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Global Research Trends in Children's Oral Health Education: A Bibliometric Analysis of Scopus Publications (1929–2023)

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Background and objective: children's oral health education plays an important role in preventing oral diseases and promoting lifelong healthy behaviors. This study aimed to systematically map global research trends, intellectual structure, and thematic development of oral health education in children.

Materials and Methods: This bibliometric analysis publications indexed in the Scopus database from 1929 to 2023. A total of 11,389 records were initially retrieved, of which 335 articles met the inclusion criteria and were analyzed. Data were examined using bibliometric indicators, co-citation analysis, bibliographic coupling, and keyword co-occurrence mapping with VOSviewer (version 1.6.20).

Results: The analysis identified ten major research clusters, including caries prevention, behavioral interventions, clinical approaches, public health promotion, and standardized indicators. The United States (43 publications, 606 citations) and India (42 publications, 573 citations) were the most productive countries. Influential studies by Samuel (2020) and Carvalho (1992) showed strong citation links. Recent research trends emphasize school-based interventions, preventive programs, and behavioral change strategies.

Conclusion: This study demonstrates a shift in pediatric oral health research from clinical treatment toward prevention-oriented and education-based approaches. The findings provide evidence for identifying research gaps, supporting international collaboration, and informing the design of effective oral health promotion programs and policies, particularly for underserved populations.

Keywords: Bibliometric, Children, Education, Oral Health, Scopus

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Introduction

The greatest national asset in any society is having healthy and capable individuals; therefore, the level of individuals' health is an effective component of national development (1). In the meantime, one criterion for measuring individuals' health throughout life is their oral health in society (2). The mouth has been described as a "mirror to the body," reflecting overall health and contributing to essential functions such as chewing, swallowing, and speech, as well as influencing systemic well-being (3).

Oral health is more than just healthy teeth, and according to the World Health Organization (WHO), it is defined as the absence of oral and facial pain, oral cavity ulcers, oral and pharyngeal cancers, congenital malformations and other disorders affecting the oral cavity (4). The WHO also contends that poor oral hygiene can profoundly affect individuals' quality of life (1). It can lead to dental problems (tooth decay, periodontitis, edentulism, etc.) and general health, low self-esteem, chronic infections (5), coronary artery disease, cancer, diabetes (6), Alzheimer's and respiratory infections (2). Oral diseases affect approximately 3.5 billion people worldwide, imposing substantial health and economic burdens (6), and ranking as the fourth most expensive disease to treat in most industrialized countries (7). Consequently, the prevention of oral diseases is a key objective of the WHO (8), with particular emphasis on early-life interventions (9). The WHO recognizes childhood tooth decay as a major public health concern, with a global prevalence ranging from 60 to 90% (10). National oral health surveys further highlight the high prevalence of dental caries and other oral diseases among children; for example, in Iran, early childhood caries affects approximately 61.7% of children (11).

There are various ways to prevent oral diseases (6), among which education and health promotion strategies play a critical role by improving preventive behaviors and raising community awareness (5). Most studies conducted on educational health methods have compared the effectiveness of various methods. Oral health education is not an exception and has used various educational methods, such as the use of visual media, educational videos, training models, lectures and group discussions in research (12). However,

implementing multiple educational interventions in oral health promotion programs has faced certain challenges in changing the sustainable behavior of target groups (12). In addition, educational programs with positive reinforcement in children and also strategies with a psychological approach, which are reinforced by intrinsic motivation, have been observed in oral health promotion programs (13).

Given the large number of studies on oral health promotion programs as a measure of community health and development, a comprehensive synthesis is needed. Bibliometric analyses provide a quantitative and qualitative approach to evaluate research data, including citation counts, and can objectively assess research trends, thematic development, and the intellectual structure of a field. This approach helps identify trends, active authors and countries, leading journals (14), and the intellectual structure of a field (15). It is also effective for studying research trends and highlighting current and emerging topics (16).

