



Dental sleep-related conditions and the role of oral healthcare providers: A scoping review



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ABSTRACT

Dental sleep medicine as a discipline was first described about a quarter of a century ago. Snoring, obstructive sleep apnea, sleep bruxism, xerostomia, hypersalivation, gastroesophageal reflux disease, and orofacial pain were identified as dental sleep-related conditions. This scoping review aimed to: i) identify previously unidentified dental sleep-related conditions; and ii) identify the role of oral healthcare providers in the prevention, assessment, and management of dental sleep-related conditions in adults. A systematic literature search was conducted in PubMed, Embase.com, Web of Science, and Cochrane. Studies that reported an actual or likely role of oral healthcare providers in the prevention, assessment, and/or management of sleep-related conditions were included. Of the 273 included studies, 260 were on previously listed dental sleep-related conditions; the other 13 were on burning mouth syndrome. Burning mouth syndrome was therefore added to the list of dental sleep-related conditions for the first aim and categorized into sleep-related orofacial pain. For the second aim, the role of oral healthcare providers was found to be significant in the prevention, assessment, and management of obstructive sleep apnea and sleep bruxism; in the assessment and management of snoring, sleep-related orofacial pain, and oral dryness; and in the assessment of sleep-related gastroesophageal reflux condition.

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1. Introduction

Dental sleep medicine (DSM) is a discipline that was first described in 1999 by Lavigne and coworkers in a narrative review entitled 'sleep disorders and the dental patient: an overview' [1]. In that landmark review, the authors described several sleep-related

Abbreviations

BMS	burning mouth syndrome
DC/TMD	diagnostic criteria for temporomandibular disorders
DSM	dental sleep medicine
EMG	electromyography
ESS	Epworth sleepiness scale
GERD	gastroesophageal reflux disease
MMA	maxillomandibular advancement
NTI-tss	nociceptive trigeminal inhibition–tension suppression system
OA	oral appliance
OSA	obstructive sleep apnea
PSG	polysomnography
RBD	rapid eye movement sleep behavior disorder
RDC/TMD	research diagnostic criteria for temporomandibular disorders
SB	sleep bruxism
STOP	snoring, tiredness, observed apnea, high blood pressure
STOP-Bang	snoring, tiredness, observed apnea, high blood pressure, body mass index, age, neck circumference, gender
TMD	temporomandibular disorder
VAS	visual analogue scale

disorders that were of interest to dentists, including snoring, obstructive sleep apnea (OSA), sleep bruxism (SB), xerostomia, hypersalivation, gastroesophageal reflux disease (GERD), and the effect of orofacial pain on sleep quality. In addition, the authors also indicated the role a dentist can play in the assessment and management of dental sleep-related conditions. However, the majority of dental sleep medicine academies [2,3] still focus on sleep-related breathing conditions (viz., snoring and OSA) only, especially regarding the use of oral appliance (OA) therapy to manage snoring and OSA. A sign of progress is that recently, in addition to snoring and OSA, the Australasian Academy of Dental Sleep Medicine [4] also introduced temporomandibular disorders (TMD) and orofacial pain as dental sleep-related conditions. In addition, the American Academy of Orofacial Pain introduced sleep in their mandate [5]. It is therefore apparent that professionals and academies are gradually starting to appreciate that DSM encompasses more than snoring and OSA. However, more effort is needed to accelerate this process for the benefit of patients with dental sleep-related conditions.

In the past few years, several papers have been published to further define and introduce DSM. In 2016, Lobbezoo et al. [6,7] classified the dental sleep-related conditions into five categories, viz., sleep-related breathing conditions, sleep-related orofacial pain, sleep-related oral moistening conditions, sleep-related gastroesophageal reflux conditions, and sleep-related mandibular movement conditions. In addition, the authors defined DSM as “the discipline concerned with the study of the oral and maxillofacial causes and consequences of sleep-related problems”. This definition broadened DSM to the assessment and management of not only snoring and OSA, but also other sleep disorders in which oral healthcare providers, i.e., dentists, orthodontists, oral and maxillofacial surgeons, and oral hygienists, play a pivotal role. In a review written by a group of DSM experts [8], it was stressed that DSM is a unique discipline, which requires collaboration between physicians and oral healthcare providers [9]. Although physicians are

responsible for the diagnosis and treatment of sleep-related disorders, as first-line health practitioners, oral healthcare providers can contribute to the screening and early recognition of patients with certain sleep disorders, e.g., by identifying risk factors or observing the consequences of certain sleep disorders in the mouth or masticatory system.

Furthermore, it has been suggested that dental sleep-related conditions frequently co-exist. For example, a recent study found that patients with OSA experience more TMD pain than otherwise healthy individuals [10]. A previous study also found that GERD and SB are temporally associated with each other, with reflux events preceding bruxism events [11,12]. In addition, Kato et al. [13] reported that jaw-closing muscle activities are related to sleep arousals caused by apneic and hypopneic events, viz., respiratory arousals, and Arab et al. [14] confirmed that effective mandibular advancement appliance therapy significantly reduces jaw-closing muscle activities time-related to respiratory arousals in OSA patients. Such findings suggest that dental sleep-related conditions are associated with each other, constituting a complex multimorbidity network. Hence, by being alert to certain combinations of complaints and symptoms, oral healthcare providers can make an important contribution to the screening and recognition of dental sleep-related conditions. Given the pivotal role of the oral healthcare provider in DSM, studies also advocated the incorporation of DSM in the dental and medical curriculum [15,16]. Taken together, even though there is increasing knowledge on dental sleep-related conditions and their mutual associations, more research is needed to lay a solid, evidence-based foundation for the emerging DSM discipline.

Considering that it has been almost a quarter of a century since Lavigne et al. published their landmark review on DSM [1], it is possible that there are previously unidentified dental sleep-related conditions, and that the oral healthcare provider has adopted, or has to adopt, new roles in DSM, given that the scope and practice of dentistry has also been changing over the past decades. It should also be noted that the landmark review on DSM was expert-based and discussed the role of dentists in the assessment and management of dental sleep-related conditions. In the present study, an evidence-based approach was adopted to identify dental sleep-related conditions and the role of the oral healthcare provider, not only in the assessment and management, but also in the prevention of dental sleep-related conditions. A scoping review was considered suitable for synthesizing the relevant evidence from a broad perspective. In addition, a panel of DSM experts from Australia, Belgium, Canada, Japan, and the Netherlands was formed to ascertain that the approach and interpretations in the present study are scientifically sound and in line with the global needs. Therefore, in the present study, the available literature was systematically reviewed with the aims to: i) identify previously unidentified dental sleep-related condition(s); and ii) identify the role of the oral healthcare provider in the prevention, assessment, and management of dental sleep-related conditions. We hypothesized that there will be previously unidentified dental sleep-related conditions, and that the oral healthcare provider can play a significant role in the prevention and/or assessment and/or management of certain sleep-related conditions.

2. Methods

2.1. Search strategy

This scoping review is reported in accordance with the PRISMA statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses; www.prisma-statement.org/Extensions/ScopingReviews). As the landmark review on DSM

was published in 1999 [1], a systematic search was conducted in the bibliographic databases PubMed, Embase.com, Web of Science, and Cochrane from January 1, 2000 up to June 9, 2022, in collaboration with a medical information specialist (RV), who provided help to formulate a comprehensive search strategy covering the two aims of this scoping review. As the first step, two searches were performed: one for dentistry-related terms (#1 in Table S1 of the Supplementary Material) and another one for sleep-related terms (#2 in Table S1), which represent the two main components of DSM. Then, the two searches were combined and the overlap between the two searches was considered to contain the potentially relevant references for this scoping review (#3 in Table S1).

2.2. Inclusion and exclusion criteria

As a general inclusion criterion covering the two aims of the present study, the following was formulated:

- Studies that report an actual or likely role of the oral healthcare provider in the prevention, assessment, and/or management of sleep-related disorders in otherwise healthy adults (≥ 18 years).

2.3. The exclusion criteria were as follows

- Reviews, case reports, editorials, and conference papers;
- Studies performed in settings other than clinics (e.g., studies performed in laboratory);
- Studies on animals or children/adolescents (< 18 years).

2.4. Study selection

Since a large number of studies ($n = 7432$) were identified for title and abstract review (see Results), two review panels (first panel: MT and LR; second panel: ZH and NZ) were formed. Both teams independently screened all titles and abstracts for eligibility, but within a team the studies were split in two parts as to make the effort as feasible as possible. Screening was preceded by a training and calibration session, in which the two panels separately reviewed the first 200 abstracts, after which the consistency in judgement between both panels on the inclusion/exclusion of studies was evaluated. Differences in judgement were resolved through a consensus procedure guided by FL and GA. The review process was conducted using ATLAS.ti (ATLAS.ti Scientific Software Development GmbH, Berlin, Germany), which enables the reviewer to add custom labels to studies. With the help of ATLAS.ti, the reported sleep-related disorders and the role of the oral healthcare provider in the prevention, assessment, and/or management of the reported disorders were labeled for each study. Differences in judgement between the two review panels on the inclusion/exclusion of studies were resolved through a consensus procedure guided by FL and GA. After the title and abstract review, the included studies were categorized into studies on known dental sleep-related conditions or studies on other conditions.

2.5. Full-text review

For the first aim, the conditions in which the oral healthcare provider can play a role in the prevention, assessment, and/or management were identified as dental sleep-related conditions. For the second aim, both studies on known dental sleep-related conditions and studies on new dental sleep-related conditions were reviewed. Unlike the criterion used for the title and abstract

review, in the full-text review, only studies that reported an actual role of the oral healthcare provider in the prevention, assessment, and/or management of dental sleep-related conditions in adult patients were included. In addition, if (part of) the clinical procedures included in a study were customarily performed by oral healthcare providers (e.g., maxillofacial advancement [MMA] surgery by oral and maxillofacial surgeons and cephalometry by orthodontists), such study was also included, even if the role of oral healthcare providers was not mentioned explicitly in the article. The decision of inclusion/exclusion of studies and data extraction were performed by two of the reviewers (ZH and NZ). Differences in judgement were resolved through a consensus procedure guided by FL and GA.

2.6. Data extraction

For the second aim, a custom data extraction table was used to include the following information: (i) condition, (ii) role of the oral healthcare provider (prevention, assessment, and management), (iii) aim, (iv) tool (subjective evaluation, clinical procedure, instrumental evaluation), (v) outcome measure, (vi) management, (vii) type of oral healthcare provider (dentist, orthodontist, oral and maxillofacial surgeon, and oral hygienist²), (viii) performed in dental setting (yes/no), (ix) included study (author[s] and year), and (x) country.

