Worldwide prevalence of carpal tunnel syndrome among dental health care personnel - A systematic review and meta-analysis [version 2; peer review: 1 approved, 1 approved with reservations]

Previously titled: Meta-analysis of the prevalence of Carpal Tunnel Syndrome (CTS) among dental health care personnel

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Abstract

\textbf{Background:} Carpal Tunnel Syndrome (CTS) is one such common disorder among dental health care personnel caused due to the entrapment neuropathy of the median nerve in the carpal tunnel. We aimed to evaluate the pooled estimates of the CTS among dental healthcare personnel.

\textbf{Methods:} We systematically reviewed the existing literature from six databases till January 1\textsuperscript{st}, 2022. Studies reported in English along with the prevalence of CTS or where prevalence could be calculated were included. Independent screening of title and abstracts, and the full text was done by two examiners. Information collected was authors, year of publication, geographic location, type of dental healthcare personnel, sample size, distribution of age, sex, CTS, method of diagnosis, and risk of bias. The random effect model was used to estimate the pooled estimates.
Results: Thirty-seven studies yielded 38 estimates. A total of 17,152 dental health care personnel were included of which 2717 had CTS. The overall pooled prevalence of CTS among the included studies was 15%, with a high heterogeneity. Meta-analysis showed no significant difference in the pooled estimates of CTS between male and female dental healthcare personnel (OR: 0.73; 95% CI: 0.52 -1.02; \( I^2 = 69.71 \)). The pooled estimates among the dentist and dental auxiliaries were 20% and 10%, respectively. The pooled prevalence of CTS with self-reported measures, clinical examination and NCS were 21%, 13% and 8% respectively. Meta-regression showed that the prevalence estimates were significantly associated with publication year (coefficient: 0.006; 95% CI= 0.002-0.01).

Conclusion: One out of seven dental health care personnel may be affected by CTS. No significant difference was seen in the prevalence of CTS between male and female dental healthcare personnel.

Keywords
Carpal Tunnel, Pain, Dentist, Dental students, Dental auxiliaries

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Introduction
Dentistry involves complex procedures with repetitive movements, firm grasp, and fine tactile movements with prolonged static postures often with poor illumination and access. Due to this dental healthcare personnel are prone to various musculoskeletal disorders.

Carpal Tunnel Syndrome (CTS) is one such common disorder among dental health care personnel caused due to the entrapment neuropathy of the median nerve in the carpal tunnel. It can cause sensorimotor symptoms like pain, numbness, tingling, and weakness in the hand leading to loss of grip strength and dexterity. CTS can have negative effects on the individual quality of life, functional disability, limitation of daily living, poor sleep quality, decreased productivity, and the discontinuation of the profession. It can have a significant impact on the individual’s family and the community.

Numerous risk factors like repetitive actions,8 use of vibrating instruments,8,9 pregnancy, diabetes,10 obesity,10 trauma, smoking,11 increasing age,8,12 female sex,9,10,13 wrist diameter ratio,9 clinical experience12 and the number of working hours per day14 have been linked to the development of CTS. Studies have used different modalities for the assessment of CTS. Self-reported measures (for ex: Boston carpal tunnel questionnaire, Nordic questionnaire, hand diagram, Clinical questionnaire by Kamath and Stothard) are the most used methods of assessment. This was followed by nerve conduction studies (NCS) and clinical examination using variety of tests (Tinel’s test, Phalen’s test, or Durkan compression test) and a combination of any of the above methods. A review by MacDermid and Wessel concluded various limitations in establishing a gold standard diagnosis for CTS. This difficulty, combined with methodologic flaws, made interpretations difficult. It was stated that findings of their review may not be conclusive concerning the value of clinical tests in the diagnosis of CTS and recommended furthermore systematic review to address using specific and documented methods.17 Therefore, discussions on why certain tests may be better in specific situations or relevant in different stages of CTS are beyond the scope of this review. Our review focussed on the burden of disease (CTS) among dental health professionals which was by pooling the estimates that have been reported from the literature. Various methods are available in the literature for the diagnosis of CTS which are broadly categorised as self-reported, clinical and nerve conduction studies.

The prevalence of CTS among dental healthcare personnel was reported to be high akin to musculoskeletal disorders when compared to the general population. Data pertaining to the pooled prevalence of CTS and associated risk factors is lacking among dental healthcare personnel. Considering this, our goal was to compile the estimates of the CTS among dental healthcare personnel and explore the potential risk factors that were reported in the literature.

Methods
We systematically reviewed the existing literature to evaluate the prevalence of CTS among dental healthcare personnel. The protocol for this study was registered with “International Platform of Registered Systematic Review and Meta-analysis Protocols” (INPLASY202210084)18 and was reported as per the “PRISMA” guidelines.

Search strategy
A methodical search of six databases (“PubMed, Embase, Dentistry and Oral Sciences Source, CINAHL, Web of Science, and Scopus”) was conducted without any date restrictions till January 1st, 2022. The search terms used were
“dentist” OR “dental student” OR “dental auxiliary” OR “dental hygienist” OR “dental personnel” AND “carpal tunnel syndrome” OR “carpal tunnel” OR “medial nerve entrapment” OR “CTS.”

**Inclusion and exclusion criteria**

Studies written in English that reported the prevalence of CTS using self-reported or clinical tests or NCS or where the prevalence could be determined were included. Studies reported as letters, commentaries, and short communications were excluded.

**Screening**

Studies obtained from various databases were added to “Rayyan – a web-based application” for duplicate removal and title and abstract screening. This was followed by full-text screening and data extraction. Two review authors did the screening independently, and the disagreements, if any, were resolved by a third review author.

**Data extraction**

Two review authors independently performed the data extraction. Information that was collected was authors, year of publication, country, type of dental personnel (Dentist, dental auxiliary or Mixed population), age and sex distribution, age, sex and clinical experience distribution with respect to the distribution of CTS, sample size, number of participants with CTS, method of diagnosis used (self-reported, clinical examination, or NCS), and risk of bias.

**Risk of bias assessments**

Two review authors independently evaluated the risk of bias using a nine-item questionnaire developed by Hoy et al. The first four questions (representative target population and sampling frame, random selection and non-response bias) assessed the external validity and the later five questions (participant or proxy data collection, acceptable case definition, validity and reliability of the instrument, similar data collection for all participants and specifying the numerators and denominators) assessed the internal validity of the study. All the questions were rated as low or high risk. The total score was obtained based on which the studies were graded as low (0-3), moderate (4-6), or high risk of bias (7-9).

**Statistical analysis**

All the analysis was done using OpenMeta software (Metafor Package 1.4, 1999). The random effect model (Restricted maximum likelihood method) was used to estimate the pooled estimates. Subgroup analysis was performed for the type of dental personnel, geographic location, and type of diagnosis. The distribution of the prevalence of CTS between males and females was evaluated using the Binary Random effect model, and the Odds ratio was calculated. Publication bias was assessed using a funnel plot and Fail-Safe N analysis using the Rosenthal approach and Egger regression test. Meta-regression was done with publication year to evaluate time trends in the prevalence estimates. Sensitivity analysis was performed using the Leave one out method. Heterogeneity among the studies was assessed using I² statistics. Underlying data for this review is available at Mendeley datasets.

**Results**

The search of six databases (Embase (n=77), Scopus (n=54), PubMed (n=120), CINAHL (n=465), DOSS (n=570), and Web of Science (n=95)) yielded 1381 studies, of which 249 were duplicates. A total of 1131 studies were subjected to title, and abstract screening out of which 43 studies were eligible for full-text screening. Another nine studies were obtained from manual searching of reference lists at the end of publications resulting in a total of 52 studies for full-text screening. After screening full-text, 15 studies were further excluded due to missing outcome (n=7), the secondary publication (n=3), or inappropriate study design (n=4) and full-text unavailable (n=1). Data extraction was performed for 37 studies which yielded 38 estimates (Figure 1, Table 1).

**Prevalence**

A total of 17,152 dental health care personnel were included in 37 studies of which 2717 had CTS. The prevalence ranged from 0 to 86%.

The overall pooled prevalence of CTS was 15%, with a high heterogeneity (I²=99.18) (Figure 2).

**Age**

Nine studies have not reported the age distribution. The age-specific estimates of CTS lacked uniformity in reporting. The mean age ranged from 21-50 years. Based on the data from the included studies, age estimates with respect to CTS and No CTS was reported by only six studies. Studies that reported age as categorical data could not be analysed as there was no similarity in the categories used (Table 2). Three studies reported age as continuous variable. Meta-analysis showed that there was no significant difference in the age between CTS and No CTS groups (SMD: 0.1; 95%CI: -0.17 – 0.38) (Figure 3).
Figure 1. PRISMA flowchart.

Table 1. Characteristics of the included studies.

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Continent</th>
<th>Diagnosis</th>
<th>Risk of bias</th>
<th>N</th>
<th>Prevalence (%)</th>
<th>Type of dental health care personnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>MacDonald et al. 1988</td>
<td>NA</td>
<td>SR</td>
<td>L</td>
<td>2464</td>
<td>8.69</td>
<td>DA</td>
</tr>
<tr>
<td>Osborn et al. 1990</td>
<td>NA</td>
<td>SR</td>
<td>M</td>
<td>394</td>
<td>6.85</td>
<td>DA</td>
</tr>
<tr>
<td>Conrad et al. 1991</td>
<td>NA</td>
<td>V</td>
<td>L</td>
<td>20</td>
<td>0.00</td>
<td>DA</td>
</tr>
<tr>
<td>Conrad et al. 1992</td>
<td>NA</td>
<td>V</td>
<td>M</td>
<td>16</td>
<td>0.00</td>
<td>DA</td>
</tr>
<tr>
<td>Conrad et al. 1993</td>
<td>NA</td>
<td>V</td>
<td>L</td>
<td>16</td>
<td>0.00</td>
<td>DA</td>
</tr>
<tr>
<td>Nakladalova et al. 1995</td>
<td>Eu</td>
<td>NC</td>
<td>M</td>
<td>120</td>
<td>3.33</td>
<td>DA</td>
</tr>
<tr>
<td>Liss et al. 1995</td>
<td>NA</td>
<td>SR</td>
<td>M</td>
<td>1058</td>
<td>10.21</td>
<td>DA</td>
</tr>
<tr>
<td>Scoggins and Campbell 1995</td>
<td>NA</td>
<td>SR</td>
<td>M</td>
<td>79</td>
<td>5.06</td>
<td>DA</td>
</tr>
<tr>
<td>Rice et al. 1996</td>
<td>NA</td>
<td>PE</td>
<td>L</td>
<td>45</td>
<td>11.11</td>
<td>Mixed</td>
</tr>
</tbody>
</table>
Eight studies have not reported the sex distribution of the participants. Twelve studies reported the prevalence of CTS concerning the sex of which one study had only female participants and was excluded from analysis. Meta-analysis showed no significant difference in the pooled estimates of CTS between male and female dental healthcare personnel (OR: 0.73; 95% CI: 0.52-1.02; P=0.07; I²=69.71) (Figure 4).

Almost half of the studies were reported from North America (n=17), followed by Asia (n=15), Europe (n=4) and South America (n=1). Only one study was reported from South America. High pooled prevalence was seen among studies that were reported from Asia (25%), followed by North America (9%) and Europe (8%) (Table 3).
Figure 2. Forest plot showing the pooled prevalence of CTS.

Table 2. Distribution of age with prevalence of CTS among the included studies.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Age group</th>
<th>No CTS</th>
<th>CTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haghighat et al.</td>
<td>25-34</td>
<td>42</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>35-44</td>
<td>110</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>45-54</td>
<td>41</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>&gt;55</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Prasad et al.</td>
<td>30-40</td>
<td>4</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>40-50</td>
<td>7</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>50-60</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Alhusain et al.</td>
<td>&lt;30</td>
<td>38</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>31-35</td>
<td>45</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>36-40</td>
<td>29</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>&gt;41</td>
<td>43</td>
<td>21</td>
</tr>
</tbody>
</table>
Type of dental personnel

More than half of the included studies were reported among dentists (n=18)\textsuperscript{9,13–15,28,29,31,34–41,43–45,48} followed by dental auxiliaries (n=16).\textsuperscript{12,22–25,28,29,32,33,35,42,49–52} The pooled estimates among the dentist and dental auxiliaries were 20% and 10%, respectively (Table 3).

### Table 3. Subgroup analysis of the pooled estimates of overall MSD.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Estimate (95% CI)</th>
<th>Q</th>
<th>I$^2$</th>
<th>Number of estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>0.15 (0.10-0.2)</td>
<td>2073.13</td>
<td>99.18</td>
<td>38</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>0.14 (0.09-0.19)</td>
<td>265.61</td>
<td>96.41</td>
<td>11</td>
</tr>
<tr>
<td>Female</td>
<td>0.17 (0.11-0.23)</td>
<td>417.15</td>
<td>95.44</td>
<td>12</td>
</tr>
<tr>
<td>Dental personnel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dentists</td>
<td>0.2 (0.12-0.28)</td>
<td>1045.42</td>
<td>99.4</td>
<td>19</td>
</tr>
<tr>
<td>Dental auxiliaries</td>
<td>0.1 (0.05-0.14)</td>
<td>182.68</td>
<td>96.6</td>
<td>16</td>
</tr>
<tr>
<td>Mixed</td>
<td>0.15 (0.03-0.27)</td>
<td>48.76</td>
<td>93.92</td>
<td>3</td>
</tr>
<tr>
<td>Continent</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North America</td>
<td>0.09 (0.05-0.12)</td>
<td>1291.72</td>
<td>97.61</td>
<td>18</td>
</tr>
<tr>
<td>Europe</td>
<td>0.08 (0.04-0.13)</td>
<td>27.46</td>
<td>90.64</td>
<td>4</td>
</tr>
<tr>
<td>Asia</td>
<td>0.25 (0.15-0.35)</td>
<td>546.87</td>
<td>97.96</td>
<td>15</td>
</tr>
<tr>
<td>Risk of bias</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>0.17 (0.11-0.22)</td>
<td>2028.49</td>
<td>99.33</td>
<td>31</td>
</tr>
<tr>
<td>Moderate</td>
<td>0.09 (0.05-0.13)</td>
<td>44.53</td>
<td>91.23</td>
<td>7</td>
</tr>
<tr>
<td>Method of diagnosis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-reported</td>
<td>0.21 (0.13-0.29)</td>
<td>1154.82</td>
<td>99.4</td>
<td>20</td>
</tr>
<tr>
<td>Physical examination</td>
<td>0.13 (0.09-0.16)</td>
<td>7.36</td>
<td>47.12</td>
<td>5</td>
</tr>
<tr>
<td>Nerve conduction studies</td>
<td>0.08 (0.03-0.12)</td>
<td>85.93</td>
<td>95.49</td>
<td>10</td>
</tr>
</tbody>
</table>
Clinical experience
A total of seven studies reported clinical experience which was either continuous (n=3) \cite{9,32,42} or categorical (n=4). \cite{14,40,43,44} Meta-analysis showed that there was no significant difference in the mean clinical experience between the groups (SMD: -0.03; 95%CI: -0.31 – 0.24) (Figure 5). Categorical data on clinical experience was categorized as < 10 years and >10 years for analysis. Meta-analysis showed no significant difference in the pooled estimates between different levels of clinical experience (OR: 0.76; 95%CI: 0.39-1.47) (Figure 6).

Method of diagnosis
The majority of the included studies (n=21) had used only self-reported measures for estimating the prevalence of CTS. \cite{13-16,23,24,30,31,38-50} Nine studies have used nerve conduction studies \cite{9,12,25,28-30,33,35,37} out of which four studies used clinical examination along with NCS. \cite{9,33-35} Only five studies have used clinical examination. \cite{26,27,32,34,36} Three studies conducted have used Vibrometry and have reported nil prevalence. \cite{22,51,52} The pooled prevalence of CTS with self-reported measures, clinical examination and NCS were 21%, 13% and 8% respectively (Table 3).

Risk of bias
Majority of the studies (n=30) were in the low-risk category with a pooled prevalence of 17% (Tables 1, 3 and 4). \cite{9,12-16,26-37,39,40,42-49,51,52}
Table 4. Continued

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q5</th>
<th>Q6</th>
<th>Q7</th>
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<td>Borhan et al. 2013</td>
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<td>Khan et al. 2014</td>
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<td>Ehsan et al. 2016</td>
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Q1: Study's target population a close representation of the national population in relation to relevant variables; Q2: Sampling frame a true or close representation of the target population; Q3: Random selection used to select the sample; Q4: Likelihood of non-response; Q5: Data collected from subjects; Q6: Acceptable case definition; Q7: Reliability and validity of the instrument; Q8: Same mode of data collection; Q9: Appropriate numerators and denominators; 0: low risk; 1: high risk.

Publication bias
The funnel plot showed publication bias (Fail safe N=26129; P-value<0.001). Egger Regression Test for Funnel Plot Asymmetry showed asymmetry (Z=2.187; P=0.029) (Figure 7). Inverse standard error in the y-axis depicts the precision of the studies. It helps in identifying the studies with lower precision which will be distributed at the bottom. Inverse standard error was selected as there was no inversion required when compared to plots that use standard error in the y-axis where studies with large sample sizes and lower standard error are place in the top of the graph. The plot showed asymmetry where in large studies showed higher precision and lower prevalence estimates whereas smaller studies had lower precision and higher prevalence estimates.

Sensitivity analysis
We performed sensitive analysis using Leave -one out method. The prevalence estimate marginally decreased to 13% after removal of Prasad et al.43

Meta-regression
A meta-regression was performed to evaluate the pooled estimates of CTS with publication year. The prevalence estimates were significantly associated with publication year (coefficient: 0.006; 95% CI=0.002-0.01; P=0.002) (Figure 8).
Discussion
We conducted a systematic review of the prevalence of CTS among dental healthcare personnel. Many systematic reviews reported a high prevalence of musculoskeletal disorders among these professionals\(^1\)–\(^7\) without emphasizing the CTS.

High heterogeneity was observed among the studies that were included in this review. The overall pooled prevalence of CTS was 15\% obtained from 38 estimates. It was higher among dentists than dental auxiliaries. The prevalence was higher than the reported studies among other professionals (9.6\%).\(^5,54\) The age-standardised prevalence rates of confirmed clinical and NCS were 2.1 and 3\% among males and females, respectively.\(^5\) A study among Danish office workers reported a confirmed CTS prevalence of 5\%.\(^5\) It was reported that repetitive activity and firm gripping could be a major risk factor for the development of CTS.\(^5\) This suggests that dental healthcare personnel have a higher risk of CTS than the general population. In our analysis, only six studies reported a prevalence of less than 5\%.\(^2,25,28,30,51,52\) More than half of the studies showed higher than 10\% prevalence.\(^9,14,16,24,26,31,45,47,48\) There was substantial variation in the estimates of CTS with geographic location. Studies reported from Asia showed a high pooled prevalence of CTS.

The pooled prevalence among male and female dental healthcare personnel was 14 and 17\%, respectively. Few studies have reported female predilection to CTS among dental healthcare personnel\(^9,1,16\) and the general population.\(^57\) However, we found no significant difference between male and female dental healthcare personnel.
There were substantial variations in the assessment of CTS among the included studies. Methods like self-reported measures, clinical examination (Tinel’s test, Phalen’s test, or compression test), Vibrometry and NCS were used for the assessment of CTS. Studies that used self-reported measures showed higher pooled prevalence than those studies that used clinical examination and NCS for the diagnosis of CTS. NCS is a useful tool and can be used as complimentary methods with clinical examination in the assessment of CTS. It is not recommended to be used as a sole method of diagnosis as it has limitations like difficulty in the assessment of nerve injuries that are very distal or proximal to the extremity, timing of the test, expertise of the examiner, multi-level injury along the course of nerve or systemic polyneuropathy. Also, the nerve latency is mainly due to the available myelinated fibers than the affected fibers. Due to the above reasons, a thorough physical examination of hand is a prerequisite for the diagnosis of CTS.

Many conditions like systemic neurologic disorders (motor neuron disease, multiple sclerosis, and hereditary neuropathy), cervical spine disorders (cervical spondylotic myelopathy, cervical radiculopathy, and syringomyelia), tumors (Pancoast tumor, benign peripheral nerve tumors, malignant peripheral nerve sheath tumors, intraneural ganglia), inflammatory and autoimmune disorders (Parsonage-Turner syndrome, Peripheral neuropathy), other nerve compression syndromes (thoracic outlet syndrome and pronator syndrome) can mimic CTS. 58

During training years, emphasis should be on the potential role of dental profession in the development of CTS and other musculoskeletal disorders. There is a need for the development and implementation of preventive strategies for early detection and prevention of CTS. Comprehensive preventive strategies like workplace postural requirements and adoption of ergonomic postures, use of ergonomically designed instruments and equipment to reduce strain on the hand and wrist, the importance of intermittent breaks between patients, an alternation between the activities, keeping wrists in a neutral position, strengthening and stretching daily which aid in alleviating the muscular tension and promote blood circulation, minimize repetitive movements and management of patient flow can be incorporated into the curriculum during training years to prevent or minimise the onset of musculoskeletal disorders. Regular monitoring and evaluation of musculoskeletal disorders need to be mandated for high-risk individuals. Workplace-associated CTS must be identified earlier, and care should be exercised on the prevention and progression of the development of CTS. Active referral should be initiated by the employer who is at risk of development of CTS. It is important for the dental health care professional to be aware of the symptoms of CTS.

The management of CTS includes conservative methods like wrist splinting in the neutral position at night, analgesics, corticosteroid injections, nerve and tendon gliding exercises with varying degrees of results. Also, the carpal tunnel can be surgically decompressed to relieve the symptoms when there is a lack of response to the above. 59 Early diagnosis will help in initiating early interventions like medication, splinting, and changes in daily activities and can be relieved without surgical interventions. Therefore, a multi-pronged approach with ergonomic guidelines, workload management strategies, and health education and prevention can significantly reduce the risk of CTS among dental personnel and enhance their occupational well-being.

Our review included studies over four decades and it was seen that there was an increasing trend in the prevalence estimates of CTS. This could be attributed to many factors like increasing workload, increasing awareness about CTS, comorbidities etc.

Further large high-quality studies using clinical examination for the identification of CTS among a representative sample of dental health care personnel using STROBE guidelines are required for calculating robust prevalence estimates. A larger sample would allow for a more representative distribution of demographic and professional characteristics, enabling researchers to explore potential subgroups that may be more susceptible to CTS. Also, a larger sample size would provide more statistical power to detect significant associations and to examine the effects of potential confounding factors. Case control studies are required to understand the role of the dental profession as a risk factor for the development of CTS. Studies can use self-reported questionnaires to screen potential participants following which a clinical examination using various tests need to be adopted to diagnose CTS. Furthermore, adapting standardized, validated diagnostic criteria for CTS across studies would facilitate more apt comparisons of different studies and enhance the reliability of the study findings.

High heterogeneity among the included studies, inclusion of only studies that were reported in English, publication bias, lack of age specific estimates, and variations in the assessment of CTS are some of the limitations. Publication bias was due to less precise studies with high prevalence estimates which could have distorted the overall estimates. Language bias due to the inclusion of studies that were reported in English could have over or under-estimated the overall pooled estimates. Although, most of the studies had low risk of bias, the lack of acceptable diagnostic standards could have caused considerable heterogeneity.
Implications of CTS can be at an individual, family or workplace level. Symptoms like pain, numbness, tingling and weakness in the hand and fingers can lead to significant functional disability to the dental personnel while performing the dental procedures. There by substantially affecting the individuals’ quality of life in performing daily activities and decreased productivity at workplace leading to loss of work, workplace absenteeism along with financial losses. Indirectly, employers can face decreased productivity and loss of time in hiring new professionals. This can affect the overall productivity. Moreover, CTS can have a profound impact on the outside of the work, affecting simple tasks like writing, typing and grasping objects which may become challenging and be a limitation in their professional and personal activities alike.

Findings of this review highlight the potential impact of CTS among dental healthcare personnel. Policymakers need to ensure the development and implementation of the guidelines for the prevention of work-related musculoskeletal disorders and the incorporation of the same into the curriculum. Occupational Safety and Health Administration guidelines on the prevention of work-related musculoskeletal disorders have elements like management support, involvement of staff, training, identification of problems, early reporting, solutions to control hazards and evaluation (https://www.osha.gov/ergonomics). It should also emphasize the importance of the number of patients seen and attended, periodic breaks, task rotation, workflow and workload in the prevention of musculoskeletal disorders.

Conclusion
One out of seven dental health care personnel may be affected by CTS. There was no difference in the prevalence of CTS between male and female dental healthcare personnel. Dentists more than dental auxiliaries are affected by CTS. No significant difference was seen with age and clinical experience of the dental health care personnel with the prevalence of CTS. Future studies should explore the relationship between various potential risk factors and CTS. There is a need to develop and incorporate guidelines for the prevention of work-related musculoskeletal disorders into the training curriculum. Continuing dental education programs for the prevention of musculoskeletal disorders need to be conducted for the benefit of dental health care personnel.

Data availability
Underlying data
Mendeley Data: Pooled prevalence of Carpal Tunnel syndrome among dental health care providers, https://doi.org/10.17632/m2tytmjdzf.2.

This project contains the following underlying data:
- Data CTS mendeley.xlsx

Reporting guidelines

Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0).

References


Open Peer Review

Current Peer Review Status: ?  ✓

Version 2

Reviewer Report 20 July 2023

https://doi.org/10.5256/f1000research.152898.r188750

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Y. Ravi Shankar Reddy
Department of Medical Rehabilitation Sciences, College of Applied Medical Sciences, King Khalid University, Abha, Aseer Province, Saudi Arabia

I believe the authors have effectively responded to the reviewers' comments in the revised manuscript, so I have no additional remarks to add.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Musculoskeletal Rehabilitation

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Version 1

Reviewer Report 19 June 2023

https://doi.org/10.5256/f1000research.144521.r178238

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Y. Ravi Shankar Reddy
Department of Medical Rehabilitation Sciences, College of Applied Medical Sciences, King Khalid University, Abha, Aseer Province, Saudi Arabia

Title: Meta-analysis of the prevalence of Carpal Tunnel Syndrome (CTS) among dental health care
personnel.

1. Provide a clear rationale for conducting the study and highlight the gap in the existing literature that the study aims to address.

2. Clearly define the inclusion and exclusion criteria for the selection of studies to ensure transparency and reproducibility.

3. Discuss the methods used for data extraction and risk of bias assessment in more detail, including the specific items evaluated in the risk of bias assessment tool.

4. Address the high level of heterogeneity among the included studies and discuss potential reasons for this heterogeneity. Explore possible sources of variation, such as differences in study design, participant characteristics, diagnostic methods, or geographic location.

5. Provide a more comprehensive discussion of the limitations of the study, including the potential impact of publication bias, language restriction, and the quality of the included studies.

6. Discuss the implications of the findings in more depth, including the potential impact of CTS on the quality of life, functional disability, and productivity of dental healthcare personnel.

7. Consider the potential confounding factors or interactions that could influence the relationship between CTS and dental healthcare personnel, such as the duration of practice, specific dental procedures performed, or the use of ergonomic interventions.

8. Provide recommendations for future research based on the identified limitations and gaps in knowledge. Discuss the need for studies with larger sample sizes, more rigorous study designs, and standardized diagnostic criteria.

9. Discuss the practical implications of the findings and potential interventions that can be implemented to reduce the risk of CTS among dental healthcare personnel. Consider the development of guidelines for ergonomic practices, workload management, and education on early detection and prevention of CTS.

10. Ensure that the conclusion aligns with the findings of the study and emphasizes the key takeaways for researchers, clinicians, and policymakers.

11. Consider the broader implications of the study findings, such as the potential impact on healthcare policy, occupational health and safety regulations, and professional training programs for dental healthcare personnel.

12. Finally, acknowledge any limitations of the study not previously discussed and provide suggestions for further research in the field of CTS among dental healthcare personnel.

Are the rationale for, and objectives of, the Systematic Review clearly stated?
Yes

Are sufficient details of the methods and analysis provided to allow replication by others?
Partly

**Is the statistical analysis and its interpretation appropriate?**

Partly

**Are the conclusions drawn adequately supported by the results presented in the review?**

Yes

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Musculoskeletal Rehabilitation

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

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**Author Response 10 Jul 2023**

**Kalyana Pentapati**

We thank your efforts in reviewing the manuscript. Below are the responses for your comments.

**Query:** Provide a clear rationale for conducting the study and highlight the gap in the existing literature that the study aims to address.

**Response:** We added the following information: Data pertaining to the pooled prevalence of CTS and associated risk factors is lacking among dental healthcare personnel.

**Query:** Clearly define the inclusion and exclusion criteria for the selection of studies to ensure transparency and reproducibility.

**Response:** We have revised as follows: Studies written in English that reported the prevalence of CTS using self-reported or clinical tests or NCS or where the prevalence could be determined were included. Studies reported as letters, commentaries, and short communications were excluded.

**Query:** Discuss the methods used for data extraction and risk of bias assessment in more detail, including the specific items evaluated in the risk of bias assessment tool.

**Response:** Revised the information as below:

Two review authors independently performed the data extraction. Information that was collected was authors, year of publication, country, type of dental personnel (Dentist, dental auxiliary or Mixed population), age and sex distribution, age, sex and clinical experience distribution with respect to the distribution of CTS, sample size, number of participants with CTS, method of diagnosis used (self-reported, clinical examination, or NCS), the sex distribution of CTS and risk of bias.

The first four questions (representative target population and sampling frame, random selection and non-response bias) assessed the external validity and the later five questions (participant or proxy data collection, acceptable case definition, validity and reliability of the instrument, similar data collection for all participants and specifying the numerators and denominators)
denominators) assessed the internal validity of the study. All the questions were rated as low or high risk.

Query: Address the high level of heterogeneity among the included studies and discuss potential reasons for this heterogeneity. Explore possible sources of variation, such as differences in study design, participant characteristics, diagnostic methods, or geographic location.

Response: We attempted to explore the reasons for heterogeneity using sub-group analysis. The nature of the study design was same for all the studies. With respect to participant characteristics, we analysed based on the type of dental health care personnel which also showed high heterogeneity. Similar, was the case with geographic location. With respect to type of diagnosis, clinical examination showed lower levels of heterogeneity (<50%) than other modalities of diagnosis. However, the number of studies that used clinical examination were less (n=5).

Query: Provide a more comprehensive discussion of the limitations of the study, including the potential impact of publication bias, language restriction, and the quality of the included studies.

Response: Added the following information: Publication bias was due to less precise studies with high prevalence estimates which could have distorted the overall estimates. Language bias due to inclusion of studies that were reported in English could have over or underestimated the overall pooled estimates. Although, most of the studies had low risk of bias, the lack of acceptable diagnostic standard could have caused considerable heterogeneity.

Query: Discuss the implications of the findings in more depth, including the potential impact of CTS on the quality of life, functional disability, and productivity of dental healthcare personnel.

Response: Added the following information: Implications of CTS can be at an individual, family or workplace level. Symptoms like pain, numbness, tingling and weakness in the hand and fingers can lead to significant functional disability to the dental personnel while performing the dental procedures. There by substantially affecting the individuals' quality of life in performing daily activities and decreased productivity at workplace leading to loss of work, work place absenteeism along with financial losses. Indirectly, employers can face decreased productivity and loss of time in hiring new professionals. This can affect the overall productivity. Moreover, CTS can have a profound impact on the outside of the work, affecting simple tasks like writing, typing and grasping objects which may become challenging and be a limitation in their professional and personal activities alike.

Query: Consider the potential confounding factors or interactions that could influence the relationship between CTS and dental healthcare personnel, such as the duration of practice, specific dental procedures performed, or the use of ergonomic interventions.

Response: We agree with reviewers about the role of potential confounders. We have included the data specific to age and clinical experience with respect to CTS. However, data on other factors like type of dental procedures and use of ergonomic interventions have not been reported in relation to the CTS prevalence among the included studies. It is crucial for further research to account for these confounding factors and assess their relationship between CTS and dental healthcare personnel.
Query: Provide recommendations for future research based on the identified limitations and gaps in knowledge. Discuss the need for studies with larger sample sizes, more rigorous study designs, and standardized diagnostic criteria.

Response: Added information as below:
Further large high-quality studies using clinical examination for the identification of CTS among a representative sample of dental health care personnel using STROBE guidelines are required for calculating robust prevalence estimates. A larger sample would allow for a more representative distribution of demographic and professional characteristics, enabling researchers to explore potential subgroups that may be more susceptible to CTS. Also, a larger sample size would provide more statistical power to detect significant associations and to examine the effects of potential confounding factors. Case control studies are required to understand the role of dental profession as risk factor for the development of CTS. Studies can use self-reported questionnaires to screen potential participants following which a clinical examination using various tests need to be adopted to diagnose CTS. Furthermore, adapting standardized, validated diagnostic criteria for CTS across studies would facilitate more apt comparisons of different studies and enhance the reliability of the study findings.

Query: Discuss the practical implications of the findings and potential interventions that can be implemented to reduce the risk of CTS among dental healthcare personnel. Consider the development of guidelines for ergonomic practices, workload management, and education on early detection and prevention of CTS.

During training years, emphasis should be on the potential role of dental profession in the development of CTS and other musculoskeletal disorders. There is need for the development and implementation of preventive strategies for early detection and prevention of CTS. Comprehensive preventive strategies like workplace postural requirements and adoption of ergonomic postures, use of ergonomically designed instruments and equipment to reduce strain on the hand and wrist, the importance of intermittent breaks between patients, an alternation between the activities, keeping wrists in a neutral position, strengthening and stretching daily which aid in alleviating the muscular tension and promote blood circulation, minimize repetitive movements and management of patient flow can be incorporated into the curriculum during training years to prevent or minimise the onset of musculoskeletal disorders. Regular monitoring and evaluation of musculoskeletal disorders need to be mandated for high-risk individuals. Workplace-associated CTS must be identified earlier and care should be exercised on the prevention and progression of the development of CTS. Active referral should be initiated by the employer who is at risk of development of CTS. It is important for the dental health care professional to be aware of the symptoms of CTS. Early diagnosis will help in initiating early interventions like medication, splinting, and changes in daily activities and can be relieved without surgical interventions. Therefore, a multi-pronged approach with ergonomic guidelines, workload management strategies, and health education and prevention can significantly reduce the risk of CTS among dental personnel and enhance their occupational well-being.

Query: Ensure that the conclusion aligns with the findings of the study and emphasizes the key takeaways for researchers, clinicians, and policymakers.

Response: Future studies should explore the relationship between various potential risk factors.
factors and CTS. There is a need to develop and incorporate guidelines for the prevention of work-related musculoskeletal disorders into the training curriculum. Continuing dental education programs for the prevention of musculoskeletal disorders need to be conducted for the benefit of dental health care personnel.

**Query:** Consider the broader implications of the study findings, such as the potential impact on healthcare policy, occupational health and safety regulations, and professional training programs for dental healthcare personnel.

**Response:** Findings of this review highlight the potential impact of CTS among dental healthcare personnel. Policymakers need to ensure the development and implementation of the guidelines for the prevention of work-related musculoskeletal disorders and the incorporation of the same into the curriculum. Occupational Safety and Health Administration guidelines on the prevention of work-related musculoskeletal disorders have elements like management support, involvement of staff, training, identification of problems, early reporting, solutions to control hazards and evaluation. It should also emphasize the importance of the number of patients seen and attended, periodic breaks, task rotation, workflow and workload in the prevention of musculoskeletal disorders.

**Query:** Finally, acknowledge any limitations of the study not previously discussed and provide suggestions for further research in the field of CTS among dental healthcare personnel.

**Response:** The information below was added:

Further large high-quality studies using clinical examination for the identification of CTS among a representative sample of dental health care personnel using STROBE guidelines are required for calculating robust prevalence estimates. A larger sample would allow for a more representative distribution of demographic and professional characteristics, enabling researchers to explore potential subgroups that may be more susceptible to CTS. Also, a larger sample size would provide more statistical power to detect significant associations and to examine the effects of potential confounding factors. Case control studies are required to understand the role of the dental profession as a risk factor for the development of CTS. Studies can use self-reported questionnaires to screen potential participants following which a clinical examination using various tests need to be adopted to diagnose CTS. Furthermore, adapting standardized, validated diagnostic criteria for CTS across studies would facilitate more apt comparisons of different studies and enhance the reliability of the study findings.

High heterogeneity among the included studies, inclusion of only studies that were reported in English, publication bias, lack of age specific estimates, and variations in the assessment of CTS are some of the limitations. Publication bias was due to less precise studies with high prevalence estimates which could have distorted the overall estimates. Language bias due to the inclusion of studies that were reported in English could have over or under-estimated the overall pooled estimates. Although, most of the studies had low risk of bias, the lack of acceptable diagnostic standards could have caused considerable heterogeneity.

**Competing Interests:** Nil
Dileep Nag Vinnakota

Department of Prosthodontics, Narayana Dental College, Nellore, Andhra Pradesh, India

Rekhalakshmi Kamatham

Department of Paedodontics and Preventive Dentistry, Narayana Dental College, Nellore, Andhra Pradesh, India

I have gone through the meta-analysis sent for peer review. The topic seems interesting, but there are lot of flaws which are of concern. I have mentioned the possibilities of changing the manuscript section wise.

Title: The authors have mentioned the title as “Meta-analysis of the prevalence of carpal tunnel syndrome among dental health care personnel”. I feel the title can be improved as “Prevalence of carpal tunnel syndrome among dental health care personnel worldwide - A systematic review and meta-analysis”

Introduction: The need for the study has been focused by the authors properly. However, can elaborate on the clinical diagnosis of the condition (including the sensitivity and specificity of the tests), and a note on the differential diagnosis. A systematic review is also published on the diagnosis of this condition. This part is important as it has a link with the way the authors can mold the quality of the present systematic review.

Methodology: Many sections are poorly written.

• The authors can mention the keywords separately as MeSH words and alternate words employed for the search.

• The inclusion and exclusion criteria are not proper. The authors can consider only those studies that have employed nerve conduction tests, instead of considering those with self-report. There are definite chances of bias, if the self-reported measures are considered for diagnosis. Also many factors like number of years practised in dentistry, number of working hours, the knowledge of ergonomics, and age of the dental personnel all play a key role on prevalence. The authors did not take any step to cut down the effect of confounding factors in their criteria for inclusion.

• Under extraction of data, in text, the authors have mentioned that ‘information regarding country of study’, but in the table the authors have considered only continent.

• Under risk of bias assessment, the authors have mentioned that risk was evaluated using a nine item questionnaire. The authors have to elaborate the items in a tabular form along with the total scores obtained by individual studies. Need to mention the reason for not
considering the STROBE guidelines for evaluation? I think they can add this part also.

○ Under statistical analysis, the authors did not mention the test employed for the publication bias. Is it Begg and Egger test?

Results:
○ It is clearly evident from Table 1 that the prevalence is more in studies that have diagnosed the condition using self-reported measures. The type of dental health care personnel also cannot be combined; the work done by dentists is different from dental assistants. The mean age as mentioned in the review is in the range of 21-50 years, which is too long. All these have an influence on the overall estimate mentioned.

○ Clarity of the forest plot showing gender differences is not clear. The authors need to mention the sides as male and female, so that the readers can easily depict the side which is favoured.

○ Under publication bias, the authors did not explain about the symmetry of the funnel plot. What is inverse standard error? Also, the reason for selecting the inverse standard error needs mentioning. The scatter plot needs explanation regarding the precision of individual studies.

○ Under sensitivity analysis, the authors need to mention the outliers and the explanation of difference in the overall estimate after removal of studies with high prevalence like Prasad et al (2017).

Discussion: Discussion is not enough. Authors can discuss the importance of case control studies to know whether dentists are really more prone for this condition compared to normal population. Authors can discuss about the ergonomics to prevent these conditions. Can discuss about differential diagnosis of this condition and discuss about other neurologic, musculoskeletal and vascular conditions that have similar symptoms as carpal tunnel syndrome. Also, management of this condition (non-surgical and exercises) needs mentioning.

References

Are the rationale for, and objectives of, the Systematic Review clearly stated?
Yes

Are sufficient details of the methods and analysis provided to allow replication by others?
Partly

Is the statistical analysis and its interpretation appropriate?
Yes

Are the conclusions drawn adequately supported by the results presented in the review?
Partly

Competing Interests: No competing interests were disclosed.
Reviewer Expertise: Implantology, Full mouth rehabilitation

We confirm that we have read this submission and believe that we have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however we have significant reservations, as outlined above.

Author Response 10 Jul 2023

Kalyana Pentapati

Thank you for the effort and time take in reviewing this manuscript. Below are our responses to your comments.

Reviewer 1:
I have gone through the meta-analysis sent for peer review. The topic seems interesting, but there are lot of flaws which are of concern. I have mentioned the possibilities of changing the manuscript section wise.

Title: The authors have mentioned the title as “Meta-analysis of the prevalence of carpal tunnel syndrome among dental health care personnel”. I feel the title can be improved as “Prevalence of carpal tunnel syndrome among dental health care personnel worldwide - A systematic review and meta-analysis”

Response: We will edit the same in our manuscript “Worldwide prevalence of carpal tunnel syndrome among dental health care personnel - A systematic review and meta-analysis”

Introduction: The need for the study has been focused by the authors properly. However, can elaborate on the clinical diagnosis of the condition (including the sensitivity and specificity of the tests), and a note on the differential diagnosis. A systematic review is also published on the diagnosis of this condition. This part is important as it has a link with the way the authors can mold the quality of the present systematic review.

Response: Thank you for your valuable insight. We had gone through MacDermid and Wessel to understand the value-added points. They concluded that the primary limitation of establishing a gold standard diagnosis for CTS. This difficulty, combined with methodologic flaws, made interpretation difficult. Also, there was no guarantee that these choices increased the validity of our results. It was also stated that we should not consider the findings of this review to be conclusive concerning the value of clinical tests in the diagnosis of CTS. Furthermore, a systematic review requires that issues be addressed using specific and documented methods. Therefore, discussions on why certain tests may be better in specific situations or relevant in different stages of CTS are beyond the scope of this review. Our review focussed on the burden of disease (CTS) among dental health professionals which was by pooling the estimates that have been reported from the literature. Various methods are available in the literature for the diagnosis of CTS which are broadly categorized as self-reported, clinical, and nerve conduction studies. All these tests have their own advantages and limitations that are discussed by the authors of these primary studies.

Methodology: Many sections are poorly written.
**Query:** The authors can mention the keywords separately as MeSH words and alternate words employed for the search.

**Response:** MeSH words are only specific for Pubmed. We have used All fields option for all the databases and have not restricted our search to title, abstract and keywords search. Based on our previous review experience on musculoskeletal disorders, we noticed that few studies that reported prevalence estimates of musculoskeletal disorders have reported carpal tunnel syndrome. If we restrict our search to title, abstract and keywords, these studies would be missed during the first stage of screening. We will reframe the sentence as search terms instead of keywords in the manuscript.

**Query:** The inclusion and exclusion criteria are not proper. The authors can consider only those studies that have employed nerve conduction tests, instead of considering those with self-report. There are definite chances of bias, if the self-reported measures are considered for diagnosis. Also many factors like number of years practiced in dentistry, number of working hours, the knowledge of ergonomics, and age of the dental personnel all play a key role on prevalence. The authors did not take any step to cut down the effect of confounding factors in their criteria for inclusion.

**Response:** There is no consensus or gold standard for the diagnosis of carpal tunnel syndrome. Nerve conduction studies are a useful tool and can be used as complementary methods with clinical examination in the assessment of CTS. Use of such methods in epidemiological surveys is quite challenging as it is costly, requires trained personnel to perform and interpret and cannot be used alone for the diagnosis of CTS. Hence, there were many attempts to develop self-reported measures and clinical examination for the diagnosis of CTS. Self-reported measures like boston carpal tunnel questionnaire has been used widely and was shown to have acceptable validity and reliability in many previous studies. We agree that there were will be bias, hence we reported the estimates of CTS as per the diagnostic method used in the primary studies.

We have revised the sentence: Studies written in English that reported the prevalence of CTS using self-reported or clinical tests or NCS or where the prevalence could be determined were included. Studies reported as letters, commentaries, and short communications were excluded.

We agree with reviewers that there are many factors (years practiced in dentistry, number of working hours, the knowledge of ergonomics, and age of the dental personnel) on the prevalence estimates. The main aim of this review was to quantify the prevalence estimates obtained from the published literature. To look at these factors that may have the effect of confounding, it is imperative that published literature reports that prevalence estimates as per age groups, work experience, level of ergonomics, etc. We have reviewed the included studies and extracted data on age, clinical experience, and gender distribution as per the CTS distribution.

**Response:** We will include the information below in the manuscript.

Based on the data from the included studies, age estimates with respect to CTS and No CTS
was reported by only six studies. Studies that reported age as categorical data could not be analysed as there was no similarity in the categories used (Table 2). Three studies reported age as continuous variable. Meta-analysis showed that there was no significant difference in the age between CTS and No CTS groups (SMD: 0.1; 95%CI: -0.17 – 0.38) (figure 3).

A total of seven studies reported clinical experience which was either continuous (n=3) or categorical (n=4). Meta-analysis showed that there was no significant difference in the mean clinical experience between the groups (SMD: -0.03; 95%CI: -0.31 – 0.24) (Figure 5). Categorical data on clinical experience was categorized as < 10 years and > 10 years for analysis. Meta-analysis showed no significant difference in the pooled estimates between different levels of clinical experience (OR: 0.76; 95%CI: 0.39-1.47) (Figure 6).

Query: Under extraction of data, in text, the authors have mentioned that ‘information regarding country of study’, but in the table the authors have considered only continent. Response: Yes. We have collected the information on country. However, country wise estimates were not feasible. Hence, we pooled the estimates as per the continent.

Query: Under risk of bias assessment, the authors have mentioned that risk was evaluated using a nine-item questionnaire. The authors have to elaborate the items in a tabular form along with the total scores obtained by individual studies. Need to mention the reason for not considering the STROBE guidelines for evaluation? I think they can add this part also. Response: Thank you for your comments. We will incorporate the item-wise scores for individual studies. The questionnaire used for quality assessment was validated and primarily developed for the assessment of risk of bias for systematic reviews on prevalence studies. STROBE guidelines are primarily intended as a checklist for reporting cross-sectional studies. The valid overall risk of bias scores cannot be computed so that studies can be rated as high or low risk of bias from STROBE guidelines. Hence, it was not used in this study.

Query: Under statistical analysis, the authors did not mention the test employed for the publication bias. Is it Begg and Egger test? Response: We have used Fail-Safe N analysis using the Rosenthal approach. We will add this information also in the manuscript. Statistical analysis: Publication bias was assessed using a funnel plot and Fail-Safe N analysis using the Rosenthal approach and Egger regression test. Publication bias: Egger Regression Test for Funnel Plot Asymmetry showed asymmetry (Z=2.187; P=0.029).

Query: It is clearly evident from Table 1 that the prevalence is more in studies that have diagnosed the condition using self-reported measures. The type of dental health care personnel also cannot be combined; the work done by dentists is different from dental
assistants. The mean age as mentioned in the review is in the range of 21-50 years, which is too long. All these have an influence on the overall estimate mentioned.

**Response:** Yes, we agree with the reviewer that self-reported measures have yielded higher estimates and we have reported the estimates as per the diagnostic criteria used in the studies. We also agree with the fact that type of dental health care personnel cannot be combined as all have different range of work but all these personnel do activities that requires repetitive movements, firm grasp, and fine tactile movements with prolonged static postures. Many studies which were included in this review have included all types of dental health personnel. Studies that reported prevalence separately were captured separately. In our review, we have mentioned the estimates as per the type of healthcare personnel. We understand that all these factors along with age and clinical experience have potential influence. This review is focussed on the burden of CTS among these dental health care personnel.

**Query:** Clarity of the forest plot showing gender differences is not clear. The authors need to mention the sides as male and female so that the readers can easily depict the side which is favoured.

**Response:** We will edit the figure in the manuscript as per your recommendation.

**Image 6**

**Query:** Under publication bias, the authors did not explain about the symmetry of the funnel plot. What is inverse standard error? Also, the reason for selecting the inverse standard error needs mentioning. The scatter plot needs an explanation regarding the precision of individual studies.

**Response:** We will add the following details to the manuscript.

Inverse standard error in the y-axis depicts the precision of the studies. It helps in identifying the studies with lower precision which will be distributed at the bottom. Inverse standard error was selected as there was no inversion required when compared to plots that use standard error in the y-axis where studies with large sample sizes and lower standard error are placed at the top of the graph. The plot showed asymmetry where in large studies showed higher precision and lower prevalence estimates whereas smaller studies had lower precision and higher prevalence estimates.

**Query:** Under sensitivity analysis, the authors need to mention the outliers and the explanation of difference in the overall estimate after the removal of studies with high prevalence like Prasad et al (2017).

**Response:** We performed a sensitivity analysis using Leave-one out method. The prevalence estimate marginally decreased to 13% after the removal of Prasad et al. We will add this information in the manuscript.

**Query:** Discussion is not enough. Authors can discuss the importance of case-control studies to know whether dentists are really more prone to this condition compared to the normal population. Authors can discuss the ergonomics to prevent these conditions. Can discuss about differential diagnosis of this condition and discuss about other neurologic, musculoskeletal and vascular conditions that have similar symptoms as carpal tunnel syndrome. Also, the management of this condition (non-surgical and exercises) needs
mentioning.

Response: The below information will be added in the manuscript.
Further case-control studies are required to understand the role of the dentistry profession as a risk factor for the development of CTS are needed.
During training years, emphasis should be on the potential role of the dental profession in the development of CTS and other musculoskeletal disorders. There is a need for the development and implementation of preventive strategies for early detection and prevention of CTS. Comprehensive preventive strategies like workplace postural requirements and adoption of ergonomic postures, use of ergonomically designed instruments and equipment to reduce strain on the hand and wrist, the importance of intermittent breaks between patients, an alternation between the activities, keeping wrists in a neutral position, strengthening and stretching daily which aid in alleviating the muscular tension and promote blood circulation, minimize repetitive movements and management of patient flow can be incorporated into the curriculum during training years to prevent or minimize the onset of musculoskeletal disorders. Regular monitoring and evaluation of musculoskeletal disorders need to be mandated for high-risk individuals.
Workplace-associated CTS must be identified earlier, and care should be exercised on the prevention and progression of the development of CTS. Active referral should be initiated by the employer who is at risk of development of CTS. It is important for the dental health care professional to be aware of the symptoms of CTS.
Many conditions like systemic neurologic disorders (motor neuron disease, multiple sclerosis, and hereditary neuropathy), cervical spine disorders (cervical spondylotic myelopathy, cervical radiculopathy, and syringomyelia), tumors (Pancoast tumors, benign peripheral nerve tumors, malignant peripheral nerve sheath tumors, intraneural ganglia), inflammatory and autoimmune disorders.

The management of CTS includes conservative methods like wrist splinting in the neutral position at night, analgesics, corticosteroid injections, and nerve and tendon gliding exercises with varying degrees of results. Also, the carpal tunnel can be surgically decompressed to relieve the symptoms when there is a lack of response to the above. Early diagnosis will help in initiating early interventions like medication, splinting, and changes in daily activities and can be relieved without surgical interventions. Therefore, a multi-pronged approach with ergonomic guidelines, workload management strategies, and health education and prevention can significantly reduce the risk of CTS among dental personnel and enhance their occupational well-being.

Competing Interests: Nil
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