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ORIGINAL ARTICLE

Association between Dentin Hypersensitivity and Health/Oral Health-related Quality of Life: A Systematic Review and Meta-Analysis

Anna Rachel dos Santos Soares[1], Rayssa Soares Barbosa[2], Julya Ribeiro Campos[1], Loliza Luiz Figueiredo Houri Chalub[3], Allyson Nogueira Moreira[4], Raquel Conceição Ferreira[3]

[1]Postgraduate Program of Dentistry, School of Dentistry, Federal University of Minas Gerais, Belo Horizonte, MG, Brazil.
[2]School of Dentistry, Federal University of Minas Gerais, Belo Horizonte, MG, Brazil.
[3]Department of Social and Preventive Dentistry, School of Dentistry, Federal University of Minas Gerais, Belo Horizonte, MG, Brazil.
[4]Department of Restorative Dentistry, School of Dentistry, Federal University of Minas Gerais, Belo Horizonte, MG, Brazil.

Correspondence: Anna Rachel dos Santos Soares, Postgraduate Program of Dentistry, School of Dentistry, Universidade Federal de Minas Gerais, Av. Antônio Carlos, 6627, Pampulha, Belo Horizonte, MG, Brazil. **E-mail:** anna.soares@outlook.com

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ABSTRACT

Objective: To investigate the association between DH and Health (HRQoL) or Oral Health-Related Quality of Life (OHRQoL). **Material and Methods:** PubMed, Web of Science, Scopus, EMBASE, Cochrane, Scielo, LILACS/BBO, *Biblioteca Digital de Teses e* Dissertações (BDTD), Open Grey, and Google Scholar databases were screened in September 2019 (updated in October 2022). Observational studies were selected to compare HRQoL/OHRQoL(outcome) according to DH(exposure) or evaluate the association among these variables. Standardized Joanna Briggs Institute critical appraisal tool for analytical cross-sectional studies was used to analyze the risk of bias. A random-effects meta-analysis was conducted to synthesize evidence for the association between DH and OHRQoL. **Results:** 10 papers met inclusion criteria and were evaluated. In most studies, presenting or having a greater intensity of DH was associated with a negative impact on one's quality of life. However, most of these studies showed a moderate to high risk of methodological bias. The consistent finding from studies with a low risk of bias suggests a significant association between DH and OHRQoL. Meta-analysis was feasible for three studies with substantial heterogeneity. The pooled Odds Ratio was 2.14 (95%CI 1.15-3.99; $I^2 = 57{,}44\%$). **Conclusion:** Many studies presented a high risk of bias; therefore, the actual effect of DH on one's quality of life remains uncertain.

Keywords: Dentin Sensitivity; Quality of Life; Oral Health; Patient Reported Outcome Measures.

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Introduction

Dentin Hypersensitivity (DH) is a frequent oral health condition and is challenging to treat in clinical practice [1,2]. It is defined as a short and sharp oral pain in response to chemical, physical, osmotic, thermal, evaporative, or tactile stimuli (or a combination of these) and cannot be attributed to other dental defects or diseases [3,4]. The incidence of DH is rising, particularly in adults, since they have retained their dentition throughout life, increasing tooth wear, combined with frequent functional and parafunctional habits [3-6]. Prevalence rates varying from 1.3% to 92.1% have been found [1].

The pain experience may be subjective and influenced by emotional status, coping, and illness beliefs [7]. The Health and Oral Health-Related Quality of Life (OHRQoL), a patient-reported outcome (PRO), is an expression of that part of a person's well-being that is affected by their health condition [8] and how it affects a person's ability to function, psychological status, social factors, and pain or discomfort [9]. Thus, it is plausible to hypothesize that the pain experienced due to DH can be associated with a worse Health-Related Quality of Life (HRQoL) and OHRQoL. Therefore, the value of PRO has been perceived through the adoption of Quality of Life (QoL) measures outcomes from oral health studies, including those on DH [7,10-18].

Incorporating individuals' perceptions in evaluating the disease-health process can contribute to understanding the effects and consequences of a health problem. Moreover, from the patient-centered care perspective, oral healthcare providers should consider not only the disease process, but also specific measures, such as one's QoL. It is also important for clinicians to understand what matters to patients, facilitating an assessment of which interventions are more effective in achieving outcomes that are important to patients [19]. Robust evidence of the association between a health problem and its effects on a PRO contributes to recognizing and valuing these answers in health planning and care [3,20-23].

Hence, a systematic review of the literature to answer the question, "Is there an association between DH and HRQoL or OHRQoL?" will allow one to evaluate the strength of available evidence, as well as to identify shortcomings for future research. Therefore, this systematic review assessed the scientific literature regarding the association between DH and HRQoL or OHRQoL.

Material and Methods

This systematic review was conducted in accordance with PRISMA [24] and registered on the PROSPERO database (CRD42020157264).

Eligibility Criteria

The inclusion criteria were based on the "PECOS principle" to provide a standardized approach in formulating questions for this study: P, participants (individuals with permanent dentition); E, exposure (self-reported DH, presence or intensity answer to stimulus); C, comparison (degrees of DH intensity or absence of DH); O, outcome (HRQoL or OHRQoL evaluated by general or specific instruments of QoL or performed the comparison of these outcomes according to presence or degrees of intensity of DH); and S, study design (observational studies).

Studies with the following characteristics were excluded: no evaluation of HRQoL or OHRQoL as the outcome; DH was not the exposure; sample of children or edentulous; experimental or qualitative studies; reviews; comments; letters; conference abstracts; book chapters; personal opinions; validation or cross-cultural

adaptation studies; and in vitro, in situ, or non-human studies. The descriptive studies with no analytical approach to compare groups or investigate associations and those that evaluated the dentists' perception of hypersensitivity reported by their patients were also excluded.

Search

The studies included in this systematic review were obtained through electronic searches on seven databases: Medline PubMed, Scopus, Web of Science, EMBASE, Cochrane, Scielo, and Lilacs/BBO. The grey literature was searched in Open Grey, *Biblioteca Brasileira de Teses e Dissertações* (BDTD), and Google Scholar. A manual search in the reference list of the full-text articles was also conducted.

The terms "quality of life" and "dentin hypersensitivity" were used in English and Portuguese, and a search strategy was developed according to each database. The search strategies used in Medline PubMed, Scopus, Web of Science, EMBASE, Cochrane, Scielo, Lilacs/BBO, and BDTD were presented in the frame below (Table 1). In Open Grey and Google Scholar, the search strategy combined the terms "quality of life" AND "dentin hypersensitivity" without synonyms. The databases were searched without language restrictions, nor type or date of publication, by the three reviewers (ARSS, RSB, and RCF) in September 2019 and updated in October 2022. Four reviewers independently applied the eligibility criteria for the selection of the studies, and disagreements were resolved by consensus. Two reviewers independently used a data extraction form, and an experienced epidemiologist resolved consensus. The PRISMA Flow Diagram of the selection process is in the Appendix, and the software EndNote® was used to organize the references and remove duplicates.

Table 1. Presentation of keywords and search strategy.

Keywords	Search Strategy
Quality of Life Dentin Hypersensitivity	(((((((((("Quality of life") OR ("Life Quality")) OR ("Health-Related Quality of Life")) OR ("Health Related Quality of Life")) OR (HRQOL)) OR ("Oral-health-related quality of life")) OR ("Oral health related quality of life")) OR ("Oral health-related quality of life")) OR (OHRQOL)) AND ((((((((((("Dentin hypersensitivity") OR "Dentin sensitivities") OR "Sensitivity, Dentin") OR "Dentine Hypersensitivity") OR "Hypersensitivity, Dentine") OR "Dentine Sensitivity") OR "Sensitivity, Dentine") OR "Tooth sensitivity") OR "Sensitivity, Tooth") OR "Tooth Sensitivities") OR "Dentin Hypersensitivities") OR "Hypersensitivity, Dentin")

Risk of Bias

The risk of bias in the included studies was independently assessed by three reviewers using the standardized Joanna Briggs Institute (JBI) critical appraisal tool for analytical cross-sectional studies [25]. The checklist consists of eight questions and determines the extent to which a study has addressed the possibility of bias in its design, conduct, and analysis. The consensual results of this appraisal were used to inform synthesis and interpretation of the results of the study, based on the options: "yes" (+), "no" (-), or "unclear" (?). Each question score was consensually discussed among reviewers, and the total score was obtained by the sum of the yes questions / applicable items ("not applicable" items were excluded from the sum). The decision concerning the methodology quality (risk of bias) was agreed to by characterization according to categories [26]: "high risk of bias" when the study reached a 49% score with yes; "moderate risk of bias" when the study reached between 50% until 69% score of yes; and "low risk of bias" when the study reached more than 70% score with yes.

Data Synthesis

The characteristics of included studies according to population, methodologies, and results obtained were pooled. A narrative synthesis of the data was conducted. Besides, three studies showed similarities regarding the outcome and exposure measurement. In these studies, the outcome was evaluated by the OHIP-14, having been dichotomized reasonably often as the cutoff point for the presence/absence of negative impact [13,18] or weak (OHIP scores from 0 to 9) and medium (OHIP scores from 10 to 18) impact [11]. The DH was evaluated by tactile [11,18], evaporative [11,13], and thermal stimulus [11]. These studies showed the frequency of oral health impact according to the presence/absence of DH. Based on these data, the odds ratio was estimated as an effect size (quantitative measure of the magnitude of a phenomenon). The results were statistically pooled through random effects model meta-analysis using the method of DerSimonian & Laird in STATA, version 17 .0. Heterogeneity among studies was quantified using the I-squared measure.

Results

The online search retrieved 436 studies from databases and 21 from grey literature. After removing the duplicated references (n= 255), 202 titles and abstracts were analyzed: 179 studies were excluded, and 23 were selected for the full-text reading. Ten studies investigated the association between DH and HRQoL or OHRQoL and were included in this systematic review [7,10-18].

These ten studies were published between 2009 [10] and 2021 [18]. They were conducted with sample sizes from 26 [14] to 814 [16] participants, with an age range between 15 [10] and 92 [16] years, in Brazil [11,13,18], China [12], England [16], Germany [10], Malaysia [14], and Turkey [15,17]. Eight studies were performed with convenience samples of patients who were recruited from dental clinics from Schools of Dentistry [11,12,14,15,17], private practices [10], or public health services [16], as well as among University staff and students [7]. Probabilistic samples from the urban adult population were obtained in two studies [13,18]. The convenience samples included patients complaining of DH [7,10,15], who were undergoing periodontal treatment [11,12,14,17] or routine dental treatment [16]. Five of these studies were classified as cross-sectional [12,13,16-18], one as a clinical study [11], and another as a prospective daily diary study [7]. Three studies did not present the classification of the study design [10,14,15].

The outcome was OHRQoL for all studies, with one also including HRQoL as a secondary outcome [7]. Specific instruments were used to evaluate OHRQoL (Oral Health Impact Profile, OHIP; Oral Impacts on Daily Performance, OIDP; Oral Health-related Quality of Life – United Kingdom – OHRQoL-UK) [10-14,17,18] and the Dentine Hypersensitivity Experience Questionnaire (DHEQ) [7,15,16]. The EuroQol five-dimensional (EQ-5D) was the instrument chosen to evaluate the general HRQoL [7] (Table 2).

The exposure DH assessment was based on the response of individuals to tactile, evaporative, and cold stimuli or a combination of them. Some studies evaluated the positive reaction to some stimulus [10,13,14,17,18], while others assessed the pain intensity using Visual or Numerical Scales [11,12,14,18] or the Schiff Cold Air Sensitive Scale [15,16]. Porritt et al. [7] evaluated the length and frequency of pain sensations due to DH with two items of an OHRQoL-specific questionnaire, the DHEQ, i.e., self-reported DH. The DH was analyzed combined with the presence or absence of gingival recession (GR) [13,17] or Non-Carious Cervical Lesions (NCCL) [18] (Table 2).

Table 2. Description of the study characteristics, outcome, exposure, and analytical approaches to investigate the association between DH, OHRQoL, and HRQoL.

Author, Location, Language	Study Design	Setting	Participants / Sample	Outcome Analysis	Methods to Assess Exposure to DH	Effect Measures
Bekes et al. [10], German, English	Unreported	Dental offices	656 patients with DH (15-82 years) *versus* 1541 general population sample (16-79 years)	The score of OHIP-49 (0-196) (higher score, higher impact of OHRQoL)	The patient who had reacted positively to air stimulus applied by the dentist treating Dentin Hypersensitivity in a dental office	Linear Regression Coefficient: Presence of DH+gender: 5.4(1.0-9.59) – p=0.016. Estimated values of OHIP-19 for groups with a combination of gender, age, and being or not a patient
Porritt et al. [7], United Kingdom, English	A Prospective Daily Diary study	United Kingdom University	101 adults were sampled purposively from staff and students (18 -63 years)	Scores of DHEQ (higher score, higher impact) and EQ-5D (higher score, better HRQoL)	The ordinal scale of the length of time and frequency of pain sensations due to DH	Linear regression coefficient: Total effect of DH on DHEQ: 0.35 (0.13;0.52) Direct effect of DH on DHEQ: 0.15 (-0.06;0.32) Indirect effect of DH on DHEQ: 0.20 (0.06;0.36) Total effect of DH on HRQoL: -0.13 (-0.26;-0.04)
Melo et al. [11], Brazil, Portuguese	Clinical study	School of Dentistry	36 patients (18-59 years)	High, medium, and low OHRQoL impact according to OHIP-14 score	The presence or absence of DH	Chi-square test with p-value = 0.0352. Estimated Rate Ratio from reported 2x2 tables: 6.0 (0.80;44.94).
Goh et al. [12], China, English	Cross-sectional	Dental Hospital	102 patients (18-75 years)	CS-OIDP scores Presence or absence of impact	The presence or absence of DH Air blast Visual Analogue Scale (VAS) score Tactile VAS score	1) Fisher Exact test with p-value: Oral impacts were higher among those with DH (p<0001). No individuals without DH reported impact. 2) The mean air-blast VAS score for those reporting impacts was 31.3 ± 21.6, and the mean tactile stimulation VAS score was 11.6 ± 15.6 mm. The mean air-blast VAS score for the 11 subjects who reported no impacts was 21.0 ± 18.6 mm, the mean tactile-stimulation VAS score was 7.6 ± 9.2 mm, and the difference in mean air-blast VAS scores (p=0.15) and mean tactile stimulation scores (p=0.42) between groups were not statistically significant. 3)ANCOVA: Higher air-blast VAS score (estimate=0.10, p<0.001), higher tactile stimulation VAS score (estimate 0.13, p<0.001), non-use of desensitizing agent (estimate 1.77, p=0.009) and higher age (estimate: 0.06, p=0.016) were associated with higher CS-OIDP (R^2=0.476)
Wagner et al. [13], Brazil, English	Cross-sectional	Urban area	750 adults (35-59 years)	Presence or absence of OHRQoL (OHIP-14)	The presence or absence of DH	Odds Ratio - impact among those with GR and DH concomitantly was 2.27 (1.15-4.44) (reference category was (0 teeth with GR > 2 mm and DH) The unadjusted rate ratio was estimated from a 2x2 table. 1.20(1.05-1.37). Higher prevalence of impact among those with > 1 tooth with DH.

Masud et al. [14], Malaysia, English	Unreported	School of Dentistry	26 patients (25-64 years)	Presence of physical, psychological, and social impacts according to modified OHIP-14	Positive/negative response to cold air applied using a dental air syringe.	- Significant p-value was reported for the association of DH with difficulty in chewing food, difficulty in tooth brushing, and avoiding certain foods (physical aspects). For psychological aspects, a significant association was observed in patients' worries. - For social aspects, there were no significant differences. It was not possible to estimate any effect measure because the number of subjects with or without DH, which show or not oral health impacts, is unclear.
Basaran and Celik [15], Turkey, English	Unreported	School of Dentistry	251 patients (18-78 years)	Total (35 - 255) and subscale score of DHEQ: functional restriction (4-28); adaptation (12-84); social impact (5-35); emotional impact (8-56), and identity (5-35)	Degree of DH using the Schiff Cold Air Sensitivity Scale	Total and subscale DHEQ scores correlated with the Schiff Cold Air scores (Correlation coefficients were not shown).
Midwood et al. [16], England, English	Cross-sectional	National Health System	814 patients (18-92 years)	Four questions derived from DHEQ-15 scored on a 7-point scale: 1) having sensations in my teeth takes a lot of the pleasure out of eating and drinking; 2) it takes a long time to finish some foods and drinks because of sensations in my teeth; 3) I have to change the way I eat or drink certain things; 4) I have to be careful how I breathe on a cold day.	DH intensity using the Schiff index following an air blast stimulus	The Spearman's rho for no pleasure in eating and drinking (r=0.141; p-value: <0.001); slow to finish eating and drinking (r=0.152, p-value: <0.001); change the way I eat or drink (r=0.176, p-value: <0.001) and change the way I breathe on a cold way (r=0.148, p-value: <0.001).
Yilmaz et al. [17], Turkey, English	Cross-sectional	School of Dentistry	205 patients (19-75 years)	16 items for four domains: two for symptoms, five for physical status, five for psychological status, and four for social status. Total OHRQoL-UK scores (16-144) (Higher score, higher impact of OHRQoL)	The comparison groups regarding gingival-related complaints were: no complaint; hypersensitivity; esthetic; esthetic + hypersensitivity or other	Patients whose hypersensitivity was a GR-related complaint presented a mean score of OHRQoL-UK of 41.23 ± 8.31, and without complaints presented a mean score of 46.34 ± 12.17 (p<0.05). There was a higher mean of OHRQoL-UK for physical, psychological, social, and symptom domains for groups with hypersensitivity as a gingival recession related complaint (p<0.05).
Soares et al. [18], Brazil, English	Cross-sectional	Urban area	197 adults (30-49 years)	Presence or absence of OHRQoL (OHIP-14 total and by dimensions)	The comparison groups were without NCCL or DH, NCCL without DH, DH without NCCL, NCCL, and DH	Adults with DH without NCCL showed a higher prevalence of oral health impact (PR: 1.57; 95% CI: 1.02-2.42). A higher impact on the physical pain dimension of OHRQoL was observed for those with DH without NCCL (PR: 2.46; 95% CI: 1.21-5.00) and with DH and NCCL (PR: 2.03; 95% CI: 1.21-3.41)

The studies consistently demonstrated a higher oral health impact (OHRQoL) or worse HRQoL among those with DH or greater DH intensity than those without this condition [7,10-18]. The response variables were analyzed considering the total scores and by dimension/subscale of the OHRQoL instruments, or the categorization was performed, such as presence (at least one impact related to frequency) or absence of impact. A single study selected four questions of the DHEQ-15 as the outcome [16]. Similarly, the DH exposure was analyzed as a binary variable (presence/absence) [7,10-14,17,18] or by the score of pain intensity [15,16]. The analytical approaches were mainly hypothetical tests to compare OHRQoL score (average or proportions of presence/absence of impact) [11-13,17] between groups with and without DH, using Chi-square, Fisher Exact, Mann Whitney, and Student's t tests. Analyses by OHRQoL dimension showed significant differences in the frequency of individuals with impacts or a greater average of OHRQoL scores in the symptom, physical, psychological, and social dimensions among those with DH ($p<0.001$) [12,14,16-18].

The bivariate analysis demonstrated a correlation between the OHRQoL scores and intensity scores of DH [15], as well as between the ordinary scores of each of the DHEQ questions with the maximum Schiff Score [16]. ANCOVA was the analytical approach demonstrating that a higher DH intensity was related to a higher OIDP [12]. One of the studies adjusted the linear regression model to identify if being a patient (with DH) compared to population data was related to a higher OHRQoL score and showed an interaction between gender and being a patient with DH. Higher OHIP scores were observed among men both in the general population and among patients, and an increased OHIP was observed up to 50 years of age, which remained stable in individuals between 60 and 80 years of age. Patients presented an OHIP score of approximately 22 points higher than the general population [10]. The model of structural equations demonstrated a direct association between the baseline frequency of sensations and the duration of DH and follow-up OHRQoL, which was, in turn, associated with HRQoL. This study showed the role of illness beliefs and pain-related active and passive coping in mediating the association between self-reported DH and OHRQoL [7].

DH combined with NCCL (PR: 2.03; 95% CI: 1.21–3.41) or without NCCL (PR: 2.46; 95% CI: 1.21–5.00) was associated with a higher OHRQoL impact on the physical pain domain after control of the confounding factors (gender, age, skin color, education, income, toothbrushing frequency, fresh fruit and soft drink consumption, smoking, alcohol consumption, medication use, temporomandibular disorders, dental caries, and periodontal disease) [18]. By contrast, another study conducted with adults demonstrated that the DH alone was not significantly associated with the impact on OHRQoL, only when combined with GR [13] and adjusted for age, gender, socioeconomic status, smoking, dental care, and missing teeth.

Meta-analysis for the association between the presence of DH and oral health impact, evaluated by the OHIP-14 (presence/absence of negative oral health impact), resulted in pooled Odds Ratio of 2.14 (95% CI 1.15-3.99; $I^2 = 57,44\%$) (Figure 1), indicating a higher chance of negative impact among those with DH. The observed value of I^2 may represent substantial heterogeneity among studies.

Risk of Bias

Four studies [12,13,17,18] presented a low risk of bias. The remaining studies presented moderate (n=4) [7,10,11,15] and high risks of bias (n=2) [14,17] (Figure 2).

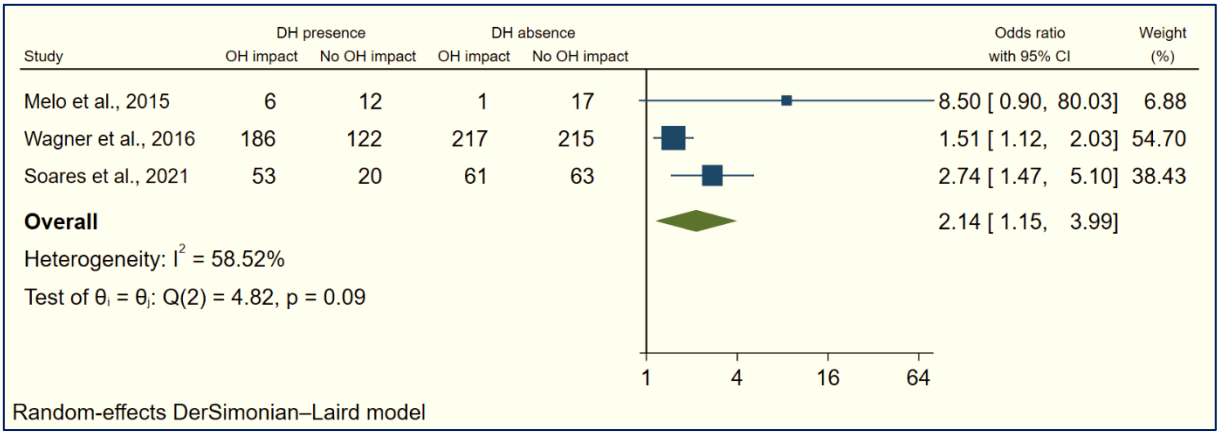

Figure 1. The pooled odds ratio of the association between dentin hypersensitive (DH) and the presence of negative oral health impact (OH).

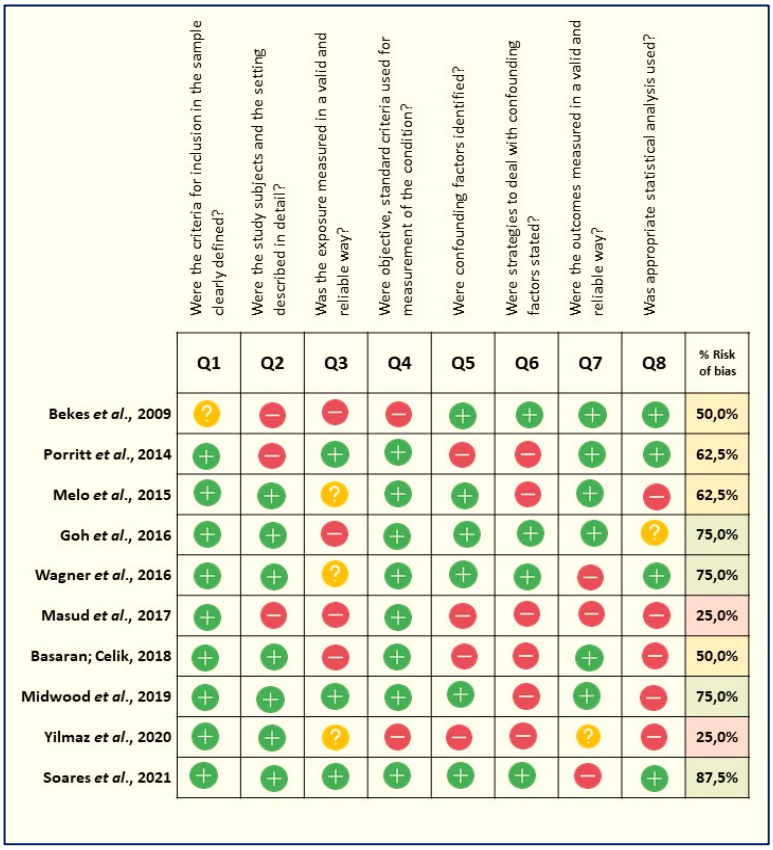

Figure 2. Risk of bias summary: reviewers' judgment about each risk of bias item for each included study (+ = yes; - = no; ? = unclear).

Discussion

This systematic review indicates that DH is associated with OHRQoL, which, in turn, influences HRQoL. However, the majority of studies presented moderate or high risks of bias. The meta-analysis of three studies showed DH was associated with a higher chance of negative oral health impact.

The QoL was the response chosen in this systematic review, considering that oral health is multi-faceted and includes physical and psychosocial functions (ability to speak, smile, smell, taste, touch, chew, swallow, and convey a range of emotions through facial expressions with confidence and without pain, discomfort, and disease

of the craniofacial complex). It is an essential component of health and the patient's physical and mental well-being, influenced by the values and attitudes of individuals and communities [27]. Moreover, instruments of one's QoL constitute a PRO, incorporating the perception of individuals in the evaluation of the health-disease process. A predominance of studies was observed in which the response variable (OHRQoL) was evaluated by means of specific instruments, such as OHIP, OIDP, OHRQoL-UK, and DHEQ [7,10-18]. It is essential to highlight that DHEQ is a condition-specific instrument for DH, in such a way that the measured impacts are restricted to the DH, which makes it possibly more sensitive to measure this aspect of the oral condition. Only one study used a generic HRQoL instrument [7]. This demonstrated that individuals with a worse OHRQoL due to the greater frequency of DH complaints also presented the worst HRQoL scores. This result indicates that new studies should expand upon the evaluation of the effects of DH beyond its impacts on oral functions. Although this study did not consider important confounding factors (such as sex and age) in the adjustment of the model, the indirect effect of the frequency of complaints of DH on OHRQoL and HRQoL were observed, mediated by negative emotional representations, health anxiety, and pain-related coping, reinforcing the need for explicative models of DH to include individuals' values and attitudes [7].

Validity is a property that prevents the incorporation of bias (measurement error) in obtaining measurements. Specifically, in the case of this study, it corresponds to the degree to which an instrument measures the construct(s) (HRQoL or OHRQoL) it seeks to measure. Reliability is the degree to which the measurement is free from measurement error [28-30]. The validity and reliability of the response variable were demonstrated in nearly all studies when authors mentioned using validated instruments and cited prior studies that had tested these properties. One of these studies described the process of the transcultural translation and adaptation of the DHEQ-48 to Turkish and showed the tests for evaluation of reliability and validity [15]. Two studies concerning this evaluation criterion were classified as "unclear" [14,17]. In one of these, the authors cited the modified version of OHIP-14 for edentulous individuals, which is inadequate to study the impact on DH [14]. The OHRQoL-UK questionnaire was used by Yilmaz et al. [17], who did not report nor mention the validation process or the reliability evaluation. The response variable, OHRQoL (OHIP-14), was evaluated by employing an interview in two studies [13,18]. Only one of these studies reported reliability throughout the study through test-retest [13], while the other cited the training of interviewers to conduct the interviews. Still, the reliability needed to be evaluated throughout the study [18]. Although the JBI criterion defines the need for trained interviewers in the validity evaluation, this criterion did not penalize the majority of studies since the response variable was evaluated through the self-administered questionnaire [7,10-12,14-17].

The exposure was the DH, evaluated by clinical exam in most studies [10-18]. Only one of the studies evaluated the self-reported length of time and frequency of DH through the items of the validated questionnaire (DHEQ) [7]. As regards the validity evaluation of the exposure variable, the risk of bias was evaluated by the performance or lack thereof of the examiners' training by experts (gold standard). In two studies, this process was reported [16,18]. Other studies cited the carrying out of training and calibration for other clinical measures but not for DH [11,13,17] or did not report the training and calibration of the examiners for any clinical conditions [10,12,14,15]. It is important to highlight the methodological difficulties in the calibration of examiners to evaluate DH, especially since it is not ethically recommendable to stimulate pain in an individual for this purpose.

Moreover, other factors affecting the reproducibility of the observed result between the two measures could not be controlled in a test-retest, such as the overestimated reaction level in a second exam. There is also difficulty reproducing the stimulus the individual feels in one's daily routine [31]. In this sense, it is essential to

use standardized methods (time and pressure of applying stimulus, pressure, and movement of the probe in the touch stimulus) to minimize measurement errors [1,31]. Additionally, different methods were used to evaluate DH, varying from self-reported [7] to the use of indices/scales to obtain pain intensity scores (pain numeric scale [11,14,15], VAS [12,18], Shiff Index [15,16], or the evaluation of the presence and absence of the condition through stimulus – air, tactile, thermal stimulation [10,13,17]).

The risk of bias due to the non-identification and control of confounding factors in investigating the association of interest or comparing groups was the most frequently observed in the studies included herein. Confounders are a crucial threat to the validity of observational studies. They occur when comparison groups differ concerning their risk of the outcome beyond the exposure(s) of interest due to a common cause of exposure and outcome. Six of the ten studies included in this work collected variables that could be considered confounding factors in the analysis: age [10,12,13,18], gender [10,13,18], socioeconomic condition [13,18], habits and health behaviors [11,13,16,18], parafunctional habits [11], and oral [13,16,18] and general [11,18] health conditions. Melo et al. [11] and Midwood et al. [16] reported that a questionnaire was answered to evaluate the variable mentioned above; however, these were not treated as confounding factors in the association between OHRQoL and DH. Another four studies [10,12,13,18] used statistical strategies to deal with confounding factors. Three studies used multiple regression models (linear, Poisson, and logistic) according to the characteristics of the dependent variable, adjusting the association through the potential confounding variable mentioned above. One study adopted the ANCOVA method to evaluate the effect of the factors of the air-blast VAS score, the tactile-stimulation VAS score, and the use of a desensitizing agent on an OIDP score that controls age [12]. However, it is essential to mention that almost none of the studies presented a model or theoretical basis to justify the selection of adjustment variables. Soares et al. used directed acyclic graph methodology to guide adjustments to the model, theoretically describing why the variables were considered confounding in the model [18]. Other studies adopted bivariate statistical analyses and reported no strategy to control confounding factors. In addition, no comparisons between groups (with and without impact) were presented that could show their comparability regarding potential confounding factors.

In most studies, there were convenience samples or recruitment from teaching institutions [7,11,12,14,15,17] or private clinics [10]. Furthermore, many samples contain only individuals with complaints of hypersensitivity, in which there was an evaluation of the intensity of DH, hindering the comparison or acquisition of measurement of association, maintaining those without pain as a reference. This situation can incorporate a selection bias since the inclusion in the study was conditioned to the presence of exposure. Future studies should include a variable that influences the development of DH, such as the measure of one's QoL, and adopt the process of randomization or pairing in defining the groups to be compared.

Another criterion of the quality of evidence is the precise description of the inclusion and exclusion criteria defined before the recruitment of the study participants and the description of the population from which participants were selected or recruited (demographics, location, and time period). Most of the studies included in this review presented the inclusion and exclusion criteria of the sample, except for Bekes et al. [10]. Three studies did not report the data collection period [7,10,14], and one did not report the participants' sociodemographic characteristics [7], compromising the comparability of the study's findings.

The evaluation of the adaptation of the statistical analysis also demonstrated that the main problem was the lack of strategies to control confounding factors in investigating the association of interest, primarily since many studies did not include such measures in their design [7,14,15,17]. However, the non-description of the criteria for the choice of statistical tests (characteristics of the variables, assumptions violation, such as normal

distribution, homoscedasticity, and linearity) represented a risk of the incorporation of bias in some studies [11,12]. Different effect estimates were reported for studies that analyzed dichotomic outcomes (odds ratios, rate ratios) or continuous outcomes (linear regression coefficient, difference in means). Nevertheless, in some studies, the analysis was limited to the correlation between the two scores [15,16] or the register of the p-value of a hypothesis test [14]. The variation in the effect measures resulted from the diversified methods used to analyze the outcome and exposure, which hindered the comparability through the presented data.

The JBI was adopted to analyze the confusion, selection, and measurement bias risks, making it possible to evaluate the validity of the findings. According to Dekkers et al. [32], the quality evaluation in a systematic etiologic review must focus on bias. The studies included herein were quite different, either statistically or in methodological terms. Differences in designs, participants, exposure measures, and analytical approaches hindered the carrying out of a meta-analysis for the combination of results.

This review demonstrates the need to improve the methodological quality of the studies addressing the association between DH and OHRQoL, especially regarding identifying and controlling the confounding factors to investigate the association of interest. The selection of appropriate statistical tests according to the characteristics of the variables was another aspect that deserves attention in future studies. Standardizing diagnostic methods and tools used to evaluate PRO are necessary to obtain pooled measures. This study selected only three studies for metanalyses because of the enormous heterogeneity in the chosen methods. Moreover, checklists should be used to report the study's findings so that all the necessary information is available for a proper judgment of the available quality of evidence. The major available evidence is either a clinical or a cross-sectional study. Thus, it is not possible to conclude on causal inference, considering that exposure and outcomes were measured at the same time.

DH is a frequent oral health condition and may influence the choice of food or drinks or impair toothbrushing. This epidemiological picture points to a growing demand for treatment for this clinical condition, challenging the permanent advance of preventive and restorative techniques with positive effects on quality of life. Including subjective oral health measures can guide oral health care to the perceived signs and symptoms of DH, making the solutions presented by professionals more effective and promoting improvements in oral health conditions with positive effects on quality of life.

Conclusion

The consistent finding from studies with a low risk of bias suggests a significant association between DH and an OHRQoL. Many studies presented a moderate and high risk of bias; therefore, the true effect of DH on one's QoL remains uncertain.

Authors' Contributions

ARSS	https://orcid.org/0000-0002-1232-1712	Conceptualization, Methodology, Formal Analysis, Investigation, Writing - Original Draft, Writing - Review and Editing and Visualization.
RSB	https://orcid.org/0000-0001-9865-6486	Conceptualization, Methodology, Formal Analysis, Writing - Original Draft, Writing - Review and Editing and Visualization.
JRC	https://orcid.org/0000-0002-1406-4166	Conceptualization, Methodology, Investigation, Writing - Review and Editing and Visualization.
LLFHC	https://orcid.org/0000-0002-0892-9047	Conceptualization, Writing - Review and Editing, Visualization and Supervision.
ANM	https://orcid.org/0000-0002-7022-5593	Conceptualization, Writing - Review and Editing, Visualization and Supervision.
RCF	https://orcid.org/0000-0001-8897-9345	Conceptualization, Methodology, Formal Analysis, Investigation, Writing - Original Draft, Writing - Review and Editing, Visualization, Supervision and Funding Acquisition.

All authors declare that they contributed to a critical review of intellectual content and approval of the final version to be published.

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Conflict of Interest

The authors declare no conflicts of interest.

Data Availability

The data used to support the findings of this study can be made available upon request to the corresponding author.

Supplementary Material

If you wish to have access to supplementary materials, please contact the corresponding author.

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