Although several bibliometric studies have explored oral health–related themes, such as oral health–related quality of life (14) and the role of poor oral health as a risk factor for specific oral diseases, including oral cancer (15), these studies have generally focused on specific topics or limited time periods and have not provided a comprehensive mapping of oral health promotion programs for children. A clearer understanding of the characteristics and development of this field may support decision-makers, oral health policymakers, and dental practitioners in designing and implementing effective health promotion strategies based on oral health education.

To address this gap, the present study provides a comprehensive bibliometric analysis of children's oral health promotion programs by integrating bibliographic coupling, co-citation, and keyword overlay analyses to examine the intellectual structure, thematic clusters, and longitudinal development of the field from 1929 to 2023. Accordingly, this study aimed to create visual knowledge maps of oral health promotion research and to analyze its current status, thematic evolution, and research trends:

1. What are the major and emerging research themes in oral health education based on keyword analysis?
2. Which articles are the most cited in oral health education research?
3. Who are the most prolific and frequently cited authors in oral health education?

4. What are the leading journals by productivity in publishing oral health education research?
5. Which countries have been the most prolific and active in publishing research on oral health education?
6. Which institutions have contributed most actively and prolifically to research in oral health education?
7. Who are the most frequently co-cited authors in oral health education, and what does this suggest about their influence in the field?
8. Which recent articles in oral health education share the highest bibliographic coupling, indicating closely aligned research topics or methodologies?

Materials and Methods

Data source and search strategy

The dataset was retrieved primarily from Scopus, which includes comprehensive and high-quality publications. Scopus is considered an optimal database for bibliometric analysis because it provides broad coverage of journals in the health sciences, including international and pediatric-focused publications. In the first step, a search strategy for the Scopus database was designed to retrieve peer-reviewed articles on educational interventions in pediatric oral health. Given the broad scope of oral health education programs, all scientific articles related to this topic published between 1929 and 2023 were reviewed. A structured search was performed in the Scopus database using the following query: TITLE-ABS-KEY (("oral health education" OR "dental health education") AND (pediatric* OR child* OR preschool* OR "pre-school*" OR "school age")). All articles without language restriction were examined in this study. Scopus search results were exported in CSV file format including all data elements such as citation information, bibliometrics (author name, number of authors, number of references, country, journal name), abstracts and keywords. The electronic search was done at the beginning of 2024. Two independent reviewers (F.G.M., M.A.) evaluated the articles and reached a final conclusion by consensus in cases of disagreement. After screening the articles, those containing the two words “oral health education” and “children” and their synonyms in their “title”, “abstract” or “keywords” were included in the research and analyzed. All retrieved articles were screened to ensure

that the participants fell within the target age range of 1–10 years. The PRISMA flowchart was used to select relevant articles from the Scopus database **(Figure 1).**

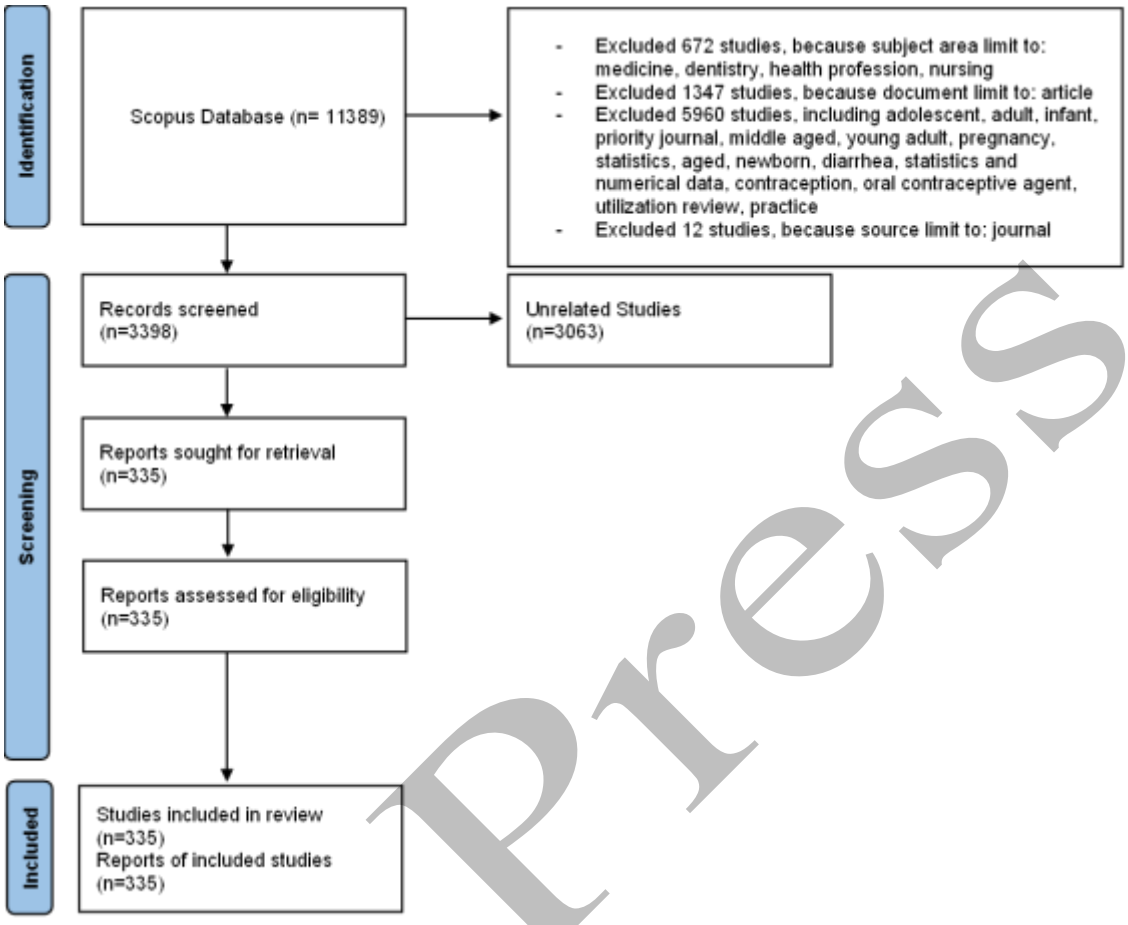

Figure 1- Literature screening flowchart

Data analysis

The data, including authors, journals, countries, and citations, were added to Microsoft Excel for analysis, ranking, and counting, and the corresponding graphs were drawn. Bibliometric analyses were conducted using quantitative and qualitative methods, including citation counts, co-citation, bibliographic coupling, and keyword co-occurrence, to identify research trends, active authors and countries, leading journals, thematic clusters, and the intellectual structure of the field. VOSviewer1.6.20, developed by Van Eck and Waltman from Leiden University in Netherlands (16), was used to create and view bibliometric maps and for co-authorship, cooccurrence, bibliographic coupling, and co-citation analyses. Thresholds in VOSviewer were selected following standard bibliometric practice (van Eck & Waltman guidelines) to balance comprehensiveness, network stability, and interpretability:

lower thresholds include too many items (risking clutter and weak clusters); higher thresholds focus on influential/core elements for clearer visualization and meaningful patterns. In the graph, each node (circle) represents a keyword, country, author, journal, etc. The distance between two circles indicates the strength of the link between indicators (17).

Results

1. Keyword analysis based on keyword index

Keyword analysis helps identify the main research themes in oral health education. The most frequent terms in this field are presented in **Table 1.** This analysis, based on index keywords and clustering performed using VOSviewer, shows that the main focus of research is on dental caries prevention, health and educational behaviors, oral hygiene and public health, and education and prevention.

The analysis of keyword overlap map **(Figure 2)** shows that the focus of oral health research has changed significantly over time. In the 1940s to 1980s, studies focused mainly on dental caries and related topics such as fluoride, DMF index, and oral health. This research was more concerned with identifying risk factors and developing treatment techniques. In the 1990s to 2000s, the research trend shifted towards behavioral and preventive approaches. Terms such as health education, tooth brushing, and parenting show a focus on educating families and children to improve health behaviors and promote oral health. Since the 2010s, contemporary research has focused more on topics such as preventive dentistry, program evaluation, and health attitudes. These changes reflect a greater focus on systematic public health interventions and assessment of their impact on society. Overall, these trends indicate a shift from clinically oriented research toward prevention-focused and comprehensive public health interventions.

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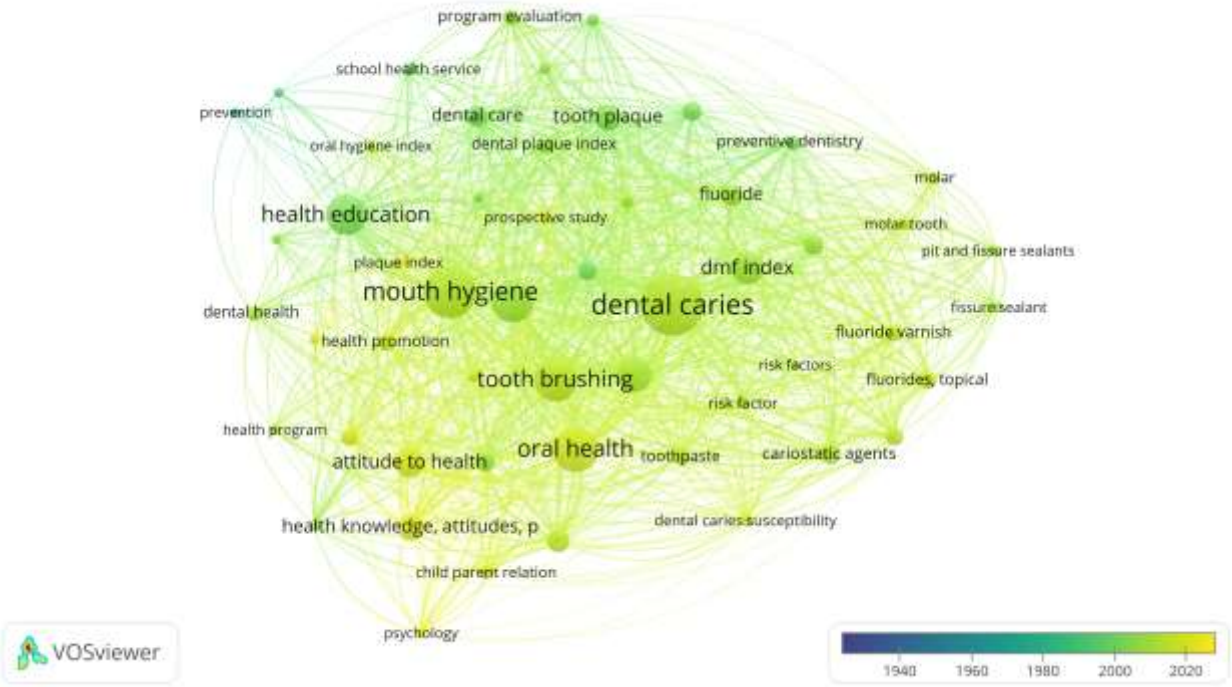

Figure 2. Index keyword overlap map (keyword threshold = 9; showing 102 of 878 keywords)

In this step, 102 keywords met the threshold and were included in the analysis are categorized into four main clusters. Each cluster represents important topics and research focus in this area. In the following, labels, analysis, and descriptive explanations are provided for each cluster.

Cluster 1: Prevention and treatment of tooth decay

Cluster label: Preventive and therapeutic interventions

This cluster focuses on the prevention and treatment of dental caries, and includes 17 keywords. Studies in this cluster examine factors such as fluoride use, fissure sealants, caries indicators such as DMF, and preventive interventions. Research in this area is particularly important for children, and efforts are made to reduce the incidence rate of caries and improve oral health through these preventive strategies.

High-frequency key terms: Dental caries, Fluoride, Fissure sealant, Preventive dentistry, Risk factors

Cluster 2: Health and educational behaviors

Cluster label: Behavioral and educational approaches

This cluster consists of 14 keywords that examine the role of education and health behaviors in promoting oral health. The main focus of this cluster is to change attitudes and behaviors related to oral health among families, especially children. The main emphasis of this research is on creating good health habits such as tooth brushing, educating parents, and the impact of parental behavior on children's oral health.

High-frequency key terms: Attitude to health, Tooth brushing, Parents, Psychology, Child behavior

Cluster 3: Oral health and general health

Cluster label: Oral health and public health programs

This cluster consists of 14 keywords and examines public health interventions, school-based oral health programs, and oral health indicators. Topics related to this cluster include program evaluation, socioeconomic status, and health service management. Research in this area plays an important role in the design and implementation of preventive programs in schools and communities.

High-frequency key terms: Mouth health, Oral health, Program evaluation, School dentistry, Plaque index

Cluster 4: Education and prevention

Cluster label: Educational and preventive strategies

This cluster consists of eight keywords and focuses on oral health education, prevention of dental problems, and individual motivation to adopt healthy behaviors. Relevant research emphasizes the role of education in reducing the risk of caries and improving oral health behaviors.

High-frequency key terms: Health education, Prevention, Dental care, Motivation, Tooth plaque.

Table 1- Top 20 frequent keywords

keyword	Occurrences	Total Link Strength
Dental caries	120	2177
Mouth hygiene	95	1857
Oral health	77	1251
Tooth brushing	72	1353
Oral hygiene	70	1284
Health education	66	936
Dmf index	48	977
Attitude to health	44	791

Tooth plaque	37	653
Health knowledge, attitudes, practice	36	685
Parents	29	623
Fluoride	28	520
Dental care	28	483
Cariostatic agents	24	565
Dental plaque	23	389
School density	22	449
Anticaries agent	21	492
Dental plaque index	21	447
Health behavior	21	418
Health promotion	21	346

2. Analysis of the article publication and citation process

The analysis of the process of publication and citation of articles in oral health education showed that significant and influential articles were published between 1990 and 2020.

Figure 3 shows the trend in citations to articles on oral health education interventions over time. This graph shows a significant scientific growth in this field in recent decades. Before 1990, citation counts were relatively low, and research during this period mainly focused on clinical treatment and the use of simple indicators such as Decayed, Missing and Filled Teeth (DMFT). In the 1990s, the number of citations increased, indicating a shift in research approach towards preventing and changing health behaviors through education. In this period, articles such as the one written by Carvalho (1992) et al. (18) were among the seminal studies that emphasized the prevention of dental caries using methods such as fluoride and sealants. Since 2010, the focus of studies shifted towards evaluating educational interventions and designing more comprehensive programs to promote oral health. Meanwhile, studies such as the one conducted by Samuel (2020) et al. showed the positive impact of school-based intervention programs that included monitored toothbrushing, hygiene education, and sugar restriction (19). The citations peaked in 2020, indicating the publication of key papers in this year. These trends show that oral health education research has moved away from traditional treatments to preventive and systematic programs, and with the growth of scientific collaborations and the use of standardized indicators, this area has become a priority of research.

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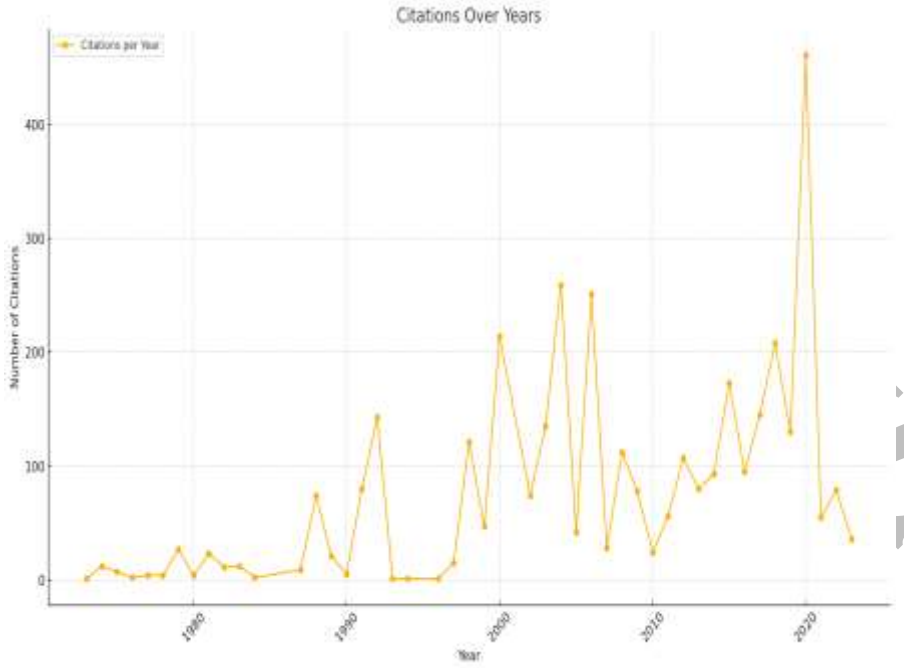

Figure 3 – Most frequently cited articles by year

From VOSviewer data, 185 articles with at least 3 citations were selected as the key articles. These articles were grouped into 12 clusters, reflecting different research patterns and citation trends in this field **(Figure 4).**

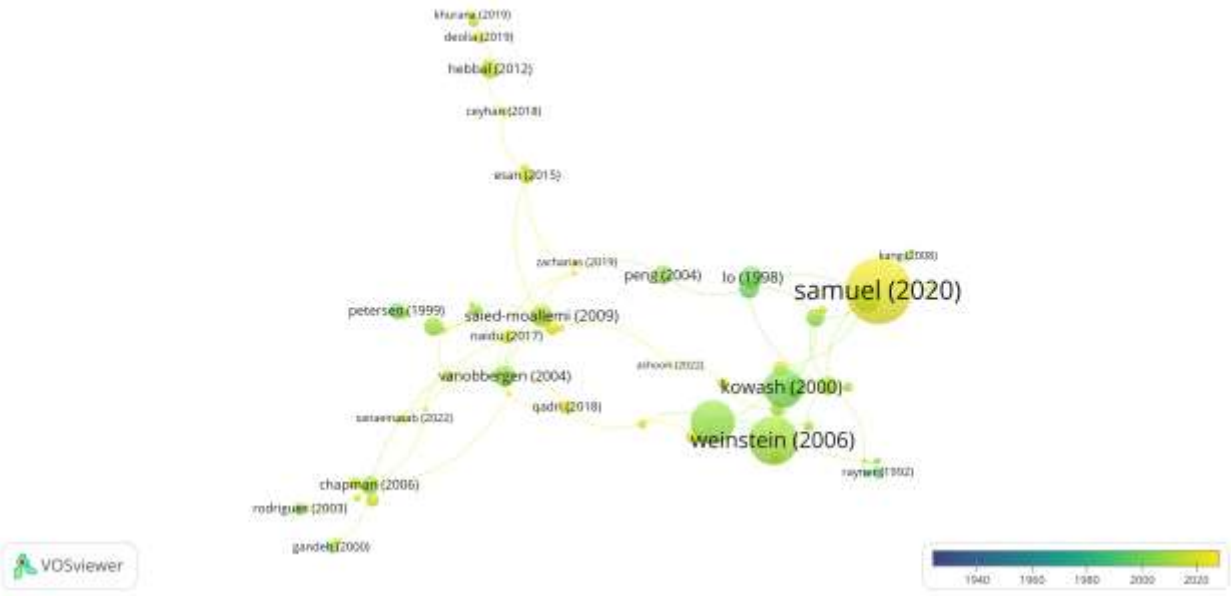

Figure 4. Graph of citation trends to articles (threshold = 3; display of 185 of 335 articles) by year

The analysis showed that the largest number of articles within the last two decades was published in 2020 (Figure 3). The most influential article was written by Samuel (2020) et al. with 286 citations. The article focused on school-level interventions such as banning sugary snacks at school, daily teacher-supervised brushing with fluoride toothpaste, and oral health education with regular follow-up at three points of time: six months after the program began, one year, and two years later (19). Weinstein (2006) et al., with 178 citations, examined the effect of counseling on changing mothers' health behaviors and its effect on reducing dental caries in children (20), and Weinstein (2004) et al., with 148 citations, compared the effects of motivational counseling with traditional health education methods on parents of toddlers at high risk of dental caries (21).

The general pattern of article publication shows that the focus on prevention research and oral health indicators emerged in the 1990s to early 2000s. For example, the study by Carvalho (1992) et al. (18) with 125 citations is among the pivotal studies during this time, emphasizing the prevention of dental caries and the use of preventive methods such as sealants and fluoride treatment.

In recent years, researchers such as Samuel (2020) et al. have shown the positive effect of school-based interventions on preventing dental caries in children (19). Kowash (2000) et al. explored the effect of an oral health education program using programs including individual consultations, group sessions, and the provision of educational materials such as brochures and videos on maternal health behaviors and children's oral health (22). Vanobbergen (2004) et al. examined the effect of a 6-year oral health education program on elementary school students with annual clinical examinations and oral health behavior assessment questionnaires (23). This body of research shows that school-based educational programs and oral health promotion programs continue to be the focus of researchers.

A review of literature also showed that the studies by Carvalho (1992) et al. (18) and Samuel (2020) et al. (19) are known as highly cited articles in this network and have the highest number of links to other articles. An example of older studies was the one conducted by Lo (1998) et al., which examined the effectiveness of three different protocols of topical fluoride application (group 1: application of 30% silver diamine fluoride solution every 12 months, group 2: three applications of 30% silver diamine fluoride solution with an interval of 1 week

at the beginning, group 3: three applications of 5% sodium fluoride varnish with an interval of 1 week at the beginning) along with follow-up checks every six months, in stopping dental caries in primary teeth of preschool children (24). In another study, Petersen (1999) et al. evaluated the effect of chewing gums containing carbamide and polyol on reducing the prevalence of dental caries in school children (25). These have shown to play an important role in preventing dental caries and have been cited as source references in recent studies.

Table 2 also lists the five most cited articles, along with the author name, journal name, year of publication, number of citations, and average citations per year.

Table 2- Top five cited articles

Title	Authors	Journal	Year	Cited by	Citations per Year
School Interventions–based Prevention of Early-Childhood Caries among 3–5-year-old children from very low socioeconomic status: Two-year randomized trial	Samuel S.R.; Acharya S.; Rao J.C.	Journal of Public Health Dentistry	2020	286	71.5
Motivating mothers to prevent caries: Confirming the beneficial effect of counseling	Weinstein P.; Harrison R.; Benton T.	Journal of the American Dental Association	2006	178	9.8
Motivating parents to prevent caries in their young children: One-year findings	Weinstein P.; Harrison R.; Benton T.	Journal of the American Dental Association	2004	148	7.4
Results after 3 years of non-operative occlusal caries treatment of erupting permanent first molars	Carvalho J.C.; Thylstrup A.; Ekstrand K.R.	Community Dentistry and Oral Epidemiology	1992	125	3.9
Effectiveness on oral health of a long-term health education programme for mothers with young children	Kowash M.B.	British Dental Journal	2000	120	5

3. Analysis of most cited authors

Data analysis **(Table 3)** showed that out of 1,308 authors, 20 authors were designated as highly cited authors because they had at least three articles and two citations. These authors were grouped into two clusters, which indicate collaborations and research connections between authors. Kowash is at the top of the list of highly cited authors with three articles and 122 citations. Declerck and Petersen, both with 76, three and four citations rank second and third. These authors are mainly active in topics such as oral hygiene, dental caries prevention and educational interventions.

The top authors in this field are from countries as wide-ranging as the UK, Brazil, Denmark and Nigeria. The presence of authors from developing countries such as Nigeria and Saudi Arabia indicates the global expansion of research on oral health education. Also, highly cited authors have had effective connections with other researchers, which is also evident in the scientific communication map.

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Table 3- Top 10 highly cited authors

Authors	Country	Cited by	Documents
Kowash, M.B.	United Kingdom	122	3
Declerck, Dominique	Belgium	76	3
Petersen, Poul Erik	Denmark	76	4
Folayan, Morenike Oluwatoyin	Nigeria	58	3
Ambrosano, Gláucia Maria Bovi	Brazil	50	3
Mialhe, Fabio Luiz	Brazil	49	3
Cruvinel, Thiago	Brazil	46	3
Aljafari, Ahmad	Saudi Arabia	45	3
Hosey, Marie Therese	United Kingdom	45	3
McGrath, Colman	Hong Kong	44	3

4. Analysis of leading journals in publication efficiency

Analysis of scientific journals on oral health education shows that out of 163 sources, 33 journals that met the criteria of at least three articles and a non-zero citation count were selected for the review. These journals were divided into seven clusters, each indicating the scientific and thematic connection between different journals **(Figure 5).** This analysis shows the key role of leading journals in guiding oral health education research and creating broad scientific networks.

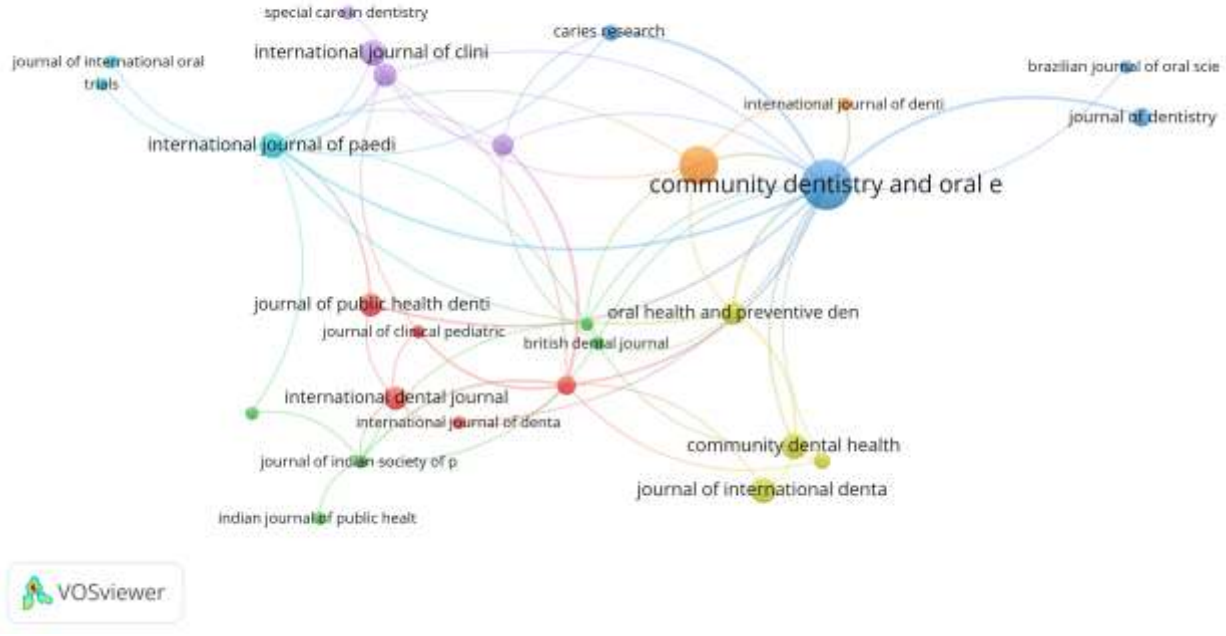

Figure 5. Journal citation graph (threshold = 3; display of 33 of 163 journals)

Table 4 shows that Community Dentistry and Oral Epidemiology is the most cited and important journal in this field with 23 articles and 619 citations. This journal has played a key role in broadening the knowledge of oral health education with 29 links to other scientific sources. The Journal of Public Health Dentistry ranks second with seven articles and 370 citations. The International Journal of Paediatric Dentistry ranks third with 202 citations. BMC Oral Health ranks next with 15 articles and 138 citations.

In cluster 3, journals such as Caries Research and Community Dentistry and Oral Epidemiology are specifically concerned with the prevention of dental caries and use of methods to assess oral health indicators. The Journal of Dentistry also falls into this group with 86 citations.

In Cluster 4, Community Dental Health and Oral Health and Preventive Dentistry are recognