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REVIEW

A systematic scoping review of oral health models

Stella Sekulic[1,2,5] · Nicole Theis-Mahon[3] · Ksenija Rener-Sitar[2,4]

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Abstract

Purpose The purpose of this systematic scoping review was to identify, analyze, and compare existing generic oral health models in English scientific dental literature.

Methods We conducted a literature search in five databases, Ovid Medline, Embase, PsycINFO, Cochrane, and Web of Science, using pre-determined inclusion and exclusion criteria and calculated the interrater agreement coefficient "prevalence-adjusted bias-adjusted kappa" (PABAK). We identified, reviewed, and displayed the generic oral health models in review tables.

Results Of the 3498 references identified, 13 oral health models from seven countries met the inclusion criteria. The interrater agreement coefficient resulted in a ''substantial agreement'' (PABAK = 0.80). Ten of the 13 (77%) generic oral health models were developed in English-speaking countries. All models were multidimensional and contained from two to 12 dimensions. Four models presented linear conception, and we observed non-linear conception in six models. Authors presented the unidirectional or reciprocal relations between dimensions in six models, and five models, respectively. Two models did not show models' relation or conception. Researchers used only experts ($N = 1$), literature ($N = 2$), dental patients ($N = 2$), or general population subjects ($N = 3$), or a combination of these sources ($N = 5$) for development of their generic oral health models. Statistical analyses supported the majority of the models ($N = 8$).

Conclusions The identified 13 oral health models vary substantially in their characteristics. This systematic scoping review of generic oral health models provides a toolbox, from which dental researchers can choose the theoretical model they consider fit best their oral health concept they want to investigate. Ideally, the international dental community will come soon to an agreement of accepting one oral health model, and this will provide an opportunity for comparison of outcomes across studies and populations and thus elevate dentistry to a higher evidence-based level.

Keywords Oral health-related quality of life · Conceptual models · Models of oral health-related quality of life · Frameworks · Biomedical models

Introduction

Assessment of a patient's self-perceived oral health by self-completed questionnaires, i.e., dental patient-reported outcomes measure (dPROM), has been increasingly utilized in dental research in the last few decades, as well as in health care, because of the need to improve evidence-based clinical research and clinical practice. Nevertheless, there are some limitations to these dPROMs [1–3], because they mostly lack a coherent theoretical conceptual framework, which should have been a prerequisite to guide their development [3]. Conceptually, dental health professionals measure oral health outcomes in clinical practice, and thus we get an objective assessment versus assessment by utilizing dPROMs to capture a patient's oral health perspective.

✉ Stella Sekulic
ssekulic@umn.edu

1 Department of Diagnostic and Biological Sciences, School of Dentistry, University of Minnesota, Minneapolis, USA

2 Department of Prosthodontics, Faculty of Medicine, University of Ljubljana, Ljubljana, Slovenia

3 Health Sciences Libraries, University of Minnesota, Minneapolis, USA

4 Department of Prosthodontics, University Dental Clinics, University Medical Center Ljubljana, Ljubljana, Slovenia

5 Dental Division, Department for Prosthetic Dentistry, Faculty of Medicine, University of Ljubljana, Vrazov trg 2, 1000 Ljubljana, EU, Slovenia

However, although clinical assessment of a patients' oral health and the patients' self-perceived outcomes is necessary, other factors also influence oral health. Access to dental services, other biological (e.g., systemic health), structural (e.g., impairment or deviation that can or cannot restrain movements), political (e.g., healthcare costs), environmental, as well as social determinants of health that directly interfere with oral health outcomes, must all be considered.

Because of the multidimensional aspect of oral health and its diverse interpretations across various oral health conditions, researchers have used a variety of conceptual models and dPROMs to conduct their investigation.

Authors of generic oral health models generally described oral health as the absence of oral/orofacial impacts [4–10]. In 2003, the World Health Organization (WHO) defined oral health as a primary indicator of general health, well-being, and quality of life as "A state of being free from chronic mouth and facial pain, oral and throat cancer, oral infection and sores, periodontal (gum) disease, tooth decay, tooth loss, and other diseases and disorders that limit an individual's capacity in biting, chewing, smiling, speaking, and psychosocial well-being" [11]. Because of a variety of oral health aspects and a basic human right to oral health care, the World Dental Federation (FDI) widened the interpretation of oral health by providing a new definition with additional attributes; "Oral health is multi-faceted and includes, but is not limited to, the ability to speak, smile, smell, taste, touch, chew, swallow, and convey a range of emotions through facial expressions with confidence and free of pain or discomfort, and disease of the craniofacial complex. (i) It is a fundamental component of health and physical and mental well-being. It exists along a continuum influenced by the values and attitudes of people and communities. (ii) It reflects the physiological, social, and psychological attributes that are essential to the quality of life. (iii) It is influenced by the person's changing experiences, perceptions, expectations, and ability to adapt to circumstances" [12]. The latter was accepted as the most comprehensive explanation of what oral health actually is by several dental organizations [12, 13].

Locker presented the first theoretical oral health model in 1988, i.e., Locker's theoretical model of oral health [4] and based it on the International Classification of Impairments, Disabilities, and Handicaps (ICIDH) developed by WHO [14]. He interpreted the oral health area as something linear and irreversible, e.g., a healthy patient gets sick, and health only gets worse. Locker did not consider that there is a possibility of complete healing or reversing the impact of a disease or impairment, of the patient [4]. Similar to Locker, other authors defined oral health in a more negative way, i.e., generic oral health models proposed by Jeboda [5], Adulyanon and Sheiham [7], Gilbert et al. [6], Williams et al. [15], and Locker and Gibson [8], instead of presenting it as the absence of disadvantageous conditions.

On the contrary, some researchers interpreted oral health more positively by clearly separating oral health from diseases and disorders, e.g., the generic oral health model proposed by MacEntee [16] and Brondani et al. [17]. Current oral health knowledge equates oral health as an essential and unifying element of general health and well-being of the patient in comparison to a few decades ago [18]. However, dental research has stayed continuous in describing and measuring self-reported oral health and utilizing different oral health models and dPROMs. Authors who developed generic dPROMs used different conceptual frameworks and sometimes they did not specify or report the conceptual frameworks for the development of these instruments. Considering a theoretical basis of oral health should be consistent in all conceptual models, the alteration in terminology for the same dimensions may prevent and misinterpret comparison of outcomes across studies, which is problematic.

