TITLE

Clinical Oral Disorders in Adults Screening Protocol

(CODA-SP)

from the 2019 Vancouver IADR Consensus Workshop

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ABSTRACT

Background: The Clinical Oral Disorder in Elders (CODE) index was proposed in 1999 to assess the oral health status and treatment needs of older people who typically were edentate or had few natural teeth. Since then, more people are retaining natural teeth into old age and have oral disorders similar to younger adults. In addition, there has been further guidance on screening for disease that includes changes to the clinical indicators of several oral disorders and greater sensitivity to people's concerns about their oral health and care needs. **Methods:** Experts in dental geriatrics assembled at a workshop in 2019 to revise the objectives and content of the CODE index. Before the workshop, 139 registrants were asked for comments on the CODE index, and 11 content experts summarized current evidence, and assembled reference lists of relevant information on each indicator. The reference lists provided the base for a narrative review of relevant evidence supplemented by reference tracking and direct searches of selected literature for additional evidence. **Results:** Analysis of the evidence by consensus of the experts produced the Clinical Oral Disorders in Adults Screening Protocol (CODA-SP). **Conclusions:** The CODA-SP encompasses multiple domains of physical and subjective indicators with weighted severity scores. Field-tests are required now to validate its effectiveness and utility in oral healthcare services, outcomes, and infrastructure.

Key words:

Oral health; Screening for disease; Physical indicators; Patient-reported Outcomes; Narrative review.

BACKGROUND

Clinical Screening

Screening for disorders or diseases can occur at a population level, among people with a

particular disease, or opportunistically in clinical practice, with the aim of identifying "a disease

or pre-disease in people who are presumed and who presume themselves to be healthy".[1]

Wilson and Jungner[2] proposed that screening or early detection of disease should simply and

rapidly distinguish people who probably have clinical signs or symptoms from those unlikely to

have a disorder. Physical indicators and patients' concerns, although not diagnostic, serve as

prognostic markers of suspicious findings for further investigation.[3,4] Screening can address

three major spheres: the disease/condition; the test/intervention; and the program/system.[5]

The first two focus on test conditions and performance (simplicity; validity etc.), as in the index

of Clinical Oral Disorders in Elders (CODE),[6] while the third relates to the infrastructure of

screening programs.[7]

Comprehensive screening protocols have been overshadowed by specific diagnostic tests for use

in clinical trials.[8] The Japanese Society of Gerodontology advocates multiple diagnostic tests for

oral hypofunction but many tests depend on electronic devices unsuitable for a comprehensive

screening protocol.[9] The Minimal Data Set (MDS), by contrast, is a comprehensive but versatile

health assessment that evolved into a multi-dimensional "international Resident Assessment

Instrument" (interRAI) for assessing physical and psychosocial dimensions of health among

residents in care facilities.[10-12] Unfortunately, the validity, relevance and use of this instrument in

the context of the Resident Assessment Instrument–Minimum Data Set 2.0 (RAI-MDS 2.0) is

dubious[13-16] and probably explains in part the conflicting priorities confronting many care-

providers to people who are frail.[17] Other comprehensive screening protocols are available

specifically for dental clinicians (Table S1)[6,18-26] or some specifically for nurses and other non-dental personnel,[27] but none address the broad range of criteria relevant to oral disorders[9,28] or gives much attention to patient-reported outcomes or concerns.[29]

The CODE index originated from epidemiological investigations as a screening protocol and ranked index for jaw movements, dentures, oral mucosa, teeth and periodontium among frail residents of care facilities.[6,30] The objectives were to provide dental professionals with a comprehensive set of criteria and clinical severity scores for each disorder. The CODE protocol is used as a laptop computer-based screening and recording guide to generate an Access®database (Microsoft Corp. Redmond: Washington, USA) to monitor clinical and financial information by the administration of a university-based geriatric dentistry program.[31-33]

The World Dental Federation (FDI) defines oral health as "multi-faceted and includes the 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", and asserts that oral health "is influenced by the individual's changing experiences, perceptions, expectations and ability to adapt to circumstances".[34] This broad perspective is compatible with other models or frameworks of oral health, and endorsed by the World Health Organization,[35] and offers a conceptual foundation for a screening protocol which is sensitive to oral health and risk of disease in adults.[36-40] The burden of comorbidity and multimorbidity in older populations has prompted interest in extending the scope of dental screening beyond the CODE index to include chewing dysfunction, dysphagia, dry mouth, dental erosion, and complaints of pain.[39,41-43] Consequently, experts in dental geriatrics and specific oral disorders assembled in June 2019 as part of the International Association of Dental Research general

session to review by consensus the scope of a screening protocol and index appropriate to adults in all age groups. This article describes and explains the screening protocol that evolved from the workshop.

METHODS

The new protocol emerged in four stages. In *Stage 1*, opinions on the CODE index were submitted electronically by 111 clinicians and researchers in 21 countries in response to a public announcement about the workshop. We forwarded the opinions to the 11 content experts who were summarizing evidence on dry mouth, periodontal disorders, dental caries, mucosal disorders, dental erosion, chewing dysfunction, dysphagia, maxillofacial pain, and quality of life (Box 1). In *Stage* 2, the experts presented the evidence at the one-day workshop with 126 participants. Four participants recorded written notes from open discussions on each expert's topic. In *Stage 3*, one investigator (MacEntee) reviewed the summaries along with the 182 articles of evidence identified by the experts, and found an additional 79 relevant articles by searching the references in each article, corresponding directly with the experts, and reference tracking with Google Scholar until the evidence on the screening protocol and criteria seemed saturated.[44-46] The list of 261 articles are available on request from the corresponding author. Finally, in *Stage 4*, the experts refined the narrative review of evidence and the protocol through four drafts to reach consensus on the new protocol and weighted severity scores.

RESULTS

Screening tests, like diagnostic tests and treatment planning indicators, are based on interactive reasoning processes by which examiners recognize and interpret physical and subjective clinical patterns.[47,48] The following descriptions along with Table 1 contain the evidence for the physical indicators, patient-reported outcomes, and their severity scores.

General Assessment and Medical Status

A review of medical records and discussion with the patient and caregivers provide an overview of physical and cognitive status and subjective patient-reported outcomes relating to general and oral health.[26,29,49-53] The physical assessment includes the hands for osteoarthritis which complicates oral hygiene, particularly in older women.[54,55]

Extra-oral Abnormalities

The physical examination begins by appraising appearance and deportment for asymmetry, swelling, ulcers, skin lesions and other signs of extraoral abnormalities of the face, neck, nose, cheeks, chin, commissures, vermillion border and jaws.[26]

Sensory-Motor Jaw Dysfunction

Pain or Discomfort

Pain and discomfort are interactive biopsychosocial phenomena reported subjectively, and responses from people in pain can be distorted and difficult to interpret.[56,57] Acute facial pain is usually tooth-related while chronic facial pain, most commonly of the jaw joints, can be unilateral or bilateral, continuous or episodic, and assessed initially by the patient's history of the pain.[58] In addition, self-reports - either verbal or non-verbal gestures, such as facial expressions, body movements, vocalizations and changes in routine behaviors - are primary sources of information obtained either directly from a patient or a care-giver about the presence and intensity of acute or chronic pain.[16,56,59-61] We modified an ultra-brief scale for assessing chronic pain by dichotomizing the severity and impact of the pain.[62]

Temporomandibular Dysfunction

We address jaw dysfunction, including jaw pain, in three sections. Firstly, we examine extra-orally and intra-orally the temporomandibular joint movements and comfort. Secondly, we judge the stability and function of the dentition by inspecting occlusal contacts, and finally we judge the person's ability to chew and swallow food. Reports over many decades suggest that

complaints about temporomandibular disorder (TMD) are unusual, especially in older people, but potentially distressing in all age groups.[63-65] Similar to the *Diagnostic Criteria for Temporomandibular Disorders*, the screening protocol includes physical appraisal of joint pain and restricted movements supplemented by the patient-reports or concerns.[66]