3. Results

3.1. Study selection

The literature search generated a total of 10,951 references. After deduplication, 7432 references remained. Of the 7432 studies, 273 studies were found eligible for inclusion in this review. The flow chart of the search and selection process is presented in Fig. S1 of the Supplementary Material.

3.2. Previously unidentified dental sleep-related conditions

For the first aim, of the 273 studies, 260 studies reported the role of the oral healthcare provider in the prevention, assessment, or management of known dental sleep-related conditions; the other 13 studies [17–29] reported the role of dentists in the assessment and management of burning mouth syndrome (BMS). In addition, these thirteen studies also reported the association between BMS and sleep disturbance/poor sleep quality. To the best of the authors' knowledge, BMS had not been included as a dental sleep-related condition before. Hence, BMS was identified as the only previously unidentified dental sleep-related condition. Given that BMS is characterized as a painful feeling with burning quality [30], it was categorized into an existing category of DSM, namely "sleep-related orofacial pain". Several other sleep-related disorders were also identified in the title and abstract review as potential dental sleep-related conditions, including catathrenia (i.e., nocturnal groaning), dysphagia, and nocturnal eating. However, the oral healthcare provider cannot make a substantial contribution to the prevention, assessment, or management of these disorders. These disorders were therefore excluded.

² According to the Manual of dental practice of the Council of European Dentists (version 5.1; 2015), oral healthcare providers were categorized into dentist, orthodontist, oral and maxillofacial surgeon, and oral hygienist [<https://www.omid.pt/content/uploads/2017/12/ced-manual-2015-completo.pdf>].

3.3. The role of the oral healthcare provider in the prevention, assessment, and management of dental sleep-related conditions

For the second aim, of the 273 included studies, 151 studies reported on the role of the oral healthcare provider in the prevention, assessment, and management of sleep-related breathing conditions, 80 studies reported on that role in sleep-related mandibular movement conditions, 79 studies reported on that role in sleep-related orofacial pain, five studies reported on that role in sleep-related oral moistening conditions, and one study reported on that role in sleep-related gastroesophageal reflux condition. It needs to be noted that a single study may report on the role of the oral healthcare provider in more than one dental sleep-related condition. Additionally, all 80 studies on sleep-related mandibular movement conditions dealt with SB, and all five studies on sleep-related oral moistening conditions were about oral dryness. Of the 273 studies, 108 were performed in Europe, 81 in Asia, 73 in America (North and South), ten in Oceania, and one in Africa (Fig. 1). All articles were in English, except for one article in French and two articles in Chinese.

3.4. Results by dental sleep-related condition

Below, the role of oral healthcare providers is presented by sleep-related condition, with subsections for prevention, assessment, and/or management. Notably, given that a large number of studies (n = 273) were included in this scoping review and many of

these studies reported well-known and similar information (e.g., the use of OA to treat OSA), to improve the readability of this review, only the most representative and characteristic studies from among the included ones were referred to. A list of all included studies and their characteristics are shown in the Supplementary material.

3.4.1. Sleep-related breathing conditions

The included 151 studies on sleep-related breathing conditions covered snoring and OSA.

3.4.1.1. Snoring. The included 151 studies on sleep-related breathing conditions covered the assessment and management of snoring.

3.4.1.1.1. Prevention. No studies related to the prevention of snoring were found in this review.

3.4.1.1.2. Assessment. Included studies reported on the role of the oral healthcare provider, especially the dentist, in recognizing snorers based on patients' subjective evaluations (i.e., self-reported intensity/frequency of snoring). See Table S2 for more information and references.

3.4.1.1.3. Management. Included studies reported on the role of the oral healthcare provider in treating snoring using OA therapy in dental settings. Studies also reported on the role of the oral healthcare provider in evaluating the treatment efficacy of snoring based on patients' subjective evaluations (i.e., self-reported

No.	Country	Number of included studies
1	Brazil	31
2	USA	27
3	China	18
4	Italy	17
5	Japan	15
6	Canada	13
7	South Korea	12
8	The Netherlands	11
9	Turkey	11
10	Australia	9
11	Finland	9
12	Denmark	8
13	India	8
14	Spain	8
15	Sweden	8
16	Poland	8
17	UK	8
18	France	7
19	Germany	6
20	Iran	5
21	Belgium	5
22	Greece	4
23	Norway	3
24	Saudi Arabia	3
25	Thailand	3
26	Israel	2
27	Jordan	2
28	Slovenia	2
29	Chile	1
30	Colombia	1
31	Croatia	1
32	Egypt	1
33	Montenegro	1
34	New Zealand	1
35	Russia	1
36	Singapore	1
37	Switzerland	1
38	Vietnam	1

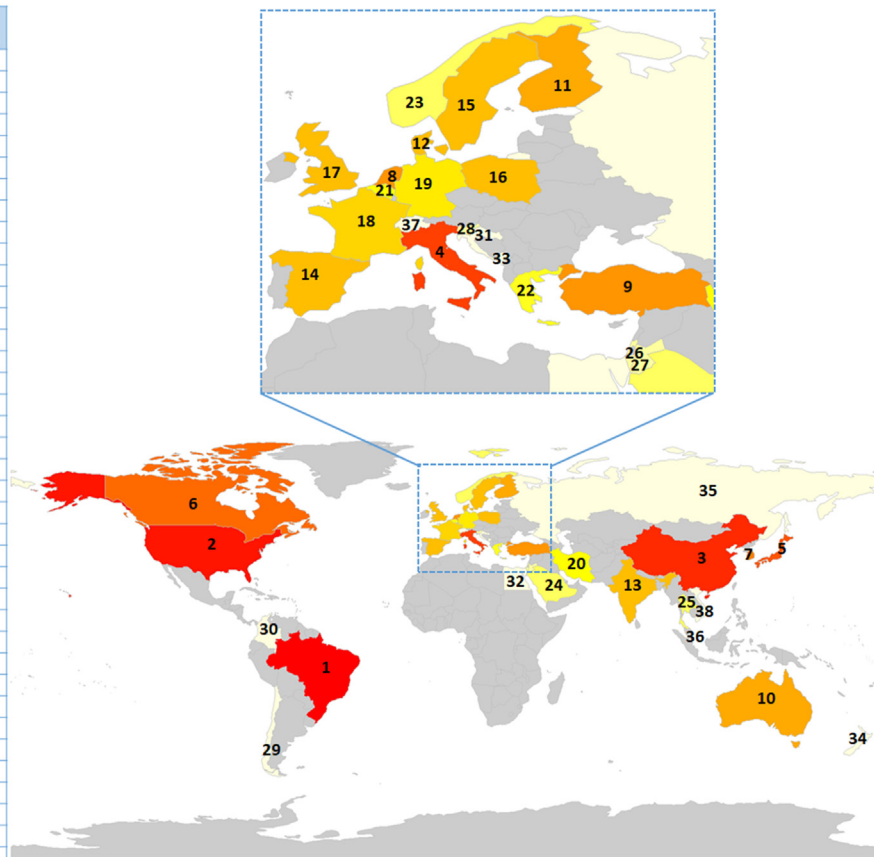


Fig. 1. Global heat map of included studies. The numbers on the maps represent the ranking of the countries: the lower the number, the larger the number of included studies of that specific country. The exact number of included studies per country is given in the table on the left. As for the color, the darker the color, the more included studies from that country. Grey means no included study from that country. USA = United States of America; UK = United Kingdom. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

annoyance/frequency of snoring). See [Table S2](#) for more information and references.

3.4.1.2. Obstructive sleep apnea. The included 151 studies on sleep-related breathing conditions covered the prevention, assessment, and management of OSA.

3.4.1.2.1. Prevention. Five studies [31–35] suggested that, due to the decrease in upper airway space, retruded position of mandible and bite raising might lead to (the aggravation of) OSA. Hence, when planning orthognathic surgery, oral and maxillofacial surgeons should be prudent with the degree of mandibular retro-positioning, especially when there is no concomitant maxillary advancement [31]. In addition, dentists should avoid bite raising when treating OSA patients using an OA [32]. For edentulous patients, conflicting results of wearing complete dentures during sleep for OSA were reported [33–38]. See [Table S2](#) for more information and references.

3.4.1.2.2. Assessment. Two studies reported to use polysomnography (PSG; the gold standard for diagnosing OSA) [39] and a home sleep study device [40] in dental clinics to assess OSA as requested by the referring physician and to evaluate the treatment efficacy of OA, respectively. The role of orthodontists in screening for high OSA risk was mentioned in studies reporting the association between PSG-diagnosed OSA and the upper airway space measured using cephalometry. A positive association between the severity of OSA and patients' periodontal condition was also reported. However, so far, the cause-effect relationship of periodontal disease and OSA is still unclear [41]. In addition, custom questionnaires (e.g., visual analogue scale [VAS]) and validated questionnaires, including STOP (snoring, tiredness, observed apnea, high blood pressure) questionnaire, STOP-Bang (snoring, tiredness, observed apnea, high blood pressure, body mass index, age, neck circumference, gender) questionnaire, Berlin questionnaire, and Epworth Sleepiness Scale (ESS) were commonly used by dentists to assess the risk of OSA and to screen for OSA patients. See [Table S2](#) for more information and references.

3.4.1.2.3. Management. Not surprisingly, OA therapy and MMA surgery were the two most common modalities that were used by oral healthcare providers (especially by dentists and orthodontists, and oral and maxillofacial surgeons, respectively) to alleviate OSA-related symptoms and to treat OSA, respectively. A study found that good response of OSA patients to OA therapy was a predictor of good response to MMA surgery [42]. ESS was frequently used to evaluate the treatment efficacy of MMA. In addition to MMA, other skeletal advancement surgeries, including sagittal split ramus osteotomy and mandibular distraction osteogenesis, were also reported to be used to treat OSA. As for the OA therapy, in this review, according to a previous study [43], OAs were divided into four categories, viz., one-piece prefabricated appliance, one-piece custom appliance, two-piece appliance with midline traction, and two-piece appliance with bilateral thrust. Custom OAs (either one-piece or two-piece) were more commonly used than prefabricated appliances by dentists and orthodontists worldwide to treat OSA. Regarding the treatment efficacy of OAs, included studies reported the use of cone beam computed tomography and cephalometry to predict compliance and treatment efficacy of OAs, or to evaluate the increase in the upper airway space caused by the use of OAs. Both self-report and validated questionnaires (e.g., ESS and STOP) were commonly used to evaluate the treatment efficacy of OAs. Of note, two studies from the USA used home sleep study devices to evaluate the efficacy of OAs [31,44]. A study reported the use of tongue stabilizing devices for the management of OSA and the use of ESS to evaluate the treatment efficiency [45]. In addition, orthodontists were reported to treat OSA by holding a patient's mandible forward using orthodontic appliances to increase the upper airway space

[46]. Orthodontic treatment combined with orthognathic surgery (viz., distraction osteogenesis maxillary expansion) were also reported in two studies [47,48] to treat OSA. A study also reported dentist treating OSA using oral myofunctional therapy, including tongue rotation exercise, cheek exercise, pronunciation exercise, and nasal breathing rehabilitation [49]. See [Table S2](#) for more information and references.

3.4.2. Sleep-related mandibular movement conditions

The included 80 studies on sleep-related mandibular movement conditions covered the prevention, assessment, and management of SB.

3.4.2.1. Prevention. The only study on the prevention of SB suggested to prevent SB by examining occlusal contacts and eliminating occlusal interferences [50].

3.4.2.2. Assessment. The majority of the included studies on SB dealt with the assessment of SB, which was mainly performed by dentists, but was also performed by an oral and maxillofacial surgeon [51] and an orthodontist [52] in two studies. According to a previously proposed diagnostic grading system [53], studies on the assessment of SB were divided into three categories, viz., studies that recognized patients with "possible" SB based on a positive self-report only, studies that recognized patients with "probable" SB based on a positive clinical examination, with or without a positive self-report, and studies that recognized patients with "definite" SB based on a positive instrumental (viz., electromyography [EMG] and PSG) assessment, with or without a positive self-report and a positive clinical examination. Studies from different countries reported very similar outcomes. For self-report, both custom criteria and criteria based on the International Classification of Sleep Disorders [54,55] were mainly about the self-awareness of clenching/grinding during sleep and the presence of discomfort (e.g., pain and fatigue) of the jaw and/or jaw muscle. Clinical examinations focused on the presence of excessive tooth wear, masseter hypertrophy, and signs on intra-oral soft tissues (e.g., cheek ridging and tongue scalloping). In addition to self-report and clinical examination, compared with PSG, portable EMG was more frequently used in dental clinics to monitor masseter activity during sleep, which is essential for a "definite" SB diagnosis. See [Table S3](#) for more information and references.

3.4.2.3. Management. As for the management of SB, an occlusal splint was the most common treatment modality used by dentists worldwide. Another less common treatment used by dentists for SB was biofeedback [56–59]. Biofeedback devices can detect masseter muscle activity and release low voltage electrical impulses, which interrupt the muscular activity and relax the muscles without waking the user [56,57]. Using gabapentin [60] and botulinum toxin [61] to treat SB in dental clinics was reported by two included studies. Both subjective evaluation and instrumental examination were reported to be used in dental clinics to evaluate the treatment efficacy of SB. For example, portable EMG was used to monitor masseter muscle activity [56,57] and pressure algometry was used to assess masseter muscle pressure pain threshold [62]. See [Table S3](#) for more information and references.

3.4.3. Sleep-related orofacial pain

The included 79 studies on sleep-related orofacial pain covered a variety of pain-related conditions, such as atypical odontalgia, BMS, headache, and TMD, which can be further divided into myofascial pain, myalgia, and arthralgia, amongst other conditions.

3.4.3.1. Atypical odontalgia. The included 79 studies on sleep-related orofacial pain covered the assessment of atypical odontalgia.

3.4.3.1.1. Prevention. No studies related to the prevention of atypical odontalgia were found in this review.

3.4.3.1.2. Assessment. Among the pain-related conditions, atypical odontalgia was reported by only one study [18], in which patients with atypical odontalgia were recognized by a dentist, according to the third edition of International Classification of Headache Disorders, based on self-reported continuous pain in tooth/teeth and a normal neurological examination result. In addition, atypical odontalgia was found to be associated with sleep disturbance (i.e., difficulty falling asleep, difficulty staying asleep, waking up too early, and feeling tired during daytime), even though a lower proportion of patients with only atypical odontalgia was found to experience this condition than those with both atypical odontalgia and BMS.

3.4.3.1.3. Management. No studies related to the management of atypical odontalgia were found in this review.

3.4.3.2. Burning mouth syndrome. The included 79 studies on sleep-related orofacial pain covered the assessment and management of BMS.

3.4.3.2.1. Prevention. No studies related to the prevention of BMS were found in this review.

3.4.3.2.2. Assessment. Included studies reported the use of subjective evaluation (i.e., pain and/or burning sensation) in combination with a clinical examination of mucosal status to assess the presence/severity of BMS in dental clinics. See [Table S4](#) for more information and references.

3.4.3.2.3. Management. Included studies also reported to treat BMS using medication (viz., clonazepam, vortioxetine, and melatonin) in dental clinics and to evaluate treatment efficacy based on self-reported pain intensity/change. See [Table S4](#) for more information and references.

3.4.3.3. Headache. The included 79 studies on sleep-related orofacial pain covered the assessment of headache.

3.4.3.3.1. Prevention. No studies related to the prevention of headache were found in this review.

3.4.3.3.2. Assessment. Two studies [22,63] reported the use of the International Headache Society criteria by dentists to assess migraine and chronic daily headache (viz., chronic migraine, chronic tension-type headache, and other chronic daily headache), which were found to be associated with the presence of pain-related awakenings and sleep disturbance, respectively. One study reported dentist assessing the frequency of morning headache based on patients' self-report [64]. See [Table S4](#) for more information and references.

3.4.3.3.3. Management. No studies related to the management of headache were found in this review.

3.4.3.4. Temporomandibular disorders. The included 79 studies on sleep-related orofacial pain covered the assessment and management of TMD.

3.4.3.4.1. Prevention. No studies related to the prevention of TMD were found in this review.

3.4.3.4.2. Assessment. The Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD), published in 1992 [65], and the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD), published in 2014 [66], were generally used by dentists around the world to diagnose TMD/recognize patients with TMD. In included studies, the RDC/TMD and the DC/TMD were used to diagnose myofascial pain, arthralgia, myalgia, osteoarthritis, osteoarthrosis, and headache attributed to TMD. An RDC/TMD or DC/

TMD diagnosis is based on self-reported pain (location and features) during the last thirty days and on a clinical examination (palpation pain and pain during jaw movement). In addition to the RDC/TMD and the DC/TMD, other diagnostic criteria were also used to diagnose TMD. Specifically, the classification of TMD of the American Academy of Craniomandibular Disorders (the old name of the American Academy of Orofacial Pain) was used in dental clinics to diagnose capsulitis/synovitis and neuropathic pain [67], and the guidelines of the American Academy of Orofacial Pain were used to diagnose arthralgia [68]. Besides, custom and validated questionnaires were also used to evaluate pain intensity. See [Table S4](#) for more information and references.

3.4.3.4.3. Management. Included studies reported to treat myofascial pain/myalgia/TMD using occlusal stabilization splints, and self-reported pain intensity and maximum mouth opening were used to evaluate the treatment efficacy. In addition to the traditional stabilization splint, a study also reported the use of an anterior bite plane named "Nociceptive trigeminal inhibition—tension suppression system" (NTI-tss) to treat myofascial pain [69]. However, compared with patients who only received guidance, assurance, and counselling for myofascial pain, the integration of NTI-tss device into the therapy protocol did not further relieve the symptoms. Another study reported the role of dentist in treating orofacial pain and sleep difficulty using analgesics, muscle relaxants, and tricyclic antidepressants [70]. The authors also reported that they referred patients with orofacial pain to a physical therapist for treatment. See [Table S4](#) for more information and references.

3.4.4. Sleep-related oral moistening conditions

The included five studies on sleep-related oral moistening conditions covered the assessment and management of oral dryness.

3.4.4.1. Prevention. No studies related to the prevention of oral dryness were found in this review.

3.4.4.2. Assessment. Included studies reported on the assessment of oral dryness in dental settings. Subjective evaluations (e.g., xerostomia inventory questionnaire [71]) and clinical examinations (e.g., Schirmer test [72] and sialometry [71,73]) were used to assess the severity of oral dryness and to measure saliva flow and oral dryness-related symptoms (e.g., moistness of the mucosa), respectively. In addition, it was found that oral dryness was associated with excessive daytime sleepiness and poor sleep quality [71,72]. See [Table S5](#) for more information and references.

3.4.4.3. Management. In the only study reporting on the management of oral dryness, a soft night guard that covered both the dental arch and the hard palate was used to treat oral dryness. The authors observed an improvement in self-reported oral dryness (viz., VAS and 5-point scale) and hypothesized several mechanisms that may explain this improvement, such as that the mechanical stimulation of the night guard to the oral mucosa may lead to salivary secretion and the night guard may be beneficial to the maintenance of saliva volume in the oral cavity [73]. See [Table S5](#) for more information and references.

3.4.5. Sleep-related gastroesophageal reflux condition

The only included study on sleep-related gastroesophageal reflux condition covered the assessment of sleep-related gastroesophageal reflux condition.

3.4.5.1. Prevention. No studies related to the prevention of sleep-related gastroesophageal reflux condition were found in this review.

3.4.5.2. Assessment. In the only included study [74], dentists used the GERD questionnaire, a validated questionnaire, to assess the likelihood of GERD being present based on the reported frequency of GERD-related symptoms (viz., heartburn, nausea, regurgitation, and pain in the middle of the upper stomach area). In addition, the authors found that GERD might lead to impaired sleep quality. See Table S6 for more information.

3.4.5.3. Management. No studies related to the management of sleep-related gastroesophageal reflux condition were found in this review.

The role of the oral healthcare provider in dental sleep-related conditions was summarized in Fig. 2.

4. Discussion

Almost a quarter of a century after the publication of the landmark review on DSM [1], we provide an updated literature review to systematically evaluate the subsequent development of DSM. The available literature was reviewed with the aims to: i) identify previously unidentified dental sleep-related conditions; and ii) identify the role of the oral healthcare provider in the prevention, assessment, and management of dental sleep-related conditions in adults. For the first aim, BMS was found to be the only previously unidentified dental sleep-related condition and was categorized as a type of sleep-related orofacial pain. For the second aim, the oral healthcare provider was found to play a significant role in the prevention, assessment, and management of OSA and SB; in the assessment and management of snoring, sleep-related orofacial pain, and oral dryness; and in the assessment of sleep-related gastroesophageal reflux condition.

In the present study, an evidence-based approach was adopted to identify previously unidentified dental sleep-related condition. The comprehensive search strategy, formulated with the input of a medical librarian, not only helped to identified BMS as a previously unidentified dental sleep-related condition, but also confirmed that the conditions proposed in the landmark review [1] (viz., SB, xerostomia, hypersalivation, gastroesophageal reflux, apnea, and orofacial pain) indeed belong to DSM. It needs to be noted that the present study distinguished different types of oral healthcare providers (viz., dentist, orthodontist, oral and maxillofacial surgeon, and oral hygienist) and identified the role of each type of the oral healthcare provider in the prevention, assessment, and management of dental sleep-related conditions using an evidence-based approach. Additionally, the expert panel has reached consensus that dental sleep-related condition(s) should be used instead of dental sleep-related disorder(s), which was commonly used in previous studies on DSM. According to the Mosby's Medical Dictionary (10th Edition) [75], condition means "a state of being,

specifically in reference to physical and mental health or well-being", while the definition of disorder is "a disruption of or interference with normal functions or established systems". In DSM, the oral healthcare provider can only screen and recognize people with certain physical states of being; they cannot diagnose disruptions of or interferences with normal functions or established systems, which should be done by physicians. Therefore, it is reasonable to use "condition" instead of "disorder" to describe, among others, OSA, BMS, SB, and oral dryness in the context of DSM. Another difference in the use of terms is that "sleep-related" was added to all five categories of dental sleep-related conditions in the present study. Of the dental sleep-related conditions, OSA and snoring only occur during sleep, while the other conditions, such as BMS and oral dryness, can occur both during wakefulness and during sleep. DSM only focuses on the sleep aspect of these conditions, such as the impact of BMS on sleep quality.

Over the past decades, the development of DSM should largely be attributed to the development of tools for the assessment/diagnosis of dental sleep-related conditions. For example, validated questionnaires like the STOP-Bang questionnaire and Berlin questionnaire can be used to screen or recognize OSA patients. For SB, a modified grading system can be used for the assessment of SB. The modified grading system was thoroughly discussed in a previous study [76]. For the orofacial pain category, a validated and comprehensive diagnostic protocol for TMD, namely DC/TMD [66], was frequently mentioned in the present review. The DC/TMD, as a dual-Axis diagnostic protocol, includes physical diagnostic algorithms (Axis I), for both pain-related TMD (e.g., arthralgia, myalgia, myofascial pain) and function-related TMD (e.g., disc displacement, subluxation), and an assessment of psychosocial status and pain-related disability (Axis II). Because DSM only focuses on orofacial pain but not the functional and psychosocial aspects, only information from the Axis I assessment of pain-related TMD was included in the present study. In addition to the DC/TMD, the International Classification of Diseases [77] and the International Classification of Orofacial Pain [78] also proposed diagnostic protocols for orofacial pain.

Another finding of the present review is that, as expected, the oral healthcare provider has adopted new roles in DSM over the past decades. For example, in addition to managing OSA with OA, the present study suggested that the oral healthcare provider may also play a role in selecting suitable patients for the OA therapy, based on patients' craniofacial characteristics and upper airway measurements [21,79,80]. The findings in the present study also suggested a larger role of the orthodontist in treating OSA patients by moving a patient's mandible forward and increasing the upper airway space using orthodontic treatment, either alone or in collaboration with oral and maxillofacial surgeons [36,47,48]. A thorough discussion about OSA and orthodontics can be found in a

Condition \ Role	Sleep-related breathing conditions		Sleep-related mandibular movement conditions	Sleep-related orofacial pain	Sleep-related oral moistening conditions	Sleep-related gastroesophageal reflux condition
	OSA	Snoring	SB		Oral dryness	
Prevention	✓		✓			
Assessment	✓	✓	✓	✓	✓	✓
Management	✓	✓	✓	✓	✓	

Fig. 2. Role of the oral healthcare provider in dental sleep-related conditions. For each dental sleep-related condition, a check mark means that, based on included studies, the oral healthcare provider could play a significant role in its prevention, assessment, and/or management; a blank cell means that the oral healthcare provider could not play the corresponding role. OSA = obstructive sleep apnea; SB = sleep bruxism.

recent white paper released by the American Association of Orthodontists [81]. In addition, the available evidence has demonstrated a positive association between obesity and the risk/severity of OSA and snoring [82,83], the most common dental sleep-related conditions. Given that people regularly visit oral healthcare providers for check-ups and preventative care, oral healthcare providers may play a pivotal role in health education on the association between obesity and OSA/snoring, depending on their training. For obese patients, oral healthcare providers may recommend weight loss and lifestyle changes to prevent OSA. It needs to be noted that although the oral healthcare provider was considered to have an important role in the assessment and management of dental sleep-related conditions [84,85], there is a lack of evidence on whether the oral healthcare provider could, as reported and expected, help to prevent, assess, and/or manage dental sleep-related conditions. The development of technology also has brought a greater role to the oral healthcare provider in DSM. EMG and PSG are generally analyzed and used by sleep technicians to diagnose sleep disorders such as OSA and SB. It was found in the present study that software-supported ambulatory somnographic studies and portable EMG, which enables automated analysis of physiologic signals, were frequently used in dental clinics to assess OSA and SB, respectively. In a study from the USA, standard PSG was even used in dental clinic to assess OSA on the referral of physician. As for the assessment of SB, it needs to be noted that some currently available electromyographic devices were reported to have compromised validity or were limited by its feasibility [86,87].

Regarding the findings reported in the present review, there are several points to note. Most importantly, the present review summarizes the reported roles of the oral healthcare provider in DSM, but it is not a practical guideline with instructions about the work of the oral healthcare provider in the clinic. Whether the procedures mentioned in this review (e.g., using PSG to assess OSA in dental clinics) can/should be performed by the oral healthcare provider and which type of the oral healthcare provider can/should perform these procedures depend on the region, local legislation, political regulations, and the training that local oral healthcare providers received. It should also be noted that some findings in the present study are not definitive and should be interpreted with caution. For example, the only study on the prevention of SB suggested to prevent SB by examining occlusal contacts and eliminating occlusal interferences [50]. However, evidence suggests that SB is mainly regulated by central factors (e.g., stress, emotion), not by peripheral factors (e.g., occlusal contacts) [88,89].

Another point to note is that dental sleep-related conditions like OSA and SB are frequently reported to be associated with other sleep disorders, such as insomnia, nocturia, and rapid eye movement sleep behavior disorder (RBD) [90–92], but the oral healthcare provider cannot play a role in the prevention, assessment, or management of these disorders. As a consequence, the following questions emerge: how do these disorders relate to DSM, and where is the boundary of DSM (i.e., the boundary between dental sleep-related conditions and other associated sleep disorders)? Regarding these two questions, consensus has been reached in the expert panel (i.e., the authors of the present paper) that DSM is a discipline with clear core conditions (viz., the known five categories of dental sleep-related conditions) and with a “grey zone” around this core. Since sleep disorders in this grey zone (e.g., insomnia, nocturia, and RBD) are quite close to the core conditions of DSM, we recommend that the oral healthcare provider should at least be aware of these disorders.

Several previous studies have discussed the most common dental sleep-related conditions (viz., OSA and SB) and sketched the role of the oral healthcare provider in these conditions [6,8,16]. Clearly, the role of the oral healthcare provider in DSM is large and important. It is imperative that the oral healthcare provider is not only willing to take on that role, but is also able to do so. This suggests that dental curricula, including postgraduate education, should take DSM into consideration, thus ensuring that the oral healthcare provider is able to help patients suffering from dental sleep-related conditions [15,16]. In addition to being aware of the role in DSM, the oral healthcare provider should also understand the importance of collaborating with physicians [9]. Prompt communication and collaboration between the oral healthcare provider and the physician are the key to successful prevention, assessment, and management of dental sleep-related conditions. The oral healthcare provider should also be alert to the potential associations between dental sleep-related conditions. Evidence suggests that dental sleep-related conditions are somehow associated with each other. Future studies should focus on the comorbidity network among the dental sleep-related conditions and identify the biological and/or psychosocial factors that are involved in these associations. In addition, more studies are needed to explore the role of the oral healthcare provider in the prevention, assessment, and management of sleep-related oral moistening conditions and sleep-related gastroesophageal reflux condition. For the contradictory findings in the present study, such as the role of complete dentures in OSA [33–38], more studies are needed for a confirmative result.

A key strength of this review was the robust approach to identify dental sleep-related conditions and the role of oral healthcare providers in these conditions. On the other hand, this review also has limitations. Firstly, like all systematic reviews and scoping reviews, it is possible that some relevant studies were not retrieved with the literature search, even though a comprehensive search strategy was used. For example, dentists were suggested to assess GERD based on the presence of chemical tooth wear [93]. However, in the present study, no such studies were retrieved based on our search strategy. Secondly, for the second aim, the present study only focused on subjective evaluation, clinical procedure, and instrumental evaluation that may help oral healthcare providers with the prevention and assessment of dental sleep-related conditions in adults. As a consequence, certain factors that were reported to be associated with dental sleep-related conditions and might contribute to the prevention and assessment of dental sleep-related conditions, such as age, gender, and body mass index for OSA, were not included in the present study. Thirdly, as mentioned above, another reason that might have led to the loss of information is that, in some studies, certain clinical procedures may actually have been performed by the oral healthcare provider, but if this could not be clearly assumed from the manuscript, these clinical procedures were not included as a possible role of the oral healthcare provider in DSM in the present study.

5. Conclusion

Based on the available evidence, BMS is added to the list of dental sleep-related conditions. The oral healthcare provider plays a significant role in the prevention, assessment, and management of OSA and SB; in the assessment and management of snoring, sleep-related orofacial pain, and oral dryness; and in the assessment of sleep-related gastroesophageal reflux condition.

Practice points

- According to the included studies, the core conditions of dental sleep medicine include sleep-related breathing conditions (snoring and obstructive sleep apnea), sleep-related mandibular movement condition (sleep bruxism), sleep-related orofacial pain (atypical odontalgia, burning mouth syndrome, headache, and temporomandibular disorder), sleep-related oral moistening conditions (oral dryness), and sleep-related gastroesophageal reflux condition.
- Dental sleep medicine is a discipline with clear core conditions and with a grey zone around this core. Given that sleep disorders in the grey zone (e.g., insomnia, nocturia, sleep related epilepsy, and rapid eye movement sleep behavior disorder) are reported to be associated with the core conditions of dental sleep medicine, oral healthcare providers should also be aware of these sleep disorders.
- Current evidence suggests that oral healthcare providers can play a significant role in the prevention, assessment, and management of obstructive sleep apnea and sleep bruxism; in the assessment and management of snoring, sleep-related orofacial pain, and oral dryness; and in the assessment of sleep-related gastroesophageal reflux condition.

Research agenda

- For better prevention and assessment of dental sleep-related conditions, future studies are needed to explore the comorbidity network among the dental sleep-related conditions, and to identify the biological and/or psychosocial factors that are involved in this comorbidity network.
- Due to the lack of relevant evidence, more studies are needed to explore the role of oral healthcare providers in the prevention, assessment, and management of sleep-related oral moistening conditions and sleep-related gastroesophageal reflux condition.
- Further research is required to identify phenotypic characteristics associated with the response to therapeutic options (e.g., use of complete denture during sleep).

Declaration of competing interest

The authors declare no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.smrv.2022.101721>.

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