In the field of health-related Quality of Life (HRQoL), a systematic review identifying general health models was performed in 2012 [19]. Bakas et al. identified and analyzed 100 articles retrieved from the investigation during a limited period, between January 1, 1999, and August 31, 2010 [19]. Their focus was to assess the most frequently used models for general health and used the Bredow's [20] criteria for evaluating theories. These criteria consist of models' internal criticisms (adequacy, clarity, consistency, logical development, and the level of development) and external criticisms (complexity, discrimination, reality convergence, pragmatic, scope, significance, and utility) [19].

In 2014, a narrative review portraying oral health through models was published [21]. Brondani and MacEntee critically reviewed and explored the extension of theoretical and pragmatic knowledge of oral *function, impairment,* and *disability* of models through a period of 30 years, precisely between January 1, 1950, and June 30, 2013 [21]. They identified 19 references about OHRQoL and oral health models which also included models that deal with general health, e.g., WHO's adaptation of the International Classification of Functioning, Disability, and Health–ICF conceptual framework [22]. Less than half of their references ($N=8$) provided information about generic oral health models, whereas three references discussed general health models. All remaining references examined the OHRQoL concept. Most of the models they reviewed focused on disease and dysfunction influenced by a negative biomedical view of oral disorders, except for three models that presented a slightly different understanding of oral health that goes beyond illness and a more dynamic representation of relationships between dimensions. They also provided graphical representations of the identified models [21].

Recently, a guest editorial about the need for a new model of oral health was published [23]. Pandit presented oral health as a fundamental part of general health showing the importance of developing a preventive and promotional model instead of clinging to "a rationally curative mainly pathogenic model" [23].

To the best of our knowledge, researchers have not performed a systematic scoping review of oral health models. Because of various interpretations of oral health, it is challenging to make progress both in dental research and consequently in dental practice. A systematic scoping review of all generic oral health models would allow researchers and clinicians to have the opportunity to compare and evaluate which models align with the oral health concept they are investigating. Moreover, they would be able to choose a dPROM [24] established by a coherent theoretical framework or develop a new dPROM that would better capture relevant areas/dimensions of the oral health concept. Thus, this systematic scoping review aimed to identify, analyze, and compare existing generic oral health models in English scientific dental literature. The specific questions guiding this scoping review were (i) How many generic oral health models can be identified in the English scientific literature? (ii) Are the models developed based on literature, experts, patients, or a combination of these sources? (iii) Does statistical analysis support all the models? (iv) What are the relation and the conception of the models? (v) What dimensions are identified in oral health models? (vi) How did the authors name their models? (vii) How did the authors define their models' dimensions? (viii) Are generic oral health models comparable?

Methods

Data sources and search design

In this review, we followed recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Extension for Scoping Reviews (PRISMA-ScR) [25]. We submitted the study protocol to the PROSPERO database (CRD42018096784) [26].

The search strategy was developed for Medline (National Library of Medicine, Bethesda, MD, USA), through the Ovid interface (Ovid MEDLINE(R) Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily, Ovid MEDLINE and Versions(R) 1946 to Present) and translated to Embase (1947 to 2018 Week 20, Elsevier, Amsterdam, Netherlands), Cochrane, PsycINFO (1806-May Week 1, 2018, American Psychological Association, Washington, DC, USA), and Web of Science (Clarivate Analytics, Philadelphia, Pennsylvania, USA). The search strategy for the Ovid Medline interface was (exp Oral Health/ AND (exp "Surveys and Questionnaires" OR exp Models, Theoretical/)) AND (model$.ab, ti. OR ("oral health" adj3 (model$ or framework$ or measur$)).ab, ti.). In our opinion, these terms covered well the broad area of oral health and provided a thorough search for references about generic oral health models. We used a combination of controlled vocabulary (MeSH terms), keywords, and phrase searching to identify generic oral health models and limited the results to English language only.

Different combinations of the following words were used in literature search which are Oral Health-Related Quality of Life, Conceptual models, Models of Oral Health-Related Quality of Life, Frameworks, and Biomedical models. "Oral Health-Related Quality of Life is a multidimensional construct that includes a subjective evaluation of the individual's oral health, functional well-being, emotional well-being, expectations and satisfaction with care, and sense of self. It has wide-reaching applications in survey and clinical research [27]." "Conceptual models are theoretical models of how different constructs within a concept are related [3]." "Models of Oral Health-Related Quality of Life are theoretical models that integrate biological, social, psychological, and cultural factors [27]." "Frameworks are models representing the relationships between the items and the construct to be measured." "Biomedical models in relation to oral health, health constitutes the freedom from disease, pain, or defect, making the normal human condition "healthy"." In our opinion, these terms cover the broad area of oral health well and, therefore, would best search for references related to generic oral health models [3]." The initial literature search was conducted on December 15, 2017, and updated on May 16, 2018. In addition to searching the five electronic databases, we also reviewed the references of all included articles for potential additional developmental studies of other generic oral health models.

Eligibility criteria

Our main inclusion criteria were articles, or studies, related to the development of generic oral health models. Additionally, we also considered references retrieved from screening included studies related to model development, observational studies, correlational studies, and descriptive studies. We included populations of both genders and all ages in this scoping review.

Our exclusion criteria were references related to a specific condition or disease-specific oral health models, non-English language articles, non-human studies, unpublished articles, preliminary results, abstracts, editorials, conference reviews, clinical opinions, guest editorials, and meeting highlights. We excluded studies related to ancillary aspects of oral health concepts (literacy, behavior, influences, and management) and also gray literature because it does not

undergo the rigorous peer-review process. Therefore, we did not consider it as reliable as scientific articles published in peer-review journals.

Reference screening and study selection

We identified 5,636 references through Ovid Medline, Embase, PsycINFO, Cochrane, and Web of Science databases as well as through scanning the references of included articles. After we removed the duplicates, 3,498 references remained. The authors SS and KRS independently screened titles and abstracts of these articles and trained to implement the inclusion criteria. SS and KRS conducted an initial training with 20 randomly selected references followed by a calibration exercise where they again independently reviewed 50 randomly selected references and compared their findings. The interrater agreement coefficient was the "Prevalence-Adjusted Bias-Adjusted Kappa" [28] (PABAK) which resulted in a ''substantial agreement'' [29] (PABAK = 0.80) between the two authors. Subsequently, after the two authors examined 70 random references for training and calibration purposes, they examined all the 3,498 results independently and afterward compared them following the before-mentioned protocol. They discussed disagreements until they obtained consensus. We excluded 3,483 references because they did not meet the inclusion criteria. We chose to read 15 references in full-text. After the full-text screening, we excluded two references due to the lack of reporting of a theoretical or conceptual examination of generic oral health model or framework development. Thus, the final number of eligible references we included in this systematic scoping review was 13.

We presented the process of reference screening and study eligibility assessment in the PRISMA flow diagram (Fig. 1).

Data extraction and administration

We extracted and displayed the data in two review tables in Microsoft Excel 2016 and exported to Microsoft Word 2016.

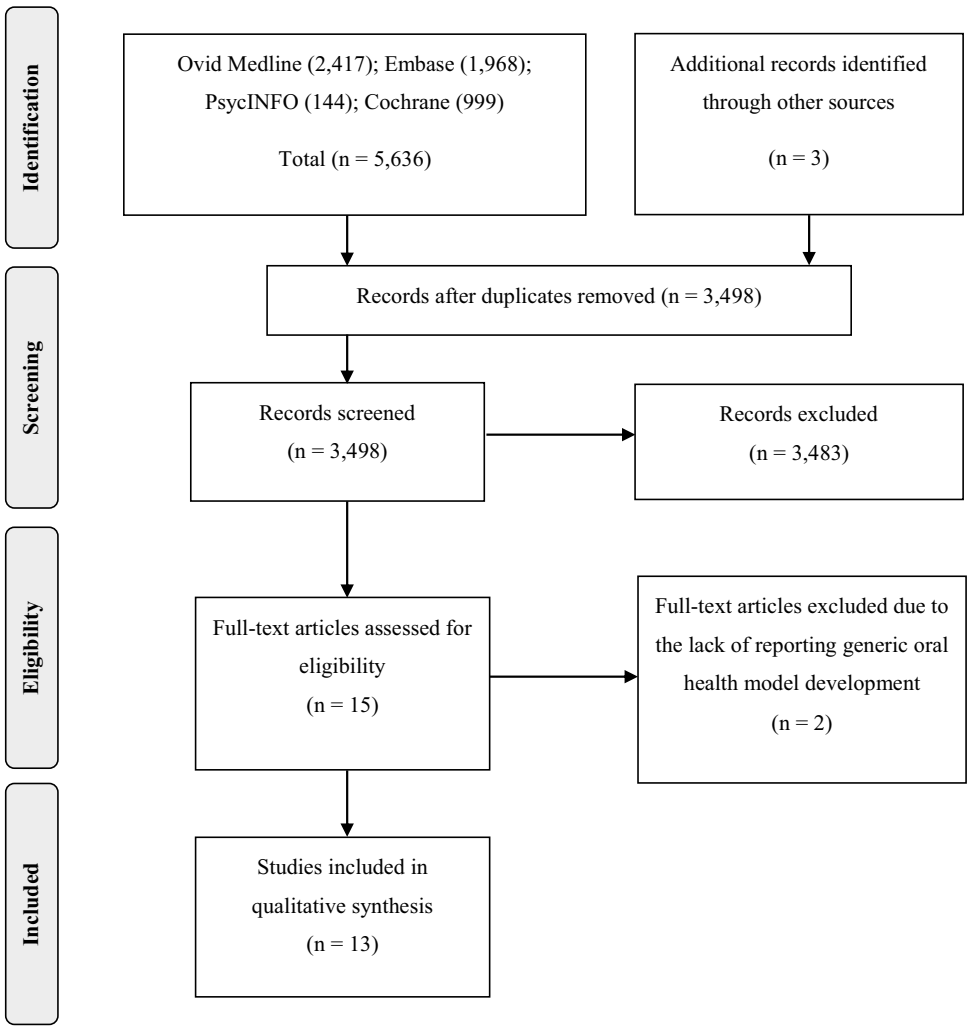

Fig. 1 Literature search flow diagram of generic oral health models

We presented in the table the author names, the original name of generic oral health models, the publication year, the source names of published models, the corresponding author's country of origin, the purpose of the model development as stated by authors, and dPROMs developed based on generic oral health models. We created an additional table to record the number of dimensions of each oral health model, dimensional names, and their definitions. We also listed the source data used to derive the generic oral health model (i.e., literature, experts, or dental patients), statistical analyses used for the model development, type of relationship between the dimensions (i.e., unidirectional or reciprocal), and the type of conceptualization of generic oral health models (i.e., linear or non-linear conceptualization). We evaluated the relation and the conception of models based on their graphical presentation given by the original authors, that is, how the original authors imagined interactions between the components of their models, and whether those components graphically followed or not the steps in a more or less straight line from beginning to an end. In instances where the author did not provide a graphical presentation of their model, we were unable to assess whether linear or non-linear conceptualization between dimensions existed.

Results

Count of publications

We identified 13 English language references presenting the development of generic oral health models.

Study characteristics

The corresponding authors of the articles presenting new generic oral health models came from seven different countries. Nine generic oral health models' corresponding authors came from countries where English is the first language; these were Canada, UK, and the USA. Four corresponding authors came from countries with languages other than English, which were Brazil, Nigeria, Switzerland, and Thailand, though they published their findings in English scientific periodical publications. The number of authors participating in model development varied from one to a group of nine authors. Authors published articles about oral health models between 1988 and 2015; they published two new generic oral health models per year in the years 1997, 1998, and 2006. International dental journals ($N=12$) and one textbook reported the development of these 13 generic oral health models. Only two journals published more than one generic oral health model; these are *Community Dental Health Journal* ($N=3$) and *Community Dentistry and Oral Epidemiology* ($N=2$). Of the 13 included generic oral health models, authors gave a specific name to six of them, while the remaining authors did not specify a name. These models are referred to by their authors' names, e.g., the *Locker's model of oral health* [4]. Only one model, has abridged name, i.e., the *POHC* for the *Primary Oral Health Care Model* [5]. We systematically presented all our findings in Table 1.