Occlusal Stability

Adequate dental stability and chewing is possible with a shortened dental arch (SDA) of 20 occluding natural teeth or fixed dental prostheses.[67,68] This includes intact sextants of anterior teeth in both jaws plus at least four occluding units bilaterally where a pair of occluding premolars constitute one unit, and a pair of occluding molars constitute two units.[69]

Chewing

Masticatory efficiency is measured usually by the number of chewing strokes to produce a specific particle size of a standardized substance, such as carrots, nuts, gum jelly, or silicone,[70] or preferably with a measurable mix of multicolored wax or chewing gum when the risk of aspiration is elevated.[71] Investigations continue to determine the optimal properties of standardized substances, especially chewing gum, and to measure the mix of colours electronically.[72-74] Unfortunately, current measurement techniques for chewing do not meet the simplicity or time limits of a screening protocol without electronic devices, which, like radiographic machines, are typically unavailable for screening examinations. Consequently, we question participants about difficulties chewing food for swallowing or without choking.[70]

Tooth Wear/Erosion

The Basic Erosive Wear Examination (BEWE) index reflects chemical, physical or abrasive damage on the surfaces of teeth with ordinal categories: (0): no wear; (1) initial loss of mamelons and surface detail; (2): wear of <50%; and (3): wear of ≥50% of a tooth's surface. The highest score from a tooth surface in each sextant provides an overall score to guide the

management of tooth wear.[75] Bruxism, salivary hypofunction, dietary acids, and regurgitation can all add to the wear or erosion of teeth and prostheses.[76-78]

Dentures

Retention, stability and occlusal contacts dominate the physical assessment of complete dentures, although there are also criteria for material structure, supporting tissues and appearance (Table S2). It is challenging to assess the physical quality of dentures based on nominal, ordinal, or dichotomous scales that depend heavily on the clinical experience and inferences of the examiner,[79-84] and on the expectations of the denture-wearer.[85]

Oral Hygiene

Poor oral hygiene could increase the risk of pneumonia, gingivitis, mucositis, periodontitis, dental caries, and aspiration pneumonia.[86-88] The Simplified Oral Hygiene Index (OHI-S)[89] and Plaque Index[90] for natural teeth, and the Denture Plaque Index (DPI)[91] and Denture Cleanliness Index (DCI)[92] for dentures, measure the distribution of microbial plaque but with little evidence on how much plaque increases risk.[87] We selected *Level 3* (soft plaque covers more than two-thirds of tooth surfaces) from the OHI-S, and *Levels 3 and 4* (denture has visible plaque and/or debris on more than half of the denture-surfaces) from the DPI/DCI to designate greater risk. We interpret soft plaque on all root surfaces as *Level 3* plaque score.

Mucosal Lesions

There are descriptions of the more common mucosal disorders along with an efficient and comprehensive screening method covering nine areas of the mouth.[26,93] Screening for potentially malignant disorders is hampered by uncertain patient-reported histories and unreliable precancerous indicators, such as autofluorescence, tissue reflectance or vital staining.[29,94] Experienced examiners for mucosal lesions can be highly (>0.80) specific but less

(0.50-0.99) sensitive for detecting lesions.[95] Heavy use of tobacco and alcohol,[96] and a history of human papillomavirus,[97] increase the risk of epithelial dysplasia. Unfortunately, self-examination for early signs is not a reliable method of detecting oral cancer.[98]

Dry Mouth

The term "dry mouth" encompasses both the subjective symptoms (xerostomia) and low salivary flow or salivary gland hypofunction (SGH); the two states coincide in about one-sixth of those with either condition.[99] The typical flow rate for unstimulated whole-mouth saliva is 0.35 ml/min, with SGH considered at <0.2 mL/min,[100] with a score of ≥5 on the Clinical Oral Dryness Score (CODS) represents SGH.[101,102] The subjective effects of a dry mouth can be very disturbing,[103,104] and reflected by a response of "frequently or always" to the question "*How often does your mouth feel dry?*", which corresponds to high scores on the 5-option Xerostomia Inventory.[105,106] Chronic dry mouth may arise from Sjögren's syndrome[107] or the side-effects of radiotherapy for head/neck cancer, but the combined prevalence of those conditions in the population is no more than 1-2%, and medication-induced dry mouth is by far the most common form. A wide range of medications is implicated, particularly antidepressants and those with anticholinergic effects.[107,108,109]

Swallowing

There are many screening tests for oropharyngeal dysphagia but none is highly predictive for aspiration risk.[110] Videofluorography and videoendoscopy is the optimal method of identifying dysphagia whereas screening tests, such as the Repetitive Saliva Swallowing Test (RSST), is helpful for excluding - with >90% specificity - an elevated risk of aspiration.[111] The RSST measures risk by palpating or observing the larynx for the number of swallows over 30 seconds after asking a patient to swallow saliva as many times as possible, and where fewer than three swallows warrants further investigation for swallowing problems. A single question to identify

swallowing complaints or concerns from the patient also indicates the need for more definitive investigations.[112]

Tooth-structure and Partial Dental Prostheses

People can be functionally compromised esthetically, socially and biologically without anterior teeth.[43] However, people generally cope adequately with a shortened dental arch when posterior teeth are missing.[67-69] There are criteria for assessing the structure, hygiene, comfort and appearance of dental restorations[113] and partial dental prostheses.[114-117] However, the physical characteristics of a prosthesis, even if inadequate, rarely influence patient satisfaction directly.[118-120] Consequently, the protocol seeks information about a patient's wishes for modifying or replacing a dental restoration or prosthesis.[37,43,121]

Dental Caries

Caries is a nutritional acidification or dysbiosis of the dental biofilm that demineralises teeth and can expose the dental pulp.[122,123] The *International Caries Detection and Assessment System* (ICDAS)[124] distinguishes early enamel demineralization from cavitated lesions, but, like the *American Dental Association Caries Classification System* (ADA CCS)[125] and the *Caries Assessment Spectrum and Treatment* (CAST),[126] it is too complicated without simplification for a screening protocol. Similarly, the *Nyvad Caries Classification* uses rough lusterless surfaces with a soft, leathery feel on clean, dry teeth to indicate demineralizing lesions but the dysbiotic activity of noncavitated lesions is difficult to judge.[127] The *Pulp, Ulcer, Fistula, and Abscess* (PUFA) system is only for deep lesions.[128] For the CODA-SP, we selected the CAST index with simplified indicators[126] supplemented by information on sugar consumption.[129-132]

Gingival and Periodontal Diseases

Gingival bleeding on probing at ≥10% of dental sites is a practical indicator of gingivitis.[133] The

protocol identifies people with severe periodontitis and risk factors likely to influence or grade management of the disease. Interdental periodontal pocket depth (PD) and clinical attachment level (CAL) of attached gingiva from the cement-enamel junction to the tactile point of resistance in a pocket are essential measurements of periodontal status.[134,135] The Classification of Periodontal and Peri-Implant Diseases and Conditions considers *Stage I* as CAL of 1-2 mm and maximum PD ≤4 mm, *Stage II* as CAL 3-4 mm and maximum PD ≤5 mm, *Stage III* as CAL ≥5 mm and PD ≥6 mm, and *Stage IV* as more severe clinical complications, such as pocket suppuration, hypermobile teeth, occlusal stress, or complicating systemic diseases.[136,137] The screening of all interdental sites identifies the stage of the tooth with the worst periodontal condition anywhere the mouth, and we selected *Stage III* as the severity threshold for further attention.[138] The assumption is that radiographs are not available for evaluating bone loss or furcation involvement in a screening examination.

Weighted Severity Scores

The experts slightly modified the scores reported previously from a survey of 33 dentists and 11 dental hygienists with the CODE index,[6] and by consensus we broadened the scope of the protocol to include all adults, and assigned new severity scores to the patient-reported outcomes or concerns (Table 1).

DISCUSSION

This CODA-SP evolved from the opinions of 124 clinicians and researchers from 21 countries and 11 content experts. It covers 17 physical domains of health and related patient-reported outcomes or concerns based on clinical criteria identified by content experts, a narrative review of relevant literature, and a consensus of clinical experts. It is more comprehensive than other multidimensional screening protocols of similar focus (Supplements 1a & 1b), and reflects current evidence on potentially burdensome but therapeutically manageable disorders in all

adult age groups.[2,5] The examination protocol is sequenced efficiently with, for example, occlusal stability (item 5) appraised before chewing and tooth wear (items 6 & 7), and prostheses/tooth structure (item 13) followed by caries (item 14) appraised before bleeding from gingival probing (items 15 & 16) obscures the dental surfaces.

The time required for the protocol depends on unpredictable circumstances. The average time-estimate during examiner training sessions for the *Index of Oral Health Status* was five minutes.[21] After one hour of training, the *CODE index* took four minutes with complete denture wearers and nine minutes with patients who had ≥14 natural teeth.[6] Burke et al.[25] found that most dentists were accustomed to the *Oral Health Score* within two weeks. They reported also that dental nurses in the United Kingdom could apply the OHS without difficulty but they offered no direct evidence for the validity of their evaluations.

Limitations

The review of evidence for physical indicators and patient-reported outcomes was based on an optimal rather than a comprehensive search of the literature and other sources. The scope and heterogeneity of a comprehensive search would almost certainly have produced an unmanageable yield of irrelevant information.[44,139] Nonetheless, the experts by consensus decided that the evidence was saturated and sufficiently strong to support the protocol.

Validation of biomarkers is a complicated and uncertain process that can be enhanced by limiting the number of markers and clarifying operational definitions.[30,134,140] The sensitivity and specificity of the CODA-SP rests on specific claims of "very good" to "excellent" by developers of each indicator and outcome, albeit on evidence from examiners' calibrating exercises.[6] Consequently, the validity of the protocol as a whole needs further investigation with

appropriate allowance for the negative bias and simplifications of patient-reported outcomes.[50,141,142] Then again, although scores based on patients' concern warrant cautious interpretation, a global rating of oral health does provide reasonable indication of need for further investigation.[53]

Implications

The disorders covered by the CODA-SP can be damaging physically and psychologically in any age group, and especially for older people who are frail. Screening should be offered without unnecessary social pressures and anxiety from delayed follow-up, resource costs and stigma. Tests should apply only to disorders with therapeutic potential, otherwise they are pointlessly intrusive. But above all, we emphasise that the CODA-SP alone is not for diagnostic or treatment decisions beyond the need for further investigation, although the information should be useful when all the necessary diagnostic and treatment options are assembled.

The weighted scores are essentially an examiner's subjective opinion on the relative significance of an item or group of items to the particular aim and application of the CODA-SP. For example, a binary "healthy" or "unhealthy" outcome without a numerical score would indicate the status of a specific indicator or concern, or the general status of a patient's oral health.[2] Alternatively, a total numerical score from part or all of the protocol provides data for comparing or monitoring the status of population groups, or for evaluating specific treatment or healthcare programs.[5] Either way, outcomes and scores should represent a reasonable balance of the examiner's observations and the patient's concerns interpreted with mature clinical judgement.[47,48] It is unlikely, therefore, that this protocol could be applied and interpreted meaningfully by non-dental personnel.

Further Needs

The CODA-SP needs standardized field-tests of measurement properties, such as construct validity and reliability, and of other response processes and consequences, such as cultural sensitivity, that influence the utility of a screening protocol.[3,143-145] The National Institutes of Health Patient Reported Outcomes Measurement Information System (PROMIS) in particular could be useful for focusing patient-reported outcome and concerns.[146] Practical experience with the protocol will reveal examiner reliability, time to apply, and predictive validity, whereas applications by a computer-based software, as with the CODE index, should enhance its utility and efficiency.[31] Moreover, the perspectives of recipients and providers offered by the CODA-SP could contribute to the development and assessment of clinical and public health programs and health products.[5,7] It could help also to explore the cognitive process of clinical reasoning across a broad range of healthcare settings.[47]

CONCLUSIONS

The CODA-SP is a comprehensive screening protocol encompassing multiple domains of physical and subjective indicators with weighted severity scores. The protocol is based on a narrative review of the literature and a consensus of content experts. Further development is required in field-tests to validate its effectiveness and utility in oral healthcare services, outcomes and infrastructure.

REFERENCES

1. Holland WW, Stewart S. Screening in disease prevention: what works?. London: CRC Press; 2018 Available at: https://doi-org.ezproxy.library.ubc.ca/10.1201/9781315377537. (Accessed December 9, 2019).

2. Wilson JMG, Jungner G. Principles and practice of screening for disease. Geneva, Switzerland: World Health Organization; 1968. Available at: https://apps.who.int/iris/handle/10665/37650 (Accessed December 7, 2019).

3. Chan EK. Standards and guidelines for validation practices: Development and evaluation of measurement instruments. In: B.D. Zumbo and E.K.H. Chan (eds.), Validity and Validation in Social, Behavioral, and Health Sciences, Social Indicators Research Series 54, Springer International Publishing Switzerland. 2014 (pp. 9-24). DOI 10.1007/978-3-319-07794-9_2.

4. FDA-NIH Biomarker Working Group, BEST (Biomarkers, EndpointS, and other Tools) Resource (Silver Spring Maryland: Food and Drug Administration (US), 2018). Available at https://www.ncbi.nlm.nih.gov/books/NBK326791/ (accessed January 17, 2020).

5. Dobrow MJ, Hagens V, Chafe R, Sullivan T, Rabeneck L. Consolidated principles for screening based on a systematic review and consensus process. CMAJ. 2018;190:E422-429. doi: 10.1503/cmaj.171154

6. MacEntee MI, Wyatt CC. An index of clinical oral disorder in elders (CODE). Gerodontology. 1999;16:85-96.

7. Pruksapong M, MacEntee MI. Quality of oral health services in residential care: towards an evaluation framework. Gerodontology. 2007;24:224-230. doi:10.1111/j.1741-2358.2007.00187.x

8. Porter ME, Larsson S, Lee TH. Standardizing patient outcomes measurement. NEJM. 2016 374:504-506. DOI: 10.1056/NEJMp1511701

9. Minakuchi S, Tsuga K, Ikebe K, Ueda T, Tamura F, Nagao K, Furuya J, Matsuo K, Yamamoto K, Kanazawa M, Watanabe Y. Oral hypofunction in the older population: position paper of the Japanese Society of Gerodontology in 2016. Gerodontology. 2018;35:317-324. DOI: 10.1111/ger.12347.

10. interRAI Organization: Who We Are. Available at: https://www.interrai.org/ (accessed November 15, 2019).

11. Tran TD, Krausch-Hofmann S, Duyck J, de Almeida Mello J, De Lepeleire J, Declerck D, Declercq A, Lesaffre E. Association between oral health and general health indicators in older adults. Sci Rep. 2018; 8:8871. doi: 10.1038/s41598-018-26789-4.

12. de Almeida Mello J, Tran TD, Krausch-Hofmann S, Meehan B, van Hout H, Turcotte L, van der Roest HG, Garms-Homolová V, Jónsson P, Onder G, Finne-Soveri H, De Lepeleire J, Declerck D, Lesaffre E, Duyck J, Declercq A. Cross-Country Validation of the Association Between Oral Health and General Health in Community-Dwelling Older Adults. J Am Med Dir Assoc. 2019; doi: 10.1016/j.jamda.2019.02.020.

13.   Krausch-Hofmann S, De Almeida Mello J, Declerck D, Declercq A, De Lepeleire J, Tran TD, Lesaffre E, Duyck J. The oral health-related section of the interRAI: Evaluation of test content validity by expert rating and assessment of potential reasons for inaccurate assessments based on focus group discussions with caregivers. Gerodontology. 2019. doi: 10.1111/ger.12421.

14.   Krausch-Hofmann S, Bogaerts K, Hofmann M, de Almeida Mello J, Fávaro Moreira NC, Lesaffre E, Declerck D, Declercq A, Duyck J. Missing oral health-related data in the interRAI-HC - Associations with selected variables of general health and the effect of multiple imputation on the relationship between oral and general health. PLoS One. 2015;10:e0146065. doi: 10.1371/journal.pone.0146065.

15.   Hoben M, Yoon MN, Lu L, Estabrooks CA. If we cannot measure it, we cannot improve it: Understanding measurement problems in routine oral/dental assessments in Canadian nursing homes—Part I. Gerodontology. 2019; in press. DOI: 10.1111/ger.12449.

16.   Yoon MN, Lu L(L), Ickert C, Estabrooks CA, Hoben M. If we cannot measure it, we cannot improve it: Understanding measurement problems in routine oral/dental assessments in Canadian nursing homes—Part II. Gerodontology. 2020;00:1–13. https ://doi.org/10.1111/ger.12467.

17.   MacEntee MI, Thorne S, Kazanjian A. Conflicting priorities: oral health in long-term care. Special Care Dentistry. 1999;19:164-172.

18.   Bulman JS, Richards ND, Slack GL, Willcocks AJ. Demand and need for dental care. A socio-dental study. London: The Nuffield Trust; Oxford University Press. 1968:97-103.

19.   Nikias MK, Sollecito WA, Fink R. An empirical approach to developing multidimensional oral status profiles. J Public Health Dent. 1978;38:148-158.

20.   Marcus M, Koch AL, Gershen JA. An empirically derived measure of oral health status for adult populations. J Public Health Dent. 1980;40:334-345.

21.   Marcus M, Koch AL, Gershen JA. Construction of a population index of adult oral health status derived from dentists' preferences. J Public Health Dent. 1983;43:284-294.

22.   Sainfort F, Zimmerman DR, Booske BC, Wickeham D. Oral health outcomes measurement using multiattribute utility theory. Unpublished manuscript, 1994; Details in Lang et al. (ref. 13).

23.   Lang WP, Borgnakke WS, Taylor GW, Woolfolk MW, Ronis DL, Nyquist LV. Evaluation and use of an index of oral health status. J Public Health Dent. 1997;57:233-242.

24.   World Health Organization. Oral health surveys: basic methods, 4th ed. World Health Organization. 1997. Available at: https://apps.who.int/iris/handle/10665/41905 (accessed November 28, 2013).

25.   Burke FJ, Busby M, McHugh S, Delargy S, Mullins A, Matthews R. Evaluation of an oral health scoring system by dentists in general dental practice. Brit Dent J. 2003;194:215-218.

26.   Petersen PE, Baez RJ, World Health Organization. Oral health surveys. Basic methods, 5th ed. Geneva: World Health Organization 2013; Available at: https://apps.who.int/iris/handle/10665/97035 (accessed November 28, 2019).

27.   Everaars B, Weening-Verbree LF, Jerković-Ćosić K, Schoonmade L, Bleijenberg N, de Wit NJ, van der Heijden GJ. Measurement properties of oral health assessments for non-dental healthcare professionals in older people: a systematic review. BMC Geriatrics. 2020;20:4. https://doi.org/10.1186/s12877-019-1349-y.

28.   Figueiredo DD, Bastos JL, Silva L, Peres KG. Multidimensional indices of clinical oral conditions from a population perspective: a systematic review. Community Dent Oral Epidemiol. 2016;44:180-187.

29.   Madera M, Franco J, Solà I, Bonfill X, Alonso-Coello P. Screening and diagnosis of oral cancer: a critical quality appraisal of clinical guidelines. Clin Oral Investig. 2019;23:2215-2226. https://doi.org/10.1007/s00784-018-2668-7.

30.   MacEntee MI, Silver JG, Gibson G, Weiss R. Oral health in a long-term care institution equipped with a dental service. Community Dent Oral Epidemiol. 1985;13:260-263.

31.   Wyatt CCL, So FHC, Williams M, Mithani A, Zed C, Yen E. The development, implementation, utilization, and outcome of a comprehensive dental program for older adults residing in long-term care facilities. J Can Dent Assoc. 2006;72:419a-h. Available at: https://www.cda-adc.ca/jadc/vol-72/issue-5/419.pdf (accessed October 27, 2019).

32.   Wyatt CCL. A 5-year follow-up of older adults residing in long-term care facilities: utilisation of a comprehensive dental programme. Gerodontology. 2009; 26: 282–290. doi:10.1111/j.1741-2358.2009.00305.x

33.   Wyatt CCL, Kawato T. Changes in oral health and treatment needs for elderly residents of long-term care facilities over 10-years. J Can Dent Assoc. 2019;85:j7:1-6.

34.   FDI's Definition of Oral Health. Available at: https://www.fdiworlddental.org/sites/default/files/media/images/oral_health_definition-exec_summary-en.pdf (Accessed January 28, 2020).

35.   WHO Expert Committee on Recent Advances in Oral Health & World Health Organization. Recent advances in oral health: report of a WHO expert committee [meeting held in Geneva from 3 to 9 December 1991]. World Health Organization1992. https://apps.who.int/iris/handle/10665/39644 (Accessed February 25, 2020).

36.   Coulter ID, Marcus M, Atchison KA. Measuring oral health status: theoretical and methodological challenges. Soc Sci Med. 1994;38:1531-1541.

37.   MacEntee MI. An existential model of oral health from evolving views on health, function and disability. Community Dent Health. 2006;23:5-14.

38.   Brondani MA, Bryant SR, MacEntee MI. Elders assessment of an evolving model of oral health. Gerodontology. 2007;24:189-195.

39. Sekulic S, Theis-Mahon N, Rener-Sitar K. A systematic scoping review of oral health models. Qual Life Res. 2019;17: 2651–2668. https://doi.org/10.1007/s11136-019-02206-9

40. Marchini L, Ettinger R, Hartshorn J. Personalized dental caries management for frail older adults and persons with special needs. Dent Clin North Am. 2019;63:631-51. https://doi.org/10.1016/j.cden.2019.06.003.

41. Ní Chróinín D, Montalto A, Jahromi S, et al. Oral health status is associated with common medical comorbidities in older hospital inpatients. J Am Geriatr Soc. 2016;64:1696-1700. DOI: 10.1111/jgs.14247

42. MacEntee MI. Oral health and mouth diseases. In: Martin FC, Watson J, Michel J-P, Beattie BL (Editors). Oxford Textbook of Geriatric Medicine (3rd Edition). Oxford: Oxford University Press. 2017; Chapter 144: 1-17. DOI: 10.1093/med/9780198701590.003.0142

43. MacEntee MI, Hole R, Stolar E. The significance of the mouth in old age. Soc Sci Med. 1997;45:1449-1458.

44. Greenhalgh T, Peacock R. Effectiveness and efficiency of search methods in systematic reviews of complex evidence: audit of primary sources. BMJ. 2005;331:1064-5.

45. Booth A. How much searching is enough? Comprehensive versus optimal retrieval for technology assessments. Int J Technol Assess Health Care. 2010;26:431-435.

46. MacEntee MI. A typology of systematic reviews for synthesising evidence on health care. Gerodontology. 2019;36:303-312. DOI: 10.1111/ger.12439. DOI: 10.1111/ger.12439

47. Khatami S, MacEntee MI. Evolution of clinical reasoning in dental education. J Dent Educ. 2011;75:321-328.

48. Ettinger RL. Rational Dental Care: Part 1. Has the concept changed in 20 Years? J Can Dent Assoc 2006;72:441–445. Accessible at: http://cda-adc.ca/jadc/vol-72/issue-5/441.pdf (accessed January 20, 2020).

49. Kressin N, Spiro III A, Bossé R, Garcia R, Kazis L. Assessing oral health-related quality of life: findings from the Normative Aging Study. Med Care. 1996;1:416-427.

50. Kressin N, Reisine S, Spiro A, Jones, J. Is negative affectivity associated with oral health-related quality of life. Community Dent Oral Epidemiol. 2001;29: 412-423.

51. Locker D, Wexler E, Jokovic A. What do older adults' global self-ratings of oral health measure?. J Public Health Dent. 2005;65:146-152.

52. Lamster IB, Myers-Wright N. Oral health care in the future: expansion of the scope of dental practice to improve health. J Dent Educat. 2017;81:eS83-90. doi: 10.21815/JDE.017.038.

53. Lundbeck HJ, Smith MB, Thomson WM. Clinical validity of self-rated oral health among New Zealand nursing home residents. Gerodontology. 2020; 00:1-5. https://doi.org/10.1111/ger.12458.

54. Zhang Y, Niu J, Kelly-Hayes M, Chaisson CE, Aliabadi P, Felson DT. Prevalence of symptomatic hand osteoarthritis and its impact on functional status among the elderly: The Framingham Study. Am J Epidemiol. 2002;156:1021-107. DOI: 10.1093/aje/kwf141.

55. Schimmel M, Müller F, Suter V, Buser D. Implants for elderly patients. Periodontology 2000. 2017;73:228-240.

56. Turk DC, Dworkin RH, Allen RR, Bellamy N, Brandenburg N, Carr DB, Cleeland C, Dionne R, Farrar JT, Galer BS et al.. Core outcome domains for chronic pain clinical trials: IMMPACT recommendations. Pain. 2003;106:337-345.

57. Turk DC, Fillingim RB, Ohrbach R, Patel KV. Assessment of psychosocial and functional impact of chronic pain. J Pain. 2016;17:T21-49. http://dx.doi.org/10.1016/j.jpain.2016.02.006.

58. Zakrzewska JM. Differential diagnosis of facial pain and guidelines for management. Br J Anaesth. 2013;111:95-104. doi:10.1093/bja/aet125.

59. Booker SQ, Herr KA. Assessment and measurement of pain in adults in later life. Clin Geriatr Med. 2016;32:677-692. http://dx.doi.org/10.1016/j.cger.2016.06.012.

60. Lobbezoo F, Delwel S, AF Weijenberg R, JA Scherder E. Orofacial pain and mastication in dementia. Curr Alzheimer Res. 2017;14:506-511. DOI: 10.2174/1567205013666160602233535.

61. Kunz M, de Waal MW, Achterberg WP, Gimenez-Llort L, Lobbezoo F, Sampson EL, van Dalen-Kok AH, Defrin R, Invitto S, Konstantinovic L, Oosterman J. The Pain Assessment in Impaired Cognition scale (PAIC15): A multidisciplinary and international approach to develop and test a meta-tool for pain assessment in impaired cognition, especially dementia. Eur J Pain. 2020;24:192-208. DOI: 10.1002/ejp.1477.

62. Krebs EE, Lorenz KA, Bair MJ, Damush TM, Wu J, Sutherland JM, Asch SM, Kroenke K. Development and initial validation of the PEG, a three-item scale assessing pain intensity and interference. J Gen Intern Med. 2009;24:733-738. DOI: 10.1007/s11606-009-0981-1.

63. Unell L, Johansson A, Ekbäck G, Ordell S, Carlsson GE. Prevalence of troublesome symptoms related to temporomandibular disorders and awareness of bruxism in 65- and 75-year-old subjects. Gerodontology. 2012;29:e772-9. doi: 10.1111/j.1741-2358.2011.00558.x.

64. Yekkalam N, Wanman A. Prevalence of signs and symptoms indicative of temporomandibular disorders and headaches in 35-, 50-, 65- and 75-year-olds living in Vasterbotten, Sweden. Acta Odontol Scand. 2014;72:458-465.

65. Yadav S, Yang Y, Dutra EH, Robinson JL, Wadhwa S. Temporomandibular joint disorders in older adults. J Am Geriatr Soc. 2018;66:1213-1217.

66. Schiffman E, Ohrbach R, Truelove E, Look J, Anderson G, Goulet JP, List T, Svensson P. Diagnostic criteria for temporomandibular disorders (dc/tmd) for clinical and research applications: recommendations of the International RDC/TMD Consortium Network and Orofacial Pain Special Interest Group. J Oral Facial Pain Headache. 2014;28:6-27.

67. Gerritsen AE, Allen PF, Witter DJ, Bronkhorst EM, Creugers NH. Tooth loss and oral health-related quality of life: a systematic review and meta-analysis. Health Qual Life Outcomes. 2010;8:126. Available at: http://www.hqlo.com/content/8/1/126. (Accessed December 22, 2019).

68. Khan S, Musekiwa A, Chikte UME, Omar R. Differences in functional outcomes for adult patients with prosthodontically-treated and –untreated Shortened Dental Arches: A systematic review. PLoS ONE. 2014;9:e101143. doi:10.1371/journal.pone.0101143

69. McLister C, Donnelly M, Cardwell CR, Moore C, O'Neill C, Brocklehurst P, McKenna G. Effectiveness of prosthodontic interventions and survival of remaining teeth in adult patients with shortened dental arches—A systematic review. J Dentistry. 2018;78:31-39. https://doi.org/10.1016/j.jdent.2018.02.003.

70. Woda A, Hennequin M, Peyron MA. Mastication in humans: finding a rationale. J Oral Rehabil. 201;38:781-784. doi: 10.1111/j.1365-2842.2011.02235.x.

71. Schimmel M, Christou P, Herrmann F, Müller F. A two-colour chewing gum test for masticatory efficiency: development of different assessment methods. J Oral Rehabil. 2007;34:671-678. doi: 10.1111/j.1365-2842.2007.01773.x

72. Yousof Y, Salleh NM, Yusof F. Assessment of masticatory performance by geometric measurement of the mixing ability with 2-color chewing gum. J Prosthet Dent. 2019;121:916-921.

73. Schimmel M, Christou P, Miyazaki H, Halazonetis D, Herrmann FR, Müller F. A novel colourimetric technique to assess chewing function using two-coloured specimens: validation and application. J Dentistry. 2015;43:955-964.

74. Buser R, Ziltener V, Samietz S, Fontolliet M, Nef T, Schimmel M. Validation of a purpose-built chewing gum and smartphone application to evaluate chewing efficiency. J Oral Rehabil. 2018;45:845-853.

75. Bartlett D, Ganss C, Lussi A. Basic Erosive Wear Examination (BEWE): a new scoring system for scientific and clinical needs. Clin Oral Investig. 2008;12:65-68.

76. Schlueter N, Luka B. Erosive tooth wear–a review on global prevalence and on its prevalence in risk groups. Br Dent J. 2018;224:364-370. DOI: 10.1038/sj.bdj.2018.167.

77. O'Toole S, Bernabé E, Moazzez R, Bartlett D. Timing of dietary acid intake and erosive tooth wear: A case-control study. J Dent. 2017;56:99-104. http://dx.doi.org/10.1016/j.jdent.2016.11.005.

78.	Moazzez R, Anggiansah A, Bartlett DW. The association of acidic reflux above the upper oesophageal sphincter with palatal tooth wear. Caries Res. 2005;39:475-478. DOI: 10.1159/000088182.

79.	Rise, J. An approach to epidemiologic assessment of complete dentures. Acta Odontol. Scand. 1979;37:57-63.

80.	Pinsent, R H, Laird W R E. Problems in the assessment of complete dentures. Community Dent Health. 1989;6:3-9.

81.	Gordon SR. Measurement of oral status and treatment need among subjects with dental prostheses: are the measures less reliable than the prostheses? Part I: oral status in removable prosthodontics. J Prosthet Dent. 1991;65:664-668.

82.	Sato Y, Tsuga K, Akagawa Y, Tenma H. A method for quantifying complete denture quality. J Prosthet Dent. 1998;80:52-57.

83.	Corrigan PJ, Basket RM, Farrin AJ, Mulley GP, Heath MR. The development of a method for functional assessment of dentures. Gerodontology. 2002;19:41-45.

84.	Anastassiadou V, Naka O, Heath MR, Kapari D. Validation of indices for functional assessment of dentures. Gerodontology. 2002;19:46-52.

85.	Mojon P, MacEntee MI. Discrepancy between need for prosthodontic treatment and complaints in an elderly edentulous population. Community Dent Oral Epidemiol. 1992;20:48-52.

86.	MacEntee MI, Donnelly L. Oral health and the frailty syndrome. Periodontology 2000. 2016;72:135-141. DOI: 10.1111/prd.12134

87.	Liu C, Cao Y, Lin J, Ng L, Needleman I, Walsh T, Li C. Oral care measures for preventing nursing home-acquired pneumonia. Cochrane Database Syst Rev. 2018; issue 9. Art. No.: CD012416. DOI: 10.1002/14651858.CD012416.pub2.

88.	Weintraub JA, Zimmerman S, Ward K, Wretman CJ, Sloane PD, Stearns SC, Poole P, Preisser JS. Improving Nursing Home Residents' Oral Hygiene: Results of a cluster randomized intervention trial. J Am Med Dir Assoc. 2018;19:1086-1091. https://doi.org/10.1016/j.jamda.2018.09.036

89.	Greene JC, Vermillion JR, The simplified oral hygiene index. JADA 1964: 68:7-13.

90.	Löe H. The Gingival Index, the Plaque Index and the Retention Index Systems. J Periodontol. 1967;38:610-616.

91.	Augsburger RH, Elahi JM. Evaluation of seven proprietary denture cleansers. J Prosthet Dent. 1982;47:356-359.

92.	Mylonas P, Afzal Z, Attrill DC. A clinical audit of denture cleanliness in general dental practice undertaken in the West Midlands. Br Dent J. 2014;217:231-234. DOI: 10.1038/sj.bdj.2014.757

93. MacEntee MI, Glick N, Stolar E. Age, gender, dentures and oral mucosal disorders. Oral Dis. 1998;4:32-36.

94. Speight PM, Epstein J, Kujan O, Lingen MW, Nagao T, Ranganathan K, Vargas P. Screening for oral cancer—a perspective from the Global Oral Cancer Forum. Oral Surg Oral Med Oral Pathol Oral Radiol. 2017;123:680-687. http://dx.doi.org/10.1016/j.oooo.2016.08.021.

95. Walsh T, Liu JL, Brocklehurst P, Glenny AM, Lingen M, Kerr AR, Ogden G, Warnakulasuriya S, Scully C. Clinical assessment to screen for the detection of oral cavity cancer and potentially malignant disorders in apparently healthy adults. Cochrane Database Syst Rev. 2013;11: Art. No.: CD010173. DOI: 10.1002/14651858.CD010173.pub2.

96. Jaber MA, Porter SR, Gilthorpe MS, Bedi R, Scully C. Risk factors for oral epithelial dysplasia—the role of smoking and alcohol. Oral Oncol. 1999;35:151-156.

97. Windon MJ, D'Souza G, Rettig EM, Westra WH, van Zante A, Wang SJ, Ryan WR, Mydlarz WK, Ha PK, Miles BA, Koch W. Increasing prevalence of human papillomavirus–positive oropharyngeal cancers among older adults. Cancer. 2018;124:2993-2999. doi: 10.1002/cncr.31385.

98. Scott SE, Rizvi K, Grunfeld EA, McGurk M. Pilot study to estimate the accuracy of mouth self-examination in an at-risk group. Head Neck. 2010;32:1393-1401. DOI: 10.1002/hed.21341.

99. Thomson WM. Issues in the epidemiological investigation of dry mouth. Gerodontology. 2005;22;65–76.

100. Proctor GB. The physiology of salivary secretion. Periodontology 2000. 2016;70:11-25.

101. Osailan SM, Pramanik R, Shirlaw P, Proctor GB, Challacombe SJ. Clinical assessment of oral dryness: development of a scoring system related to salivary flow and mucosal wetness. Oral Surg Oral Med Oral Pathol Oral Radiol. 2012;114:597-603.

102. Jager DHJ, Bots CP, Forouzanfar T, Brand HS. Clinical oral dryness score: evaluation of a new screening method for oral dryness. Odontology. 2018; 106: 439-444.

103. Enoki K, Ikebe K, Matsuda K, Yoshida M, Maeda Y, Thomson WM. Influence of xerostomia on oral health-related quality of life in the elderly: a 5-year longitudinal study. Oral Surg Oral Med Oral Pathol Oral Radiol. 2014;117:716-721. http://dx.doi.org/10.1016/j.oooo.2014.03.001.

104. Benn AML, Broadbent JM, Thomson WM. Occurrence and impact of xerostomia among dentate adult New Zealanders: findings from a national survey. Aust Dent J. 2015;60:362-367. doi: 10.1111/adj.12238.

105. Thomson WM, Williams SM. Further testing of the xerostomia inventory. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2000;89:46-50.

106. Thomson WM, van der Putten GJ, de Baat C, Ikebe K, Matsuda KI, Enoki K, Hopcraft MS, Ling GY. Shortening the xerostomia inventory. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2011;112:322-327. doi:10.1016/j.tripleo.2011.03.024.

107. Tiisanoja A, Syrjälä AM, Kullaa A, Ylöstalo P. Anticholinergic burden and dry mouth in middle-aged people. JDR Clin Trans Res. 2019;5:62-70. DOI: 10.1177/2380084419844511.

108. Nguyen CT, MacEntee MI, Mintzes B, Perry TL. Information for physicians and pharmacists about drugs that might cause dry mouth: a study of monographs and published literature. Drugs Aging. 2014;31:55-65. DOI 10.1007/s40266-013-0141-5.

109. Wolff A, Joshi RK, Ekström J, Aframian D, Pedersen AM, Proctor G, Narayana N, Villa A, Sia YW, Aliko A, McGowan R. A guide to medications inducing salivary gland dysfunction, xerostomia, and subjective sialorrhea: a systematic review sponsored by the world workshop on oral medicine VI. Drugs R D. 2017;17:1-28. DOI 10.1007/s40268-016-0153-9.

110. Virvidaki IE, Nasios G, Kosmidou M, Giannopoulos S, Milionis H. Swallowing and aspiration risk: a critical review of non instrumental bedside screening tests. J Clin Neurol. 2018;14:265-274. https://doi.org/10.3988/jcn.2018.14.3.265.

111. Persson E, Wårdh I, Östberg P. Repetitive saliva swallowing test: norms, clinical relevance and the impact of saliva secretion. Dysphagia. 2019;34:271-278. https://doi.org/10.1007/s00455-018-9937-0(0123456789().,-volV)(0123456789().,-volV))

112. Heijnen BJ, Speyer R, Bülow M, Kuijpers LM. 'What About Swallowing?' Diagnostic performance of daily clinical practice compared with the Eating Assessment Tool-10. Dysphagia. 2016;31:214-222. DOI 10.1007/s00455-015-9680-8.

113. Jokstad A, Bayne S, Blunck U, Tyas M, Wilson N. Quality of dental restorations FDI Commission Project 2–95. Int Dent J. 2001;51:117-158.

114. Abduo J, Lyons KM. Interdisciplinary interface between fixed prosthodontics and periodontics. Periodontology 2000. 2017;74:40-62.

115. Preshaw PM, Walls AW, Jakubovics NS, Moynihan PJ, Jepson NJ, Loewy Z. Association of removable partial denture use with oral and systemic health. J Dentistry. 2011;39:711-719. doi:10.1016/j.jdent.2011.08.018.

116. Graham R, Mihaylov S, Jepson N, Allen PF, Bond S. Determining 'need' for a removable partial denture: a qualitative study of factors that influence dentist provision and patient use. Br Dent J. 2006;200:155-158. doi: 10.1038/sj.bdj.4813193.

117. Kim JJ. Revisiting the removable partial denture. Dent Clin North Am. 2019;63:263-278. https://doi.org/10.1016/j.cden.2018.11.007.

118. Marachlioglou CR, Dos Santos JF, Cunha VP, Marchini L. Expectations and final evaluation of complete dentures by patients, dentist and dental technician. J Oral Rehabil. 2010;37:518-524

119. De Kok IJ, Cooper LF, Guckes AD, McGraw K, Wright RF, Barrero CJ, Bak SY, Stoner LO. Factors influencing removable partial denture patient-reported outcomes of quality of life and satisfaction: a systematic review. J Prosthodont. 2017;26:5-18. doi: 10.1111/jopr.12526.

120. Øzhayat EB, Gotfredsen K. Patient-reported effect of oral rehabilitation. J Oral Rehabil. 2019;46:369-376. DOI: 10.1111/joor.12756.

121. Allen PF, Jepson NJ, Doughty J, Bond S. Attitudes and practice in the provision of removable partial dentures. Br Dent J. 2008;204:E2. DOI: 10.1038/bdj.2007.568.

122. MacEntee MI, Bryant SR, Keller H, Nguyen C, Yao CS. Caries control for frail elders. In: Fejerskov O, Baelum V, Nyvad B, Kidd E (Editors). Dental Caries (3rd Edition), Chichester UK: John Wiley & Sons, Ltd. 2015; Chapter 18:321-332.

123. Innes NPT, Chu CH, Fontana M, Lo ECM, Thomson WM, et al. A century of change towards prevention and minimal intervention in cariology. J Dent Res. 2019;98:611-617. DOI: 10.1177/0022034519837252.

124. Pitts NB, Ekstrand KR, ICDAS Foundation. International Caries Detection and Assessment System (ICDAS) and its International Caries Classification and Management System (ICCMS)–methods for staging of the caries process and enabling dentists to manage caries. Community Dent Oral Epidemiol. 2013;41:e41-52. doi: 10.1111/cdoe.12025.

125. Young DA, Nový BB, Zeller GG, Hale R, Hart TC, Truelove EL, Ekstrand KR, Featherstone JD, Fontana M, Ismail A, Kuehne J. The American Dental Association caries classification system for clinical practice: a report of the American Dental Association Council on Scientific Affairs. J Am Dent Ass. 2015;146:79-86.

126. Frencken JE, de Amorim RG, Faber J, Leal SC. The Caries Assessment Spectrum and Treatment (CAST) index: rationale and development. Int Dent J. 2011;61:117-123.

127. Nyvad B, Baelum V. Nyvad Criteria for caries lesion activity and severity assessment: A validated approach for clinical management and research. Caries Res. 2018;52:397–405. DOI: 10.1159/000480522

128. Monse B, Heinrich-Weltzien R, Benzian H, Holmgren C, van Palenstein Helderman W. PUFA–an index of clinical consequences of untreated dental caries. Community Dent Oral Epidemiol. 2010;38:77-82.

129. Featherstone JDB, Chaffee BW. The evidence for Caries Management by Risk Assessment (CAMBRA®). Adv Dent Res. 2018;29:9-14. https://doi.org/10.1177/00220345177365

130. Moynihan PJ, Kelly SA. Effect on caries of restricting sugars intake: systematic review to inform WHO guidelines. J Dent Res. 2014;93:8-18. DOI: 10.1177/0022034513508954.

131. Bernabé E, Vehkalahti MM, Sheiham A, Lundqvist A, Suominen AL.The shape of the dose-response relationship between sugars and caries in adults. J Dent Res. 2016;95:167-172. DOI: 10.1177/0022034515616572.

132. Arheiam A, Brown SL, Burnside G, Higham SM, Albadri S, Harris RV. The use of diet diaries in general dental practice in England. Community Dent Health. 2016;33:267-273.

133. Tonetti MS, Sanz M. Implementation of the new classification of periodontal diseases: Decision-making algorithms for clinical practice and education. J Clin Periodontol. 2019; 46:398-405. Available at: https://doi.org/10.1111/jcpe.13104 (accessed November 10, 2019).

134. Holtfreter B, Albandar JM, Dietrich T, Dye BA, Eaton KA, Eke PI. Joint EU/USA Periodontal Epidemiology Working Group. Standards for reporting chronic periodontitis prevalence and severity in epidemiologic studies: proposed standards from the joint EU/USA Periodontal Epidemiology Working Group. J Clin Periodontol. 2015;42(5):407-12. doi: 10.1111/jcpe.12392.

135. Corraini P, Lopez R, Vaeth M. Implications of less-than-perfect reliability of clinical parameters for the misclassification of periodontitis. Community Dent Oral Epidemiol. 2015;43:183-192. doi: 10.1111/cdoe.12142.

136. Tonetti MS, Greenwell H, Kornman KS. Staging and grading of periodontitis: Framework and proposal of a new classification and case definition. J Periodontol. 2018;89:S159-72. DOI: 10.1111/jcpe.12945.

137. Papapanou PN, Sanz M, Buduneli N, Dietrich T, Feres M, Fine DH, Flemmig TF, Garcia R, Giannobile WV, Graziani F, Greenwell H. et al. Periodontitis: Consensus report of workgroup 2 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions. J Periodontol 2018;89:S173-82. Available at: https://doi.org/10.1002/JPER.17-0721 (accessed November 12, 2019).

138. Persson GR. Dental geriatrics and periodontitis. Periodontol 2000. 2017;74:102-115. doi: 10.1111/prd.12192.

139. Egger M, Juni P, Bartlett C, Holenstein F, Sterne J. How important are comprehensive literature searches and the assessment of trial quality in systematic reviews? Empirical study. Health Technol Assess. 2003;7:1-76.

140. Hey SP, D'Andrea E, Jung EH, Tessema F, Luo J, Gyawali B, Kesselheim AS. Challenges and opportunities for biomarker validation. J Law Med Ethics. 2019;47:357-361. DOI: 10.1177/1073110519876162

141. MacEntee MI. Measuring the impact of oral health in old age: a qualitative reaction to some quantitative views. Gerodontology. 1996;13:76-81.

142. Locker D, Allen F. What do measures of 'oral health-related quality of life' measure?. Community Dent Oral Epidemiol. 2007;35:401-411.

143. Brondani MA, MacEntee MI. **The concept of validity in sociodental indicators and oral health-related quality-of-life measures.** *Community Dent Oral Epidemiol* 2007;*35:472-478.*

144. Terwee CB, Mokkink LB, Knol DL, Ostelo RW, Bouter LM, de Vet HC. Rating the methodological quality in systematic reviews of studies on measurement properties: a scoring system for the COSMIN checklist. Qual Life Res. 2012;21:651-657. DOI 10. 1007/sl 1 136-01 1-9960-1.

145. Mokkink LB, Prinsen CA, Patrick DL, Alonso J, Bouter LM, De Vet HC, Terwee CB. COSMIN Study Design checklist for Patient-reported outcome measurement instruments. Available at: https://www.cosmin.nl/wp-content/uploads/COSMIN-study-designing-checklist_final.pdf (accessed February 26, 2020).

146. Cella D, Riley W, Stone A, Rothrock N, Reeve B, Yount S, Amtmann D, Bodea R, Buysse D, Choi S, Cooke K, DeVellis R, DeWalth D, Fries JF, Gershon R, Hahn EA, Lai JS, Pilkonis P, Revicki D, Rosek M, Weinfurt K, Hays R, on behalf of the PROMIS Cooperative Group. The Patient-Reported Outcomes Measurement Information System (PROMIS) developed and tested its first wave of adult self-reported health outcome item banks: 2005-2008. J Clin Epidemiol 2010;63:1179-1794. https://doi.org/10.1016/j.jclinepi.2010.04.011.

Box 1. Topics, presenters and affiliations

Box 1. Topics presented formally by content experts at the consensus workshop.

Topics	Presenter	Affiliation
Development of CODE Index	Dr. Michael MacEntee	Department of Oral Health Sciences; Faculty of Dentistry, University of British Columbia, Canada
The CODE Protocol in the UBC Geriatric Dentistry Program	Dr. Christopher Wyatt	Department of Oral Health Sciences; University of British Columbia, Canada
Oral health assessment by allied professionals	Dr. Joke Duyck	Department of Oral Health Sciences, KU Leuven; Prosthetic Dentistry University Hospitals Leuven, Belgium
Chewing and Temporomandibular Joint	Dr. Martin Schimmel	Department of Reconstructive Dentistry and Gerodontology, University of Bern, Switzerland
Dry mouth and polypharmacy	Dr. W Murray Thomson	Department of Oral Health Sciences, University of Otago, New Zealand
Swallowing	Dr. Kazuhiro Hori	Division of Comprehensive Prosthodontics. Niigata University Graduate School of Medical and Dental Sciences, Japan
Clinical assessment of hard tissues	Dr. Avanti Karve	Special Needs Dentistry, Westmead Centre for Oral Health, University of Sydney. Australia
Tooth wear	Dr. David Bartlett	Department of Prosthodontics, Oral and Craniofacial Sciences, Faculty of Dentistry, King's College London, United Kingdom
Periodontium and gingiva	Dr. G Rutger Persson	Department of Periodontics, School of Dentistry, University of Washington, Seattle, WA. USA
Pain, oral sensorimotor function and control	Dr. Limor Avivi-Arber	Division of Prosthodontics, Faculty of Dentistry, University of Toronto, Canada
Oral health and quality of life	Dr. Mario Brondani	Department of Oral Health Sciences; Dental Public Health; University of British Columbia, Canada

TABLE 1.

Table 1. The sequence of physical indicators, patient-reported outcomes or concerns, and associated severity scores of oral health disorders forming the Clinical Oral Disorders in Adults Screening Protocol (CODA-SP).

Physical Indicators of Disorder	Severity Score	Patient-reported Outcomes or Concerns	Severity Score	Total Score/per Indicator
1. GENERAL ASSESSMENT AND MEDICAL STATUS[26,40]				*(Maximum: 12)*
- Obvious extraoral abnormality likely to influence dental care.	2	- Requests dental consult – not urgent.	1	
- Cognitive impairment, dependency on caregivers, polypharmacy, and/or poor manual dexterity.	2	- Describes physical function as fair or poor;[49,51,53] and/or oral health as constantly fair or poor.[51]	2	
- Medical status (e.g. frailty; osteoarthritis) requires special care.	2	- Requests urgent dental care.[26]	3	

2. EXTRAORAL ABNORMALITIES[26]		*(Maximum: 7)*
- Asymmetry, swelling, ulcers skin lesions or other signs of extraoral abnormality of the face, neck, nose, cheeks, chin, commissures, vermillion border or jaws.	2	- Concerned about condition around face or jaws. 2
- Urgent care needed for extraoral physical abnormality.	3	
3. PAIN OR DISCOMFORT[56]		*(Maximum: 9)*
- Verbal or non-verbal gestures or other indications of acute or chronic pain or severe discomfort evoked or worsened by movement or stimulus.	3	- Toothache or mouth-pain occurs ≥5 times in past week. 3 - Pain interferes with enjoyment, eating and/or activities most of the time.[49,57,62] 3
4. TEMPOROMANDIBULAR DYSFUNCTION[66]		*(Maximum: 6)*
- Pain when moving jaw or palpating the joints or temporalis/masseter muscles; or Joint locked open; OR - Restricted opening <35 mm between incisors, or <50 mm between residual ridges at mid-line; OR - Opening deviation >10 mm at mid-line with mouth open ≥20 mm.	3	- Jaw locked within last 30 days so mouth would not open all the way; OR Jaw movements disturb eating or cause pain, headache or noisy grating around TMJ, temple or ear.[66] 3
5. OCCLUSAL STABILITY [68]		*(Maximum: 3)*
- <20 teeth; OR Bilaterally <4 occluding units of premolars or molars. (1 unit = pair of occluding premolars; 2 units = pair of occluding molars).[69]	1	- Wants missing teeth replaced. 2
6. CHEWING		*(Maximum: 3)*
		- Prolonged chewing before swallowing. OR 1 - Avoids foods when difficult to chew, or frequently chokes or swallows unchewed food.[70] 3

7. TOOTH WEAR/EROSION *(Maximum: 5)*

- Wear/erosion of ≥50% of a tooth's surface.[75] OR   1
- Erosive lesion with exposed pulp.[26]   3

- Bite or appearance of tooth wear frequently bothersome; or regurgitation, vomiting, acidic drinks; or ≥4 intakes of fruit between meals; or eating disorder.[76-78]   2

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8. COMPLETE DENTURES[79] *(Maximum: 4)*

a) Mandibular denture

- Missing or not used when probably a denture could be managed; OR Structural defect (missing parts, fractures, obvious porosity).   2

- Requests mandibular denture modified or replaced.[120]   2

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b) Maxillary denture *(Maximum: 5)*

- Missing or not used when probably a denture could be managed; OR
- Unstable with light finger pressure to a premolar; OR retention lost when licking lips with the mouth open ≥15; OR
- Structural defect (missing parts, fractures, porosity).   2

- Requests maxillary denture modified or replaced.   3

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9. ORAL HYGIENE[89,91,92] *(Maximum: 5)*

- Soft plaque covers >66% of natural tooth surfaces or >50% of denture surface.   2

- Needs help brushing teeth or denture.   3

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10. MUCOSAL LESIONS[26,93-95] *(Maximum: 7)*

- Angular cheilitis; OR
- Extreme alveolar atrophy (<I mm of attached mucosa facially or lingually from crest of residual ridge along ≥ 2 cm of alveolus; OR
- Ridge fibrosis with >2 mm mobility along ≥2 cm of residual ridge; OR
- Denture induced hyperplasia/epulis; OR
- Stomatitis (generalised or papillomatous > 1 sq. cm).   1

- ≥1 of: glossitis; white patch; red or pigmented patch; ulcers; abnormal lump; sinus or fistula.   3

- Smokes tobacco (20+ cigarettes) and >1 alcoholic drink per day.[96] OR   1

- Noticed unusual red or white patches, sores, ulcers, swellings or lumps on lips, gums, cheeks, tongue or roof of your mouth;[98] or history of human papillomavirus infection.   3

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11. SALIVA[101,102] *(Maximum: 6)*

- Mouth frequently or always feels dry.[99,105-109]   3

- ≥5 of the following (Clinical Oral Dryness Score):
    - Mirror adheres to buccal mucosa;
    - Mirror adheres to the tongue;
    - Frothy saliva;
    - No saliva pooling in floor of mouth;
    - Tongue shows loss of papillae;
    - Unusual shape of gingiva
    - Glassy appearance of other oral mucosa, especially palate;
    - Tongue lobulated/fissured;
    - Carious lesion <u>or</u> cervical restoration in >2 teeth within last 6 months;   3
    - Debris on palate (excluding under a denture).

12. SWALLOWING/DYSPHAGIA[111]			*(Maximum: 6)*
- Palpation of larynx detects fewer than three swallows per 30 seconds.	3	- Complains of swallowing and choking when eating.[112]	3
13. TOOTH-STRUCTURE AND PARTIAL FIXED, REMOVABLE OR IMPLANT PROSTHESES[113,114,117]			*(Maximum: 4)*
- Fractured tooth, dental restoration or dental prosthesis. <u>OR</u>	1	- Uncomfortable with dental appearance, hygiene, structure or function of a tooth, dental restoration or prosthesis.[43,113,115,116,121]	
- Combination of ≥3 of the above.	2		2
14. DENTAL CARIES[131]			*(Maximum: 5)*
- 1-2 lesions clearly penetrating coronal or root surface. <u>OR</u>	1	- Consumes 10+ teaspoons (>40-55 g) of sugar in food or drinks per day; <u>OR</u> three or more sugared snacks between meals/day.[130]	
- ≥3 lesions clearly penetrating coronal or root surfaces. <u>OR</u>	2		
- ≥1 lesion clearly involving the pulp.	3		2
15. GINGIVITIS[133]			*(Maximum: 2)*
- Gingival bleeding on probing at ≥10% of dental sites.	1	- Needs help to clean teeth.	1
16. PERIODONTITIS[136,137]			*(Maximum: 5)*
- CAL ≥5 mm and PD ≥6 mm without purulent discharge. <u>OR</u>	1	- Concerned about periodontal problem; <u>OR</u> Smoker <u>OR</u> Diabetic. <u>OR</u> Other poorly controlled systemic disesase.[136]	
- Hypermobile tooth. <u>OR</u>	2		
- PD ≥6 mm with purulent discharge.	3		2
(PD: pocket depth; CAL: Clinical attachment loss from cementoenamel junction)			

17. OTHER PROBLEM(S)   *(Maximum: 6)*

   - Needs urgent referral.   **-** Wants a referral.   3

                                                     3

(Maximum: 100)

TOTAL SEVERITY SCORE: