 studies reported a significant association between work stress and tooth loss. However, due
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26 276 to the above limitations, it is difficult to derive any form of conclusion. In the future, a cohort
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28 277 study including general workers should be conducted to confirm these findings.

29 30 278 **Conclusions**

31
32 279 Based on the findings, this systematic review suggests a lack of evidence on the association
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34 280 of work stress with dental caries and tooth loss. Although eight of the nine studies reported
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36 281 significant associations between multiple periodontal measures and work stress, no study
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38 282 used valid epidemiological definitions of periodontal disease. For future research, well-
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40 283 designed cohort studies including potential confounding factors and the use of generally
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42 284 accepted measurements of work stress and periodontal disease are needed.
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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) 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) 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) 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) 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 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)
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 55.6%	Unknown	Job satisfaction: Coefficients = -0.014 (p-value < 0.01) Type A: Coefficients = 0.026 (p-value < 0.05)
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) 43.5%	Age and social class of the household	

established periodontitis
(13 men and 10 women)

Locus of control: Coefficients =
-0.035 (p-value \geq 0.05)
(statistical model was not
reported)

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

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)
52.0%

Age, gender, and levels of
smoking.

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 (\geq 4.0 mm)

Problems of
Everyday Living
Scale of Pearlin and
Schooler

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)
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

Mean clinical attachment loss
<1.5 mm were assigned to a non-
diseased group and those with
mean clinical attachment loss \geq 1.5
mm were assigned to a diseased
group

Life events scale
(yes or no)

Job stress (reference: No): Odds
ratio = 1.71 (95% confidence
interval = 1.10, 2.67) from a
logistic regression analysis

The mean gingival index
yes = 1.851 and no = 1.586 (p-
value > 0.05)

64 working dental
patients of both genders
with ages ranging from
23 to 65 years

Mean age and sex
were not reported.

None

Gingival Index, probing pocket
depth, bleeding on probing, and
clinical attachment level

Life events scale
(yes or no)

Total mean percentage of sites
with probing pocket depth \geq 4
mm
yes = 6.277% and no = 4.762%
(p-values <0.05)

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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)

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)

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 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. 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 reported.	None	
Ramji, (2011) ²³	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 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		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,	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

1 and High stress-low
2 coping)
3 *coping was
4 assessed using a
5 questionnaire
6 developed by a
7 Japanese company

8 **Tooth loss**

9									
10	Hayashi et al.	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 $3 \leq$ teeth lost)	252 male workers employed at a manufacturing company aged 20–59 years	Mean age = 38.7 (standard deviation = 11.0) 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
11	(2001) ³⁴								
12									
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16	Sato et al.	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)	Median age = 37 (1st and 3rd quartiles = 31 and 43) 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
17	(2020) ³⁵								
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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

1 exposure, or exposure measured as continuous variable)?

2
3 Q9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?

4
5 Q10. Was the exposure(s) assessed more than once over time?

6
7 Q11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?

8
9 Q12. Were the outcome assessors blinded to the exposure status of participants?

10
11 Q13. Was loss to follow-up after baseline 20% or less?

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13 Q14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and
14 outcome(s)?
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1 Figure 1. Flow of search strategy and selection of studies for a systematic review.
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1 The search of two databases (PubMed
2 and Scopus) on August 12, 2020
3 identified 402 records

4
5 129 duplicated records were removed

6
7 The titles and abstracts of 273 records
8 were screened
9

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12
13 Among them, 11 articles met the
14 inclusion criteria
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18 Three additional records were identified
19 through other sources (reference lists and hand
20 search)
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23 Full text assessment of 14 articles were
24 performed
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26
27 Excluded articles after full-text assessment
28 (n=3; Retracted [n=1] and used composite
29 outcome [n=2])
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31 Finally, 11 articles were included
32 (n=1, caries and periodontal status; n=8,
33 periodontal status, n=2: tooth loss)
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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

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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:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-046532.R3
Article Type:	Original research
Date Submitted by the Author:	19-Apr-2021
Complete List of Authors:	Sato, Yukihiro; Asahikawa Medical University, Division of Public Health and Epidemiology, Department of Social Medicine Saijo, Yasuaki; Asahikawa Medical University, Division of Public Health and Epidemiology, Department of Social Medicine Yoshioka, Eiji ; Asahikawa Medical University, Division of Public Health and Epidemiology, Department of Social Medicine
Primary Subject Heading:	Occupational and environmental medicine
Secondary Subject Heading:	Dentistry and oral medicine
Keywords:	OCCUPATIONAL & INDUSTRIAL MEDICINE, SOCIAL MEDICINE, EPIDEMIOLOGY

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Title

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

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1 **Abstract (300/300)**

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

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

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

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

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

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

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

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6 26 work stress. Cohort studies using the major work stress measures and adjusting for the
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8 27 potential confounders are needed.
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12 29 **Keywords**

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14 30 systematic review, work stress, job stress, occupational stress, oral health, oral diseases
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6 31 **Strengths and limitations of this study**
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8 32 ► This is the first systematic review to evaluate and summarise the literature on the
9
10 33 association between work stress and oral conditions, including dental caries, periodontal
11
12 34 status, and tooth loss.

13
14 35 ► This systematic review provides a comprehensive insight into the quality of the included
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16 36 papers.

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18 37 ► The systematic literature search, screening, and quality assessments were conducted by
19
20 38 only one investigator.

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22 39 ► A meta-analysis could not be conducted because of the heterogeneity of work stress
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24 40 measures and outcome definitions.
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41 INTRODUCTION

42 Oral diseases, such as dental caries and periodontal disease, are a major health concern
43 worldwide. The Global Burden of Disease study has estimated that 2.3 billion individuals
44 had untreated dental caries, 796 million had severe periodontal disease, and 267 million had
45 a complete loss of natural teeth in 2017.¹ Dental caries is the destruction of dental hard tissues
46 in the crowns and roots of the teeth.² Periodontal diseases are chronic inflammatory
47 conditions with disorders of the tissues surrounding and supporting the teeth.³ Tooth loss is
48 mainly the consequence of dental caries and periodontal disease.^{2,3} Because oral diseases
49 result in severe toothache and eating, sleeping, and communication disabilities,^{4,5} poor oral
50 conditions can restrict work performance^{4,5} and create a significant economic burden.⁶ Indeed,
51 work productivity loss due to oral conditions is estimated at 187.61 billion US dollars
52 annually.⁶ The necessity of preventing oral diseases for working adults is highlighted.

53 Since the 1990s, rapid changes in the global economy and the diverse markets have
54 occurred, and psychological workplace stress has become more prevalent and severe,
55 especially among industrialised countries.⁷ Indeed, Kivimäki et al. reported a 15% prevalence
56 of job strain measured using job-content and demand-control questionnaires from 13
57 European cohorts' data (1985–2006).⁸ Besides, work stress can have profound effects on
58 health. There is accumulating evidence of the risk of work stress on cancer, cardiovascular
59 diseases, diabetes, and depression.^{9,10} Béjean and Sultan-Taïeb estimated that the work-
60 related stress costs due to illnesses could range between €1,167 million and €1,975 million
61 in France in 2000.¹¹ Work stress affects workers' health and productivity.

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

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6 66 reviews suggested potential associations of psychological stress with dental caries and
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8 67 periodontitis.^{14,15} However, there seems to be no review on the association between work
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10 68 stress and oral diseases. Today, work stress has become an increasingly serious problem.
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12 69 Besides, the number of women in the workforce and dual-earner families have been
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14 70 increasing.¹⁶ A wide range of populations can suffer the risk of oral diseases from exposure
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16 71 to work stress. Thus, the aim of this systematic review was to evaluate and summarise the
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18 72 literature on the association between work stress and oral conditions, including dental caries,
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20 73 periodontal status, and tooth loss. We set the following review question: Is work stress
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22 74 associated with dental caries, periodontal status, and tooth loss among working adults?
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76 **METHODS**

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28 77 The reporting of this systematic review conforms to the Preferred Reporting Items for
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30 78 Systematic Reviews and Meta-Analyses (PRISMA) guidelines.^{17,18} We also followed the
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32 79 Conducting Systematic Reviews and Meta-Analyses of Observational Studies of Etiology
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34 80 (COSMOS-E) guidance¹⁹ and the reporting of Meta-analysis Of Observational Studies in
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36 81 Epidemiology (MOOSE).²⁰ The protocol of this systematic review was not registered.

38 **Eligibility criteria**

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40 83 Published studies were eligible if they: 1) were published in English; 2) were epidemiological
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42 84 studies on humans (except case studies, reviews, letters, commentaries, and editorials); and
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44 85 3) examined the association of work stress with dental caries, periodontal status, and tooth
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46 86 loss.

48 **Information sources and searches**

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50 88 On August 12, 2020, we identified potentially relevant published studies in PubMed (1966
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52 89 to August 12, 2020) and Scopus (1966 to August 12, 2020) databases. As PubMed and
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54 90 Scopus have only data back to 1966, we focused on articles published after 1966. We used
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6 91 the following script to obtain a wide range of literature: ("job strain" OR "effort reward")
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8 92 AND (dental OR oral); ("job stress" OR "work stress" OR "occupational stress") AND
9
10 93 (dental OR oral). The details of the search strategies for each database are shown in
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12 94 Supplemental Table 1. Besides, we manually hand-searched for potentially suitable studies
13
14 95 through the reference lists of identified articles and Google scholar. After excluding duplicate
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16 96 articles, one author (YuS) assessed the titles and abstracts according to the aforementioned
17
18 97 criteria. Then, eligible studies were selected for the full-text review.

98 **Data extraction**

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

104 **Quality assessment**

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

111 **Synthesis of results**

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

114 **Patient and public involvement**

115 No patient involved.

116

117 **RESULTS**

118 Figure 1 presents the flow diagram of information through the phases of the systematic
119 review. Of the 402 articles identified in PubMed and Scopus databases, 129 duplicated
120 articles were removed, the titles and abstracts of 273 were screened, and 11 met the eligibility
121 criteria. Three more articles identified through reference lists and hand-search were added.
122 One article was identified by a hand-search using Google Scholar,²² one was from a reference
123 list,²³ and the third was an article²⁴ plagiarised by a retraction paper. Because the article²⁴
124 which was plagiarised by the retracted one was published officially and has not been retracted,
125 it was included in our references. After full-text assessments of 14 articles, three were
126 excluded due to retraction (n=1) and the use of composite outcomes including dental caries
127 and periodontal status (n=2).^{25,26} Finally, 11 articles were included in this systematic
128 review.^{22-24,27-34}

129 **Study characteristics of individual studies**

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

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

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6 141 reported job stress,²⁴ the Occupational Stress Indicator,^{23,28} an occupational stress index by
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8 142 Srivastava and Singh,³¹ the Life events scale,^{22,30} and the Problems of Everyday Living Scale
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10 143 by Pearlin and Schooler.²⁹
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12 144 Three studies presented only descriptive statistics.^{22,29,31} Eight studies performed
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14 145 regression analyses;^{23,24,27,28,30,32–34} but two of the eight studies did not report the types of a
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16 146 regression modeling used.^{23,28} Only two studies sufficiently adjusted for potential
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18 147 confounders such as socioeconomic status and work-related variables.^{27,34}
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20 148 **Dental caries and work stress**

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22 149 One study reported the cross-sectional association between work stress and dental caries,
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24 150 which included 164 paid male workers aged 35 to 44 years in Brazil.²⁷ Work stress was
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26 151 assessed according to the Karasek job strain model.³⁵ Dental caries status was assessed using
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28 152 the DMFS index (the number of decayed [D], missing [M], and filled [F] teeth surfaces per
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30 153 person). After adjusting for covariates, one-point increases in the work mental demand, work
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32 154 control, and work variety scores were associated with 0.19 (95% confidence interval [CI] =
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34 155 -0.91, 1.29), 0.87 (95% CI = -0.18, 1.91), and -0.06 (95% CI = -1.57, 1.45) increases in the
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36 156 DMFS index, respectively, in a multivariable regression analysis. Consequently, this study
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38 157 reported a nonsignificant association between work stress and dental caries.²⁷
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40 158 **Periodontal status and work stress**

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42 159 Eight of nine studies reported a significant association between work stress and worse
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44 160 periodontal status.^{22–24,27–32} The measurements of periodontal status varied across the
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46 161 included studies. The measurements included probing pocket depth,^{22,23,31} clinical attachment
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48 162 level,^{22,28,29} alveolar bone loss,²⁹ gingival index,²² bleeding on probing,²² the Community
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50 163 Periodontal Index and Treatment Needs protocol,²⁴ and a composite outcome, including these
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52 164 measures.^{27,32} Eight studies assessed periodontal status based on oral examination with probe,
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54 165 but one study was based on only visual inspection by dentists.³²
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6 166 Among the nine studies, two studies had unclear methodology; therefore, they were
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8 167 categorised as unknown.^{23,28} Freeman and Goss assessed work stress and periodontal status
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10 168 over a 12-month period.²³ However, they did not clearly report when work stress and
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12 169 periodontal status variables were assessed and how they were used in the statistical models.
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14 170 Linden et al. followed-up patients for 5.5 years, but work stress was only assessed at the
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16 171 follow-up examination, not at the baseline survey.²⁸

17 172 Among the remaining seven studies, after excluding the above two studies, three
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19 173 studies presented only descriptive statistics.^{22,29,31} The remaining four papers reported
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21 174 significant associations following regression analyses.^{24,27,30,32} However, Akhter et al. used
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23 175 general stress questions not specific to work stress and included nonworking adults.³⁰ Islam
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25 176 et al. used the Brief Job Stress Questionnaire derived from the demand-control-support model
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27 177 in Japan, and periodontal status was assessed based on the visual inspection by dentists.³²
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29 178 Important potential confounders such as socioeconomic status and work-related variables,
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31 179 were not included. Ramji assessed work stress using a single job stress question and did not
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33 180 adjust for covariates in the statistical models.²⁴ Marcenes and Sheiham reported a significant
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35 181 association between periodontal status and work stress.²⁷ Periodontal status was assessed by
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37 182 the presence or absence of gums bleeding on probing or with pockets. The authors divided
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39 183 periodontal measures into groups based on “complete absence of teeth with gums bleeding
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41 184 on probing and with pockets,” or “the presence of any tooth with gums bleeding on probing
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43 185 or pockets,” and defined the latter as those with periodontal disease. After adjusting for
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45 186 covariates, one-point increases in work mental demand scores, work control scores, and work
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47 187 variety scores were associated with ORs of 1.22 (95%CI = 1.06, 1.37), 0.97 (95%CI = 0.88,
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49 188 1.07), and 0.99 (95%CI = 0.85, 1.16), respectively, for having periodontal disease, in a
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51 189 logistic regression model.

52 53 54 190 **Tooth loss and work stress**

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6 191 Two studies on the association between work stress and tooth loss were identified. One of
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8 192 the two reported a significant association between work stress and tooth loss.^{33,34} Hayashi et
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10 193 al. reported the association between work stress, assessed using the Karasek job strain model,
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12 194 and tooth loss.³³ A total of 322 male workers employed at a manufacturing company were
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14 195 included. They dichotomised the number of tooth loss into ≤ 3 and ≥ 4 . After adjusting for
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16 196 covariates, high job demand and low control conditions were associated with high odds of
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18 197 having ≥ 4 teeth loss but not significant (OR = 1.2 [95% CI = 0.40, 3.42]). This study did not
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20 198 adjust for the important potential confounders such as socioeconomic status and work-related
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22 199 variables. Sato et al. reported the association between work stress, assessed using the effort–
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24 200 reward imbalance model, and self-reported tooth loss.³⁴ After adjusting for covariates
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26 201 including socioeconomic status and work-related variables, a high effort-reward imbalance
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28 202 ratio was significantly associated with a high prevalence of ≥ 1 tooth loss (prevalence ratio =
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30 203 1.20 [95% CI = 1.01, 1.42]).

32 204 **Study quality**

34 205 Table 2 presents the results of the quality assessments for each study. Eight studies (73%)
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36 206 had poor quality, while three (27%) were rated as fair. None of the studies addressed question
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38 207 6 (“For the analyses in this paper, were the exposure(s) of interest measured prior to the
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40 208 outcome(s) being measured?”); 7 (“Was the timeframe sufficient so that one could
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42 209 reasonably expect to see an association between exposure and outcome if it existed?”); and
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44 210 10 (“Was the exposure(s) assessed more than once over time?”); because all the studies were
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46 211 cross-sectional or the study design was unclear.

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50 213 **DISCUSSION**

52 214 This is the first systematic review to evaluate and summarise the existing literature on the
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54 215 associations between work stress and oral conditions. As our findings showed, only one study

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6 216 reported on dental caries and periodontal status, nine on periodontal status, and two on tooth
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8 217 loss. Based on the findings of this review, the evidence is lacking on the association of work
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10 218 stress with dental caries and tooth loss. Eight of nine studies reported the significant
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12 219 associations between multiple periodontal measures and work stress.

14 220 **Limitations of the review**

16 221 This systematic review has four limitations. First, the systematic literature search, screening,
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18 222 and quality assessments were conducted by only one investigator. A single screening could
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20 223 miss more studies than a double screening.³⁶ Second, only English language literature was
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22 224 included. Although a systematic review found no bias due to English-language restriction in
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24 225 systematic reviews,³⁷ this review might include bias. Third, there was no protocol for this
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26 226 systematic review. A priori systematic review protocol registration provides the rigor and
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28 227 trustworthiness of the reviews.³⁸ This might weaken the rigor and trustworthiness of our
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30 228 review. Finally, a meta-analysis could not be conducted owing to the heterogeneity of the
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32 229 included studies. Work stress was assessed using varied measures. Particularly, only a few
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34 230 studies used the current major measures of work stress. Indicators of periodontal status were
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36 231 also varied. No study used valid epidemiological definitions for periodontal disease as the
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38 232 outcome. The cut-off points differed between the two studies on tooth loss and work stress.
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40 233 Besides, there was only one study on dental caries and work stress. These limitations
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42 234 hindered us from performing a meta-analysis.

44 235 **Dental caries and work stress**

46 236 We found only one study on the cross-sectional association between work stress and dental
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48 237 caries.²⁷ The conclusion was that there was no significant association between work stress
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50 238 and dental caries. However, since the sample size was relatively small (n=164), there is the
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52 239 possibility of a false negative association. Besides, each subscale of the Karasek job strain
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54 240 model was simultaneously included in the statistical model. Generally, in the Karasek job

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6 241 strain model, the recommendation is to use four categories of job strain generated by the
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8 242 interaction of the subscales: High-strain jobs, active jobs, low-strain jobs, and passive jobs.⁹
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10 243 Due to the above treatments of the subscales, it is possible that the association was
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12 244 underestimated. Additionally, as there was no cohort study, we could not assess the
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14 245 prospective associations. Considering the above limitations, it was difficult to determine
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16 246 whether work stress is associated with dental caries. A further study should include a cohort
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18 247 design and a relatively large sample size with appropriate work stress measures.

20 248 **Periodontal status and work stress**

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22 249 Nine studies reported on the association between work stress and periodontal status.^{22–24,27–}
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24 250 ³² However, the outcome measures were varied across the included studies. Although there
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26 251 are the accepted epidemiological definitions of periodontitis according to the European
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28 252 Workshop in Periodontology and the Centers for Disease Control/American Academy of
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30 253 Periodontology,^{39,40} there was no study that used the definitions. It means that the included
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32 254 studies reported the associations between work stress and periodontal measures, not
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34 255 periodontal disease. In addition, the measurement of work stress was measured also varied
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36 256 across studies. Each measure assessed different dimensions of work stress.⁴¹ Due to the
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38 257 heterogeneity of exposures and outcomes, we could not conduct a meta-analysis.

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40 258 Of the nine studies, only one study adjusted for the potential confounders, such as
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42 259 socioeconomic status and work-related variables.²⁷ Besides, no cohort study was found. The
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44 260 failure to adjust for the confounders and consider the induction time weakens the research
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46 261 evidence. However, despite the above limitations, the consistent association between work
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48 262 stress and worse periodontal status is noteworthy. To verify the current results, a further
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50 263 cohort study using the validated definitions of periodontal disease and current measurements
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52 264 of work stress, in addition to adjusting for the potential confounders should be performed.

54 265 **Tooth loss and work stress**

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6 266 Two studies on the association between work stress and tooth loss were identified. Hayashi's
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8 267 study included only male workers employed at one manufacturing company.³³ In contrast,
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10 268 Sato's study included active workers sampled from a general population.³⁴ However, the
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12 269 response rate was relatively low (32%). The generalisability of both studies could be limited.

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14 270 The two studies had different cut-off points of tooth loss. Hayashi's study used the
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16 271 cut-off point of more than 4 teeth lost. The cutoff point is higher than the mean number of
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18 272 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,
19
20 273 respectively) reported by the national statistical surveys.⁴² This study targeted severe cases
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22 274 only. In Sato's study, the outcome was the loss of at least more than one tooth. However, this
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24 275 outcome relied on self-reported answers; therefore, self-reported bias might exist.

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26 276 Both studies showed an increased risk of tooth loss, although only one of the two
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28 277 studies reported a significant association between work stress and tooth loss. However, due
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30 278 to the above limitations, it is difficult to derive any form of conclusion. In the future, a cohort
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32 279 study including general workers should be conducted to confirm these findings.

33 34 280 **Conclusions**

35
36 281 Based on the findings, this systematic review suggests a lack of evidence on the association
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38 282 of work stress with dental caries and tooth loss. Although eight of the nine studies reported
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40 283 significant associations between multiple periodontal measures and work stress, no study
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42 284 used valid epidemiological definitions of periodontal disease. For future research, well-
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44 285 designed cohort studies including potential confounding factors and the use of generally
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46 286 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) 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) 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) 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 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)
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%	Unknown	Job satisfaction: Coefficients = -0.014 (p-value < 0.01) Type A: Coefficients = 0.026 (p-value < 0.05)
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) 43.5%	Age and social class of the household	

established periodontitis
(13 men and 10 women)

Locus of control: Coefficients =
-0.035 (p-value \geq 0.05)
(statistical model was not
reported)

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

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)
52.0%

Age, gender, and levels of
smoking.

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 (\geq 4.0 mm)

Problems of
Everyday Living
Scale of Pearlin and
Schooler

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)
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

Mean clinical attachment loss
<1.5 mm were assigned to a non-
diseased group and those with
mean clinical attachment loss \geq 1.5
mm were assigned to a diseased
group

Life events scale
(yes or no)

Job stress (reference: No): Odds
ratio = 1.71 (95% confidence
interval = 1.10, 2.67) from a
logistic regression analysis

The mean gingival index
yes = 1.851 and no = 1.586 (p-
value > 0.05)

64 working dental
patients of both genders
with ages ranging from
23 to 65 years

Mean age and sex
were not reported.

None

Gingival Index, probing pocket
depth, bleeding on probing, and
clinical attachment level

Life events scale
(yes or no)

Total mean percentage of sites
with probing pocket depth \geq 4
mm
yes = 6.277% and no = 4.762%
(p-values <0.05)

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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)

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)

Having self-reported job stress:
Odds ratio = 7.5 (95% confidence interval = 3.7, 15.02) from a logistic regression analysis

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

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. 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 reported.	None
Ramji, (2011) ²⁴	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 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		None
Islam et al. (2019) ³²	Cross-sectional	Japan	Brief Job Stress Questionnaire developed by referring the demand-control-support model in Japan (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) 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

1 and High stress-low
2 coping)
3 *coping was
4 assessed using a
5 questionnaire
6 developed by a
7 Japanese company

8 **Tooth loss**

9									
10	Hayashi et al.	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 $3 \leq$ teeth lost)	252 male workers employed at a manufacturing company aged 20–59 years	Mean age = 38.7 (standard deviation = 11.0) 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
11	(2001) ³³								
12									
13									
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15									
16	Sato et al.	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)	Median age = 37 (1st and 3rd quartiles = 31 and 43) 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
17	(2020) ³⁴								
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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

1 exposure, or exposure measured as continuous variable)?

2
3 Q9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?

4
5 Q10. Was the exposure(s) assessed more than once over time?

6
7 Q11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?

8
9 Q12. Were the outcome assessors blinded to the exposure status of participants?

10
11 Q13. Was loss to follow-up after baseline 20% or less?

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13 Q14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and
14 outcome(s)?
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1 Figure 1. Flow of search strategy and selection of studies for a systematic review.
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1 The search of two databases (PubMed
2 and Scopus) on August 12, 2020
3 identified 402 records

4
5 129 duplicated records were removed

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7 The titles and abstracts of 273 records
8 were screened
9

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12
13 Among them, 11 articles met the
14 inclusion criteria
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16

17
18 Three additional records were identified
19 through other sources (reference lists and hand
20 search)
21

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23 Full text assessment of 14 articles were
24 performed
25

26
27 Excluded articles after full-text assessment
28 (n=3; Retracted [n=1] and used composite
29 outcome [n=2])
30

31 Finally, 11 articles were included
32 (n=1, caries and periodontal status; n=8,
33 periodontal status, n=2: tooth loss)
34

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

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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

Page 1 of 2

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
Page 1 of 2			
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			



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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
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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

For more information, visit: www.prisma-statement.org.

Page 2 of 2

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BMJ Open

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

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-046532.R4
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Date Submitted by the Author:	27-Apr-2021
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Primary Subject Heading:	Occupational and environmental medicine
Secondary Subject Heading:	Dentistry and oral medicine
Keywords:	OCCUPATIONAL & INDUSTRIAL MEDICINE, SOCIAL MEDICINE, EPIDEMIOLOGY

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Title

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

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1 **Abstract (300/300)**

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

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

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

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

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

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

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

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6 26 work stress. Cohort studies using the major work stress measures and adjusting for the
7
8 27 potential confounders are needed.
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12 29 **Keywords**

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14 30 systematic review, work stress, job stress, occupational stress, oral health, oral diseases
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6 31 **Strengths and limitations of this study**
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8 32 ► This is the first systematic review to evaluate and summarise the literature on the
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10 33 association between work stress and oral conditions, including dental caries, periodontal
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12 34 status, and tooth loss.

13
14 35 ► This systematic review provides a comprehensive insight into the quality of the included
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16 36 papers.

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18 37 ► The systematic literature search, screening, and quality assessments were conducted by
19
20 38 only one investigator.

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22 39 ► A meta-analysis could not be conducted because of the heterogeneity of work stress
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24 40 measures and outcome definitions.
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41 INTRODUCTION

42 Oral diseases, such as dental caries and periodontal disease, are a major health concern
43 worldwide. The Global Burden of Disease study has estimated that 2.3 billion individuals
44 had untreated dental caries, 796 million had severe periodontal disease, and 267 million had
45 a complete loss of natural teeth in 2017.¹ Dental caries is the destruction of dental hard tissues
46 in the crowns and roots of the teeth.² Periodontal diseases are chronic inflammatory
47 conditions with disorders of the tissues surrounding and supporting the teeth.³ Tooth loss is
48 mainly the consequence of dental caries and periodontal disease.^{2,3} Because oral diseases
49 result in severe toothache and eating, sleeping, and communication disabilities,^{4,5} poor oral
50 conditions can restrict work performance^{4,5} and create a significant economic burden.⁶ Indeed,
51 work productivity loss due to oral conditions is estimated at 187.61 billion US dollars
52 annually.⁶ The necessity of preventing oral diseases for working adults is highlighted.

53 Since the 1990s, rapid changes in the global economy and the diverse markets have
54 occurred, and psychological workplace stress has become more prevalent and severe,
55 especially among industrialised countries.⁷ Indeed, Kivimäki et al. reported a 15% prevalence
56 of job strain measured using job-content and demand-control questionnaires from 13
57 European cohorts' data (1985–2006).⁸ Besides, work stress can have profound effects on
58 health. There is accumulating evidence of the risk of work stress on cancer, cardiovascular
59 diseases, diabetes, and depression.^{9,10} Béjean and Sultan-Taïeb estimated that the work-
60 related stress costs due to illnesses could range between €1,167 million and €1,975 million
61 in France in 2000.¹¹ Work stress affects workers' health and productivity.

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

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6 66 reviews suggested potential associations of psychological stress with dental caries and
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8 67 periodontitis.^{14,15} However, there seems to be no review on the association between work
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10 68 stress and oral diseases. Today, work stress has become an increasingly serious problem.
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12 69 Besides, the number of women in the workforce and dual-earner families have been
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14 70 increasing.¹⁶ A wide range of populations can suffer the risk of oral diseases from exposure
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16 71 to work stress. Thus, the aim of this systematic review was to evaluate and summarise the
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18 72 literature on the association between work stress and oral conditions, including dental caries,
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20 73 periodontal status, and tooth loss. We set the following review question: Is work stress
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22 74 associated with dental caries, periodontal status, and tooth loss among working adults?
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26 76 **METHODS**

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28 77 The reporting of this systematic review conforms to the Preferred Reporting Items for
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30 78 Systematic Reviews and Meta-Analyses (PRISMA) guidelines.^{17,18} We also followed the
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32 79 Conducting Systematic Reviews and Meta-Analyses of Observational Studies of Etiology
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34 80 (COSMOS-E) guidance¹⁹ and the reporting of Meta-analysis Of Observational Studies in
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36 81 Epidemiology (MOOSE).²⁰ The protocol of this systematic review was not registered.

38 82 **Eligibility criteria**

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40 83 Published studies were eligible if they: 1) were published in English; 2) were epidemiological
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42 84 studies on humans (except case studies, reviews, letters, commentaries, and editorials); and
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44 85 3) examined the association of work stress with dental caries, periodontal status, and tooth
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46 86 loss.

48 87 **Information sources and searches**

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50 88 On August 12, 2020, we identified potentially relevant published studies in PubMed (1966
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52 89 to August 12, 2020) and Scopus (1966 to August 12, 2020) databases. As PubMed and
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54 90 Scopus have only data back to 1966, we focused on articles published after 1966. We used
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6 91 the following script to obtain a wide range of literature: ("job strain" OR "effort reward")
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8 92 AND (dental OR oral); ("job stress" OR "work stress" OR "occupational stress") AND
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10 93 (dental OR oral). The details of the search strategies for each database are shown in
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12 94 Supplemental Table 1. Besides, we manually hand-searched for potentially suitable studies
13
14 95 through the reference lists of identified articles and Google scholar. After excluding duplicate
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16 96 articles, one author (YuS) assessed the titles and abstracts according to the aforementioned
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18 97 criteria. Then, eligible studies were selected for the full-text review.

98 **Data extraction**

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

104 **Quality assessment**

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

111 **Synthesis of results**

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

114 **Patient and public involvement**

115 No patient involved.

116

117 **RESULTS**

118 Figure 1 presents the flow diagram of information through the phases of the systematic
119 review. Of the 402 articles identified in PubMed and Scopus databases, 129 duplicated
120 articles were removed, the titles and abstracts of 273 were screened, and 11 met the eligibility
121 criteria. Three more articles identified through reference lists and hand-search were added.
122 One article was identified by a hand-search using Google Scholar,²² one was from a reference
123 list,²³ and the third was an article²⁴ plagiarised by a retraction paper. Because the article²⁴
124 which was plagiarised by the retracted one was published officially and has not been retracted,
125 it was included in our references. After full-text assessments of 14 articles, three were
126 excluded due to retraction (n=1) and the use of composite outcomes including dental caries
127 and periodontal status (n=2).^{25,26} Finally, 11 articles were included in this systematic
128 review.^{22-24,27-34}

129 **Study characteristics of individual studies**

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

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

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6 141 reported job stress,²⁴ the Occupational Stress Indicator,^{23,28} an occupational stress index by
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8 142 Srivastava and Singh,³¹ the Life events scale,^{22,30} and the Problems of Everyday Living Scale
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10 143 by Pearlin and Schooler.²⁹
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12 144 Three studies presented only descriptive statistics.^{22,29,31} Eight studies performed
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14 145 regression analyses;^{23,24,27,28,30,32–34} but two of the eight studies did not report the types of a
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16 146 regression modeling used.^{23,28} Only two studies sufficiently adjusted for potential
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18 147 confounders such as socioeconomic status and work-related variables.^{27,34}
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20 148 **Dental caries and work stress**

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22 149 One study reported the cross-sectional association between work stress and dental caries,
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24 150 which included 164 paid male workers aged 35 to 44 years in Brazil.²⁷ Work stress was
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26 151 assessed according to the Karasek job strain model.³⁵ Dental caries status was assessed using
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28 152 the DMFS index (the number of decayed [D], missing [M], and filled [F] teeth surfaces per
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30 153 person). After adjusting for covariates, one-point increases in the work mental demand, work
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32 154 control, and work variety scores were associated with 0.19 (95% confidence interval [CI] =
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34 155 -0.91, 1.29), 0.87 (95% CI = -0.18, 1.91), and -0.06 (95% CI = -1.57, 1.45) increases in the
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36 156 DMFS index, respectively, in a multivariable regression analysis. Consequently, this study
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38 157 reported a nonsignificant association between work stress and dental caries.²⁷
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40 158 **Periodontal status and work stress**

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42 159 Eight of nine studies reported a significant association between work stress and worse
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44 160 periodontal status.^{22–24,27–32} The measurements of periodontal status varied across the
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46 161 included studies. The measurements included probing pocket depth,^{22,23,31} clinical attachment
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48 162 level,^{22,28,29} alveolar bone loss,²⁹ gingival index,²² bleeding on probing,²² the Community
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50 163 Periodontal Index and Treatment Needs protocol,²⁴ and a composite outcome, including these
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52 164 measures.^{27,32} Eight studies assessed periodontal status based on oral examination with probe,
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54 165 but one study was based on only visual inspection by dentists.³²
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6 166 Among the nine studies, two studies had unclear methodology; therefore, they were
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8 167 categorised as unknown.^{23,28} Freeman and Goss assessed work stress and periodontal status
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10 168 over a 12-month period.²³ However, they did not clearly report when work stress and
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12 169 periodontal status variables were assessed and how they were used in the statistical models.
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14 170 Linden et al. followed-up patients for 5.5 years, but work stress was only assessed at the
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16 171 follow-up examination, not at the baseline survey.²⁸

17 172 Among the remaining seven studies, after excluding the above two studies, three
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19 173 studies presented only descriptive statistics.^{22,29,31} The remaining four papers reported
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21 174 significant associations following regression analyses.^{24,27,30,32} However, Akhter et al. used
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23 175 general stress questions not specific to work stress and included nonworking adults.³⁰ Islam
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25 176 et al. used the Brief Job Stress Questionnaire derived from the demand-control-support model
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27 177 in Japan, and periodontal status was assessed based on the visual inspection by dentists.³²
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29 178 Important potential confounders such as socioeconomic status and work-related variables,
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31 179 were not included. Ramji assessed work stress using a single job stress question and did not
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33 180 adjust for covariates in the statistical models.²⁴ Marcenes and Sheiham reported a significant
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35 181 association between periodontal status and work stress.²⁷ Periodontal status was assessed by
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37 182 the presence or absence of gums bleeding on probing or with pockets. The authors divided
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39 183 periodontal measures into groups based on “complete absence of teeth with gums bleeding
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41 184 on probing and with pockets,” or “the presence of any tooth with gums bleeding on probing
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43 185 or pockets,” and defined the latter as those with periodontal disease. After adjusting for
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45 186 covariates, one-point increases in work mental demand scores, work control scores, and work
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47 187 variety scores were associated with ORs of 1.22 (95%CI = 1.06, 1.37), 0.97 (95%CI = 0.88,
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49 188 1.07), and 0.99 (95%CI = 0.85, 1.16), respectively, for having periodontal disease, in a
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51 189 logistic regression model.

52 53 54 190 **Tooth loss and work stress**

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6 191 Two studies on the association between work stress and tooth loss were identified. One of
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8 192 the two reported a significant association between work stress and tooth loss.^{33,34} Hayashi et
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10 193 al. reported the association between work stress, assessed using the Karasek job strain model,
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12 194 and tooth loss.³³ A total of 322 male workers employed at a manufacturing company were
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14 195 included. They dichotomised the number of tooth loss into ≤ 3 and ≥ 4 . After adjusting for
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16 196 covariates, high job demand and low control conditions were associated with high odds of
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18 197 having ≥ 4 teeth loss but not significant (OR = 1.2 [95% CI = 0.40, 3.42]). This study did not
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20 198 adjust for the important potential confounders such as socioeconomic status and work-related
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22 199 variables. Sato et al. reported the association between work stress, assessed using the effort–
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24 200 reward imbalance model, and self-reported tooth loss.³⁴ After adjusting for covariates
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26 201 including socioeconomic status and work-related variables, a high effort-reward imbalance
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28 202 ratio was significantly associated with a high prevalence of ≥ 1 tooth loss (prevalence ratio =
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30 203 1.20 [95% CI = 1.01, 1.42]).

32 204 **Study quality**

34 205 Table 2 presents the results of the quality assessments for each study. Eight studies (73%)
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36 206 had poor quality, while three (27%) were rated as fair. None of the studies addressed question
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38 207 6 (“For the analyses in this paper, were the exposure(s) of interest measured prior to the
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40 208 outcome(s) being measured?”); 7 (“Was the timeframe sufficient so that one could
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42 209 reasonably expect to see an association between exposure and outcome if it existed?”); and
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44 210 10 (“Was the exposure(s) assessed more than once over time?”); because all the studies were
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46 211 cross-sectional or the study design was unclear.

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50 213 **DISCUSSION**

52 214 This is the first systematic review to evaluate and summarise the existing literature on the
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54 215 associations between work stress and oral conditions. As our findings showed, only one study

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6 216 reported on dental caries and periodontal status, nine on periodontal status, and two on tooth
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8 217 loss. Based on the findings of this review, the evidence is lacking on the association of work
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10 218 stress with dental caries and tooth loss. Eight of nine studies reported the significant
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12 219 associations between multiple periodontal measures and work stress.

14 220 **Limitations of the review**

16 221 This systematic review has four limitations. First, the systematic literature search, screening,
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18 222 and quality assessments were conducted by only one investigator. A single screening could
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20 223 miss more studies than a double screening.³⁶ Second, only English language literature was
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22 224 included. Although a systematic review found no bias due to English-language restriction in
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24 225 systematic reviews,³⁷ this review might include bias. Third, there was no protocol for this
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26 226 systematic review. A priori systematic review protocol registration provides the rigor and
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28 227 trustworthiness of the reviews.³⁸ This might weaken the rigor and trustworthiness of our
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30 228 review. Finally, a meta-analysis could not be conducted owing to the heterogeneity of the
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32 229 included studies. Work stress was assessed using varied measures. Particularly, only a few
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34 230 studies used the current major measures of work stress. Indicators of periodontal status were
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36 231 also varied. No study used valid epidemiological definitions for periodontal disease as the
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38 232 outcome. The cut-off points differed between the two studies on tooth loss and work stress.
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40 233 Besides, there was only one study on dental caries and work stress. These limitations
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42 234 hindered us from performing a meta-analysis.

44 235 **Dental caries and work stress**

46 236 We found only one study on the cross-sectional association between work stress and dental
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48 237 caries.²⁷ The conclusion was that there was no significant association between work stress
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50 238 and dental caries. However, since the sample size was relatively small (n=164), there is the
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52 239 possibility of a false negative association. Besides, each subscale of the Karasek job strain
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54 240 model was simultaneously included in the statistical model. Generally, in the Karasek job

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6 241 strain model, the recommendation is to use four categories of job strain generated by the
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8 242 interaction of the subscales: High-strain jobs, active jobs, low-strain jobs, and passive jobs.⁹
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10 243 Due to the above treatments of the subscales, it is possible that the association was
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12 244 underestimated. Additionally, as there was no cohort study, we could not assess the
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14 245 prospective associations. Considering the above limitations, it was difficult to determine
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16 246 whether work stress is associated with dental caries. A further study should include a cohort
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18 247 design and a relatively large sample size with appropriate work stress measures.

20 248 **Periodontal status and work stress**

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22 249 Nine studies reported on the association between work stress and periodontal status.^{22–24,27–}
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24 250 ³² However, the outcome measures were varied across the included studies. Although there
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26 251 are the accepted epidemiological definitions of periodontitis according to the European
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28 252 Workshop in Periodontology and the Centers for Disease Control/American Academy of
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30 253 Periodontology,^{39,40} there was no study that used the definitions. It means that the included
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32 254 studies reported the associations between work stress and periodontal measures, not
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34 255 periodontal disease. In addition, the measurement of work stress was measured also varied
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36 256 across studies. Each measure assessed different dimensions of work stress.⁴¹ Due to the
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38 257 heterogeneity of exposures and outcomes, we could not conduct a meta-analysis.

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40 258 Of the nine studies, only one study adjusted for the potential confounders, such as
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42 259 socioeconomic status and work-related variables.²⁷ Besides, no cohort study was found. The
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44 260 failure to adjust for the confounders and consider the induction time weakens the research
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46 261 evidence. However, despite the above limitations, the consistent association between work
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48 262 stress and worse periodontal status is noteworthy. To verify the current results, a further
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50 263 cohort study using the validated definitions of periodontal disease and current measurements
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52 264 of work stress, in addition to adjusting for the potential confounders should be performed.

54 265 **Tooth loss and work stress**

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6 266 Two studies on the association between work stress and tooth loss were identified. Hayashi's
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8 267 study included only male workers employed at one manufacturing company.³³ In contrast,
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10 268 Sato's study included active workers sampled from a general population.³⁴ However, the
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12 269 response rate was relatively low (32%). The generalisability of both studies could be limited.

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14 270 The two studies had different cut-off points of tooth loss. Hayashi's study used the
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16 271 cut-off point of more than 4 teeth lost. The cutoff point is higher than the mean number of
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18 272 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,
19
20 273 respectively) reported by the national statistical surveys.⁴² This study targeted severe cases
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22 274 only. In Sato's study, the outcome was the loss of at least more than one tooth. However, this
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24 275 outcome relied on self-reported answers; therefore, self-reported bias might exist.

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26 276 Both studies showed an increased risk of tooth loss, although only one of the two
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28 277 studies reported a significant association between work stress and tooth loss. However, due
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30 278 to the above limitations, it is difficult to derive any form of conclusion. In the future, a cohort
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32 279 study including general workers should be conducted to confirm these findings.

33 34 280 **Conclusions**

35
36 281 Based on the findings, this systematic review suggests a lack of evidence on the association
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38 282 of work stress with dental caries and tooth loss. Although eight of the nine studies reported
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40 283 significant associations between multiple periodontal measures and work stress, no study
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42 284 used valid epidemiological definitions of periodontal disease. For future research, well-
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44 285 designed cohort studies including potential confounding factors and the use of generally
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46 286 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) 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) 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) 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 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)
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%	Unknown	Job satisfaction: Coefficients = -0.014 (p-value < 0.01) Type A: Coefficients = 0.026 (p-value < 0.05)
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) 43.5%	Age and social class of the household	

established periodontitis
(13 men and 10 women)

Locus of control: Coefficients =
-0.035 (p-value \geq 0.05)
(statistical model was not
reported)

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

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)
52.0%

Age, gender, and levels of
smoking.

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 (\geq 4.0 mm)

Problems of
Everyday Living
Scale of Pearlin and
Schooler

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)
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

Mean clinical attachment loss
<1.5 mm were assigned to a non-
diseased group and those with
mean clinical attachment loss \geq 1.5
mm were assigned to a diseased
group

Life events scale
(yes or no)

Job stress (reference: No): Odds
ratio = 1.71 (95% confidence
interval = 1.10, 2.67) from a
logistic regression analysis

The mean gingival index
yes = 1.851 and no = 1.586 (p-
value > 0.05)

64 working dental
patients of both genders
with ages ranging from
23 to 65 years

Mean age and sex
were not reported.

None

Gingival Index, probing pocket
depth, bleeding on probing, and
clinical attachment level

Life events scale
(yes or no)

Total mean percentage of sites
with probing pocket depth \geq 4
mm
yes = 6.277% and no = 4.762%
(p-values <0.05)

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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)

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)

Having self-reported job stress:
Odds ratio = 7.5 (95% confidence interval = 3.7, 15.02) from a logistic regression analysis

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

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. 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 reported.	None
Ramji, (2011) ²⁴	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 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		None
Islam et al. (2019) ³²	Cross-sectional	Japan	Brief Job Stress Questionnaire developed by referring the demand-control-support model in Japan (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) 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

1 and High stress-low
2 coping)
3 *coping was
4 assessed using a
5 questionnaire
6 developed by a
7 Japanese company

8 **Tooth loss**

9									
10	Hayashi et al.	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 $3 \leq$ teeth lost)	252 male workers employed at a manufacturing company aged 20–59 years	Mean age = 38.7 (standard deviation = 11.0) 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
11	(2001) ³³								
12									
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16	Sato et al.	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)	Median age = 37 (1st and 3rd quartiles = 31 and 43) 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
17	(2020) ³⁴								
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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

1 exposure, or exposure measured as continuous variable)?

2
3 Q9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?

4
5 Q10. Was the exposure(s) assessed more than once over time?

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

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

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

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13 Q14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and
14 outcome(s)?
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1 Figure 1. Flow of search strategy and selection of studies for a systematic review.
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1 The search of two databases (PubMed
2 and Scopus) on August 12, 2020
3 identified 402 records

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5 129 duplicated records were removed

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7 The titles and abstracts of 273 records
8 were screened
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13 Among them, 11 articles met the
14 inclusion criteria
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18 Three additional records were identified
19 through other sources (reference lists and hand
20 search)
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23 Full text assessment of 14 articles were
24 performed
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27 Excluded articles after full-text assessment
28 (n=3; Retracted [n=1] and used composite
29 outcome [n=2])
30

31 Finally, 11 articles were included
32 (n=1, caries and periodontal status; n=8,
33 periodontal status, n=2: tooth loss)
34

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

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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

Page 1 of 2

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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

For more information, visit: www.prisma-statement.org.

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