Generic oral health models' dimensional characterization

Additionally, we assessed the generic oral health models based on their dimensions and model characteristics. In total, 46 authors presented 119 dimensions and sub-dimensions in the 13 included models. We identified a total of 68 primary models' dimensions and nine of them contained several sub-dimensions ($N=51$). We presented in Table 2 the detailed division and original definitions of the oral health models' dimensions as the original authors provided them.

The number of dimensions per model varied from two to 12 primary dimensions. Four of the models presented a four-dimensional structure. Three models consisted of six dimensions; two of the models indicated five dimensions, while the rest ($N=4$) of the models showed two, three, seven, and 12 dimensions. Dimensional names were wide ranging. Only some models showed identical dimensional names, i.e., models proposed by Locker [4], Adulyanon and Sheiham [7], Gilbert et al. [6], and Nuttall et al. [9] included *Functional Limitations* as one of their dimensions. The authors of the generic oral health models labeled some dimensions as relating to oral function, but they had slightly different names, such as *Functional Status* [15, 30], *Compromised Physical and Psychosocial Functioning* [8], *Functional and Structural Layer* [16], and *Oral Function* [31].

Researchers used *Discomfort* [4], *Relief of Pain* [5], *Pain* [7], *Oral Pain & Discomfort* [6], *Comfort* [16, 17], *Pain/Discomfort* [9], and *Orofacial Pain* [31] as labels to describe the dimensions of oral pain of dental patients. Only *Comfort* dimension was mentioned twice [16, 17].

Some authors included more than one dimension describing the psychosocial aspects of oral health in their models, e.g., Locker incorporated in his theoretical model dimensions, such as *Limitation in Social Roles, Psychological*, and *Social well-being* [4]. Adulyanon and Sheiham also included three psychosocial dimensions, namely, *Impacts on Daily Performances, Psychological,* and *Social* [7], while Williams et al. presented two of them, the *Psychological* and *Social* dimension [15]. Other dimensions about the psychosocial impact on dental patients' oral health were proposed, such as *Psychosocial Functioning* [8], *Socio-Cultural Environment* [17], and *Psychosocial Impact* [16, 31]. However, the authors reported these dimensions only in their generic oral health model.

Table 1 Generic oral health models' general information

No.	Author(s)	Model name (abridged name)	Publication year	Journal or book name	Corresponding author's country	Purpose of model development	dPROM name (abridged name)
1	Locker [4]	Model of Oral Health	1988	Community Dental Health	Canada	"Presentation of a conceptual framework for understanding oral disease and its consequences and provides a basis for the development of a broad range of measures and indicators which take account of the multidimensional character of health" [4]	Oral Health Impact Profile (OHIP) [39]
2	Jeboda [5]	Primary Oral Health Care (POHC)	1990	Tropical Dental Journal/ Odonto-Stomatologie Tropicale	Nigeria	"Development of a model for primary oral health care practice which can be adapted for different populations depending on the various resources available in the different populations" [5]	–
3	Adulyanon and Sheiham [7]	Theoretical Framework of Oral Impact on Daily Performances	1997	Measuring Oral Health and Quality of Life (pp. 151–160)	Thailand	"To provide an alternative socio-dental indicator which focuses on measuring the serious oral impacts on the person's ability to perform daily activities" [7]	Oral Impacts on Daily Performances (OIDP) [7]
4	Gift et al. [34]	Conceptual Framework for Oral Health	1997	Social Science and Medicine	USA	"To apply a conceptual framework of selected health-related quality of life components to the measurement of oral health" [34]	–
5	Williams et al. [15]	Model for Dental Hygiene	1998	Journal of Dental Hygiene	USA	"To introduce a conceptual model for dental hygiene, the Oral Health-Related Quality of Life Model" [15]	–
6	Gilbert et al. [6]	Multidimensional Conceptual Model of Oral Health	1998	Medical Care	USA	"To describe self-rated oral health in dentate adults, to quantify associations between self-rated oral health and other measures of oral health, and to assess the construct validity of a model of oral health proposed herein" [6]	–

Table 1 (continued)

No.	Author(s)	Model name (abridged name)	Publication year	Journal or book name	Corresponding author's country	Purpose of model development	dPROM name (abridged name)
7	Corrigan et al. [10]	Conceptual Model of Oral Health	2001	Community Dental Health	UK	"To identify and describe conceptual models of oral health shared by people from different minority ethnic groups. In particular the relationship between 'oral health' and 'general health", and to see how these conceptions vary across social factors" [10]	–
8	Locker and Gibson [8]	Adaptation of Wilson and Cleary's Model of Oral Health	2005	Community Dentistry and Oral Epidemiology	Switzerland	"To assess the relationship between self-rated oral health and satisfaction with oral health in two studies of older adult populations" [8]	–
9	MacEntee [16]	Existential Model of Oral Health	2006	Community Dental Health	Canada	"To explore the evolution of conceptual frameworks and models of health and disability to construct an explanatory model of oral health" [16]	–
10	Nuttall et al. [9]	Population-Response Model	2006	Community Dentistry and Oral Epidemiology	UK	"To model the consequences of dental conditions from an empirical basis and testing model's ability to predict response combinations" [9]	–
11	Brondani et al. [17]	Refined Model of the Key Components Relating to Oral Health	2007	Gerodontology	Canada	"To evaluate qualitatively a model of oral health through focus groups among elders" [17]	–
12	John et al. [31]	Four-Dimensional Oral Health Model	2014	Journal of Oral Rehabilitation	USA	"Examination and confirmation of the new four-dimensional oral health model using factor analyses" [31]	–
13	Santos et al. [30]	Final Model	2015	Reports in Public Health/ Cadernos de Saude Publica	Brazil	"To test Wilson & Cleary's conceptual model of the direct and mediated pathways between clinical and non-clinical variables in relation to oral health-related quality of life, and to develop the Final Model" [30]	–

dPROM dental patient-reported outcomes measure

Table 2 Generic oral health model's dimension characterization

No.	Model names	Dimensions/*Sub-dimensions*			Characteristics			
		No.	Name	Definition	Source data (*N*, age)	Statistical analysis	Relation	Conception
1	Model of oral health [4]	7	Death	"Mortality rates, life expectancy, potential years of life lost" [4]	Literature	–	Unidirectional	Linear
			Disease	–				
			1. Self-report	"Patient listings of diagnoses or medical conditions" [4]				
			2. Clinical Diagnoses	"Diagnoses found on clinical examinations" [4]				
			Impairment	"Extent of anatomical loss or structural abnormality" [4]				
			Functional limitation	"Extent of loss of function of body parts or systems" [4]				
			Discomfort	"Self-reported physical and psychological distress, including pain and other feeling states not directly observable" [4]				
			Disability	–				
			1. Physical well-being	–				
			1.1. Activity restriction	"Acute or chronic limitation in physical activities of daily living" [4]				
			1.2. Limitations in social roles	"Acute or chronic problems in work, school, household management and recreation" [4]				
			2. Psychological well-being	–				
			2.1. Affective states	"Emotional states, anxiety, depression" [4]				
			2.2. Cognitive states	"Problems in concentration, reasoning" [4]				
			3. Social well-being	–				
			3.1. Integration	"Participation in community life" [4]				
			3.2. Social contacts	"Interaction with family, friends" [4]				
			3.3. Intimacy	"Perceived feelings of closeness/support" [4]				
			Disadvantage	–				
			1. Inequality of opportunity	"Lack of access to social opportunities, including careers, education" [4]				
			2. Deprivation	"Inequality of outcomes in terms of income self-image, self-esteem" [4]				
			3. Dissatisfaction	"With health and/or overall quality of life" [4]				

Table 2 (continued)

No.	Model names	Dimensions/*Sub-dimensions*			Characteristics			
		No.	Name	Definition	Source data (*N*, age)	Statistical analysis	Relation	Conception
2	Primary oral health care (POHC) [5]	2	Preventive oral health care services	"Prevention of onset of oral disease in all its ramifications" [5]	Experts	–	Unidirectional	Linear
			1. Prevention of onset of oral disease	–				
			1.1. Integration of general and oral health preventive programmes	–				
			1.2. Information	–				
			1.3. Advice	–				
			1.4. Plaque Control	–				
			1.5. Dietary control	–				
			1.6. Nutrition	–				
			1.7. General and oral hygiene	–				
			1.8. Fluorides	–				
			1.9. Fissure Sealants—HRPs	–				
			Emergency oral health care services	"Hospital-based or community-based services" [5]				
			1. Prevention of Further Progression of Disease	–				
			1.1. Temporary fillings	–				
			1.2. Simple Class I and II Amalgam fillings	–				
			1.3. Scaling and polishing with oral hygiene instructions	–				
			2. Relief of pain and debilitating Consequences of Disease	–				
			2.1. Extraction of painful and unsaveable teeth	–				
			2.2. Extraction of grossible mobile and non-functional teeth	–				
			2.3. Smoothening of minimally fractured tooth surfaces and application	–				
			2.4. Medication patients involving injuries to the maxillofacial complex	–				
			2.6. Reduction	–				
			2.7. Referrals	–				
			3. Rehabilitation	–				
			3.1. Provision of dentures to edentulous patients	–				

Table 2 (continued)

No.	Model names	Dimensions/*Sub-dimensions*			Characteristics			
		No.	Name	Definition	Source data (*N*, age)	Statistical analysis	Relation	Conception
3	Theoretical framework of Oral impacts on daily performances [7]	6	Impairment	"Oral status" [7]	Experts, GP (*N* = 501, 35–44)	Internal consistency analysis and item-total score correlation	Unidirectional	Linear
			Pain	"Possible earliest negative impacts. May impact on performance ability" [7]				
			Discomfort	"Possible earliest negative impacts. May impact on performance ability" [7]				
			Functional limitation	"Possible earliest negative impacts. May cause pain, discomfort or dissatisfaction with appearance and vice versa, and may impact on performance ability" [7]				
			Dissatisfaction with appearance	"Major dimension of oral health outcomes" [7]				
			Impacts on daily performances	"Impacts on ability to perform daily activities" [7]				
			1. Physical	–				
			2. Psychological	–				
			3. Social	–				
4	Conceptual Framework for Oral Health [34]	4	Severe oral disease and tooth loss, highlighting accumulated oral neglect	–	DP (*N* = 1315, 18 +)	Principal Component Analysis (PCA)	–	–
			Self-perceived symptoms and problems	–				
			Reparable oral disease	–				
			Oral health values and priorities	–				

Table 2 (continued)

No.	Model names	Dimensions/*Sub-dimensions*			Characteristics			
		No.	Name	Definition	Source data (*N*, age)	Statistical analysis	Relation	Conception
5	Model for Dental Hygiene [15]	6	Health and preclinical Disease	"Positive state in which an individual is in a self-defined ideal level of physical, psychological, social, and emotional well-being" [15].	Experts, literature	–	Reciprocal	Non-linear
			Biological and physiological: clinical variables	"Assessment of signs of disease in determining differential diagnoses" [15].				
			Symptom status	"Recognition of health and disease as a complex relationship between the individual/population and environment, and subsequently considering and responding to these issues when determining interventions" [15].				
			Functional status	"Ability of an individual to perform specific oral functions, life tasks, and other roles that may be influenced by the oral cavity" [15].				
			1. Physical	"Physical functions of the oral cavity, such as chewing, eating, and speaking" [15].				
			2. Social	"Social functions, such as avoidance of social interaction, decreased communication with others, and a decrease in perceived usefulness" [15].				
			3. Role	"Role functions, such as impaired family interactions, interference with job responsibilities, interrupted travel, and impaired household management" [15].				
			4. Psychological	"Psychological functions, such as depression, embarrassment, decreased self—confidence, and decreased concentration" [15].				
			Health perceptions	"An individual's or population's subjective opinion of their physical, emotional, and oral conditions" [15].				
			General Quality of Life	"Overall satisfaction with life as a whole" [15].				
6	Multidimensional Conceptual Model of Oral Health [6]	5	Oral disease and tissue damage	"Duration and tissue damage" [6].	Experts, GP ($N=873$, 45+)	Factor Analysis	Unidirectional	Linear
			Oral pain and discomfort	"Presence and duration of toothache pain, root sensitivity to hot/cold changes, and denture soreness" [6].				
			Oral functional limitation	"Current chewing ability, difficulty speaking or pronouncing words because of problems with teeth, mouths, or dentures" [6].				
			Oral disadvantage	"Whether mouth problems caused patients to avoid certain activities and the frequency of that disadvantage" [6].				
			Self-rated oral health	"Self-rated oral, dental, and periodontal health" [6].				

Table 2 (continued)

No.	Model names	Dimensions/*Sub-dimensions*			Characteristics			
		No.	Name	Definition	Source data (*N*, age)	Statistical analysis	Relation	Conception
7	Conceptual Model of Oral Health [10]	4	Oral health as the absence of disease	–	GP (*N* = 95, all age groups)	Interpretative Analysis	–	–
			Preventive approach to oral health	"Oral Health is a state to be maintained which included but was not simply the absence of disease" [10].				
			Relationship between oral hygiene and personal hygiene	"Poor oral hygiene indicates poor personal hygiene" [10].				
			Relationship between oral health and general health	–				
			1. A Dualist Model of the relationship	"Oral health problems can give rise to general health problems and vice versa" [10].				
			2. A holistic model	"Oral health and general health are inseparable" [10].				
8	Adaptation of Wilson and Cleary's Model of Oral Health [8]	4	Oral diseases and disorders	–	GP, DP (*N* = 766, 50+)	Mann–Whitney and Fisher's exact tests	Unidirectional	Linear
			Oral symptoms and compromised Physical and psychosocial functioning	–				
			Negative oral health perceptions	–				
			Quality of Life	–				
9	Existential model of oral health [16]	3	Outer contextual or environmental layer	"Interactions of personal and social factors and skills" [16].	Literature	–	Reciprocal	Non-linear
			Functional and structural layer	"Potential for impairments or deviations in structure that might or might not restrict participation or limit activities" [16].				
			Inner layer	–				
			1. Hygiene	–				
			2. Comfort	–				
			3. General health	–				
10	Population-response model [9]	6	Disease	–	DP (*N* = 5281, > 60)	–	Reciprocal	Non-linear
			Impairment	–				
			Functional limitation	–				
			Pain/discomfort	–				
			Disability	–				
			Handicap	–				

Table 2 (continued)

No.	Model names	Dimensions/*Sub-dimensions*			Characteristics			
		No.	Name	Definition	Source data (*N*, age)	Statistical analysis	Relation	Conception
11	Refined model of the key components relating to oral health [17]	12	General Health	–	GP (*N* = 42, 64–85)	Framework and Cross-group pattern analysis	Reciprocal	Non-linear
			Comfort	–				
			Diet	"Not only for the amount, composition, and nutritional value of daily meals, but also for the social and psychological role that food plays in the quality of life and enjoyment of almost every sociocultural group, and especially in old age" [17].				
			Hygiene	–				
			Activity	–				
			Participation	–				
			Expectations	"From teeth, dental treatment and other aspects of oral health" [17].				
			Coping and adapting	–				
			Health values and beliefs	"Things that are affected by beliefs" [17]				
			Economic priorities	–				
			Personal environment	"Associated not only with family values on education and friendship but also with genetics and physical structure that allows diseases to pass from one generation to another" [17]				
			Socio-cultural environment	"Current views on the role that culture plays in society, especially when many different cultural groups live together" [17]				
12	Four-dimensional oral health model [31]	4	Oral function	–	GP, DP(*N* = 5146, –)	Factor Analysis	Reciprocal	Non-linear
			Orofacial pain	–				
			Orofacial appearance	–				
			Psychosocial Impact	–				
13	Final model [30]	5	Biological variable	–	GP (*N* = 578, 68)	Structural equation modeling (SEM)	Unidirectional	Non-linear
			Symptom status	–				
			Functional status	–				
			Oral health perception	–				
			Oral health-related quality of life	–				

N number of subjects, *Age* age range or age mean in years, *GP* general population, *DP* dental patients

Regarding the theoretical value of aesthetics for a patients' oral health, only two generic oral health models have added such dimensions, namely, *Dissatisfaction with Appearance* [7] and *Orofacial Appearance* [31]. Authors also presented some model dimensions that can have different meanings and are therefore difficult to interpret, i.e., *Impairment* [7]. Yet many included dimensions described as *Self-Report* [4], *Quality of Life* [4, 8, 15, 21, 30], and *General Health* [10, 16, 21]. Authors rarely provided definitions for their model's dimensions and sub-dimensions, i.e., only 50 out of 119 dimensions and sub-dimensions had definitions (42%).

Source data for the development of the 13 generic oral health models also varied substantially. Authors developed oral health models based on one or more sources of data. Researchers used only experts ($N=1$), literature ($N=2$), dental patients ($N=2$), or general population subjects ($N=3$), or a combination of these sources ($N=5$) for the development of their generic oral health models.

Statistical analyses were the basis for the development of eight generic oral health models, such as Principal Components Analysis, Factor Analysis, Structural Equation Modeling, or other less demanding analyses, i.e., interpretative analysis, Mann–Whitney, and Fischer's exact test, item-total score correlation analysis, internal consistency analysis.

The relationship between dimensions was unidirectional in six models and reciprocal in five models. Two models did not specify the type of relationship between dimensions.

For the majority of the presented oral health models, the conceptualization was non-linear ($N=6$). Five models presented a linear conceptualization, and two models did not specify their models' conception.

Discussion

In this systematic scoping review, we identified 13 different generic oral health models, which present 13 different theoretical conceptualizations of oral health.

Oral research used the generic biomedical model that used an approach based on diagnoses and diseases before the first oral health model was developed [32]. David Locker was the first researcher to show the aspects of oral disease as oral impairment and disability [4]. He presented the first multidimensional oral health model [4], which was an adaptation from the International Classification of Impairments, Disabilities, and Handicaps (ICIDH) [14]. Locker's model illustrates *"ill/oral health and oral disease, disability, and handicap modeled by pain and several other variables"* [4]. In this model, he shows the connection and relationships between dimensions in a linear manner expressing that impairment does not necessarily provoke disability or handicap. However, Locker's model did not take into account prevention or recurrence. Notwithstanding, it is considered to be the most influential model in international dental research and education because of his interpretation of how a patient's health relates to oral impairments and oral disability [4, 33].

Based on the assumption that patients' oral health and pathological conditions influence their daily life, several oral health models have emerged since Locker's model. Jeboda described a linear model with two major dimensions and sub-dimensions [5]; the dimension *Preventive oral health care services* focused on prevention of oral diseases, while the *Emergency oral health care services* dimension emphasized the negative aspect of health without taking into consideration a patients' subjective experience [5]. In contrast, Adulyanon and Sheiham took into account a patient's psychosocial impact and developed an oral health model with linearly linked dimensions, namely, *Pain, Dissatisfaction, Physical Impacts, Psychological Impacts,* and *Social Impacts* [7]. Comparable to this is the Gilbert et al. model of oral health [6]. They integrated dimensions such as *Oral Disadvantage* and *Limitations* that allude to illness and disease and their impact on daily activities [6]. The authors developed these models [5–7] from expert opinion, and therefore overlooked or omitted a patient's perception of disease or health and their experience.

Gift et al. used demographic and socioeconomic indicators from personal interviews, reported symptoms, attitudes, perceptions from self-administered questionnaires, and indicators of disease and needs for treatment from oral examinations to investigate the relationships among variables [34]. They performed principal component analysis (PCA) and regression analyses to explore whether a set of conceptual factors can substitute a more extensive initial set of variables but found no evidence. Corrigan et al. identified two different models based on a patient's perception of disability and oral health [10]; the first model related health to the lack of disease, while the second included a definition of health affirmed by the participants including physical, social, and psychological well-being, as well as, the capacity to perform workaday activities [10]. They also found two other models showing the relationships between oral and systemic health. In the first model, the two concepts were distinct but connected, while in the second model the two concepts were indivisible [10]; however, they did not present the models' dimensions, nor explained their relationships, or graphically displayed them [10].

The generic oral health models proposed by Williams et al. [15], Locker and Gibson [8], and Nuttall et al. [9] did not refer to the biopsychosocial view of health. Instead, they favored disease and dysfunction while presenting their concept of oral health models [8, 9, 15]. As a result, they emphasized the negative aspect of the oral health concept [4, 8, 9, 14, 15, 35]. Locker and Gibson's model, as well as

Nuttall's model [8, 9], followed linear conception, while the model proposed by Williams et al. [15] used bidirectional arrows showing a possible continuum transition among dimensions. After that, researchers have begun to design models that include a patient's own interpretation of health and take into account positive aspects of how disease(s) impact a patient's daily function, oral health values, and beliefs [8, 16, 17, 21, 35, 36].

More recently, the authors have not presented or developed new oral health models [15–17] with linearly connected dimensions, but have rather designed them as dynamic structures, mostly in a circular model. This circular design allows for dimensional reversal effects, that is, once a patient reaches disability, he is not considered to stay disabled, but could reduce, prevent, or reverse disablement, even revert back to a healthy status [17]. The *"Existential model of oral health"* presented by MacEntee [16] contained a positive movement toward oral health because he endorsed variations of patients' views of health and disability, along with eventual limitations. He stated that the patient's oral impairments do not constrain daily activities [16]. However, by using a circular structure to present model dimensions, various dimensions' significances can be implicated, either as less relevant aspects of oral health and disease or as more important aspects [37]. Therefore, Brondani et al. [17] further refined MacEntee's model [16] accounting for an equal component's influence on oral health. They furthermore incorporated influences of *Socio-cultural Environment, Expectations, Economic Priorities, Health values and beliefs*, and *Diet* upon oral health in their model [17]. Regardless, these models [16, 17, 21] were too complicated to interpret and to work with. Thus, a group of international researchers [31, 38] from seven countries explored the dimensionality of the dPROM Oral Health Impact Profile [39] (OHIP) which was based on the Locker's model of oral health [4]. They found that differentiated four-dimensional structure of oral health exists [31, 38, 40, 41] and defined it as four major components, namely, *Oral Function, Orofacial Pain, Orofacial Appearance,* and *Psychosocial Impact*. In 2015, Santos et al. [30] tested Wilson and Cleary's conceptual model [42] adding modification indices and using a structural equation modeling (SEM) analysis. Nevertheless, the model's development resulted in its rejection. Based on these findings, Santos et al. developed a new model of oral health, the *"Final model"* [30], which incorporated straightforward and middle pathways between clinical and non-clinical parameters in connection to oral health [30].

By revising previous models, some authors aimed to define the oral health concept from their perspective. Some defined oral health as linear and constant with the presentation of the models' dimensions on a timeline [4–8, 30]. Others embedded etiological factors related to oral health in their frameworks [15–17, 30]. However, the majority of authors considered or included the possibility of dimensional fluctuation in their models which allowed for the possibility to revert to the previous condition [9, 15–17, 31]. Most dental researchers used data from the general public and dental patients [6–9, 15, 17, 30, 31]. Additionally, authors also used literature [4, 15, 16] or experts' opinions [5–7, 15]. The statistical analyses used by authors were very diverse, except for two models [6, 31] which authors confirmed both by factor analysis. Some models [4, 5, 9, 15, 16] are not based on statistical analysis; therefore, it is challenging to present a meeting point of the identified 13 generic oral health models, because the only consistent is the concept of oral health as a multidimensional concept. It is also evident that there is confusion about the "true" concept of oral health, and this has led to a variety of oral health models, which would explain this theoretical concept. Therefore, it is beyond the bounds of possibility to show a significant juncture of the 13 models because all models differ considerably in all their characteristics, namely, dimensional and sub-dimensional number, dimensional names, models' source data, statistically versus theoretically based models, dimensions' relation, and models' conception.

Authors used several definitions of oral health for generic oral health model development, e.g., Gift and Atchison described oral health as "Self-report specifically pertaining to oral health capturing both the functional, social, and psychological impacts of oral disease" [34]. Other investigators interpreted it as "The extent to which oral disorders affect functioning and psychosocial well-being" [43], or "Symptoms and functional and psychosocial impacts that emanate from oral diseases and disorders" [44]. Investigators used several dimensions to describe better oral health. Nevertheless, all these dimensions are not always clearly defined and easy to interpret. Only five of the 13 models identified generic oral health models comply with the current definition of oral health by FDI from 2017 [12], as their goal was to identify patients' oral/orofacial impacts [4, 7, 9, 10, 16, 30] and the vast majority of dimensions coincide with the FDI definition of oral health, e.g., *Disease, Disability, Impairment*.

Factors that have the most significant influence on, and straightforwardly intercede with oral health outcomes are social, cultural, economic, structural, and biological determinants, as well as likeliness to access oral health care services [4, 7, 8, 10, 15–17, 31]. Researchers who proposed the 13 generic oral health models rarely incorporated the influence of culture or religion on oral health as a concept per se, because study participants used for model development evaluated themselves as "one world" even though they might have different responses and cultural backgrounds [17]. When Corrigan et al. explained their version of generic oral health model, they emphasized that ethnic and cultural

factors can explain the variation of the understanding of oral health and its connection to general health [10].

Political determinant is also getting increasingly important in every society. The economics of oral health care is spreading outside the limits of patients' budgets to combine social determinant where health care is established and accessible [17]. Though access to dental treatments and dental services, in general, is not evenly enabled around the world. Some countries have social health policy and, therefore, dental health care is mostly accessible to everyone, while other countries do not cover dental health care for the entire population. For instance, two patients with the same oral health impact and limitation, but different access to dental service (one has access, while the other has not) can either regain his/her physical, psychological, and social well-being or become further impaired and handicapped [16]. Interestingly, the possibility of accessing dental care and other environmental determinants about oral health were weak measures of oral health only in MacEntee's study [16].

Lastly, social and environmental characteristics can directly or indirectly impact all facets of an individual's oral health, and this should, therefore, be reflected in domains/dimensions of generic oral health models. The identified generic oral health models labeled these characteristics as *Social Well-Being* or *Social Contacts* [4], *Social* dimension or sub-dimension [7, 15], *Psychosocial Functioning* [8] or *Psychosocial Impact* [31], *Outer Contextual or Environmental Layer* [16], and *Socio-Cultural Environment* [17].

Comparison with the literature

To the best of our knowledge, this is the first scoping review about oral health models. Only in medicine has a systematic review identifying general health models has been performed [19]. Bakas et al. found a hundred published references related to models about general health in over 10 years [19]. Despite that, they mainly focused on the three most commonly used models for general health for which Bredow's [20] criteria for evaluating theories were applied [19]. In comparison, our systematic scoping review investigated, reviewed, and analyzed all existing generic oral health models through identifying models' characteristics by capturing their general and dimensional information, without restrictions on time.

Brondani and MacEntee reported a narrative review of oral health models in 2014 [21], whereas our systematic scoping review of the literature has the aim to provide a comprehensive and systematic examination of existing generic oral health models in the English scientific literature. We did not consider references about general health models or models about oral health behavior and oral health literacy, considering them as the ancillary aspects of the oral health concept and did not limit the search to a particular time range.

Strengths and limitations

To understand various interpretations of the theoretical concept of oral health, we aimed to perform a systematic scoping review of existing generic oral health models. By knowing the current availability of international scientific literature regarding all generic oral health models and their characteristics, researchers will be more knowledgeable about existing concepts of oral health. Based on this study's results, researchers will have the opportunity to determine which generic oral health model describes the vast area of oral health best. They will also be able to select which model is best for assessing their patients' oral health outcomes and a theoretical model for the development of new dPROMs for measuring a patients' self-perceived oral health and thus their quality of life [45].

This systematic scoping review has some limitations. The search strategy was limited to five electronic databases (Medline, Embase, PsycINFO, Cochrane, and Web of Science) and was created to capture references that presented new generic oral health models. Nevertheless, these widely known electronic databases in the international dental research community contain a vast majority of all scientific references for dentistry. We reviewed only English language scientific literature and for this reason, could have missed some models published in other languages. We assumed that researchers, who developed a new generic oral health model, would want to present their findings to the international dental community and thus would publish their studies in English since it is such an internationally accepted language to report significant scientific discoveries.

Moreover, we did not search for generic oral health models in the gray literature because we wanted to focus on peer-reviewed journals since this is where authors have published the majority of well-conducted studies related to model development. We considered the gray literature had less scientific value than the peer-reviewed literature, precisely because we aimed to perform a sensitive search about generic oral health models development. We also reviewed references from the 13 included articles that met the inclusion criteria, as well as, references from an identified narrative review. We did not find any additional articles after reviewing these references. Additionally, we did not use a quality assessment tool, because the focus was on the detection of developmental studies of generic oral health models for which none of the proposed instruments, to assess the quality of the studies, were applicable.

Conclusions

The identified 13 generic oral health models vary substantially. Currently, selecting the best theoretical concept of oral health presents a substantial challenge for international dental researchers due to the wide choice of models, their diversity, and above all confusion in dimensionality. Based on this study, investigators now have the opportunity to choose an appropriate generic oral health model, which aligns with their understanding of the oral health concept. The lack of a coherent scheme of oral health does not lead international researchers and clinicians in their efforts for improving dental patients' oral health and quality of life. Ideally, international researchers will accept a single uniform generic oral health model, which will allow for comparison of oral health outcomes across studies and populations and thus elevate science and research in dentistry to a higher level of evidence-based practice.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This review does not contain any studies with human participants performed by any of the authors.

Informed consent Informed consent was not applicable to this review as no primary data were collected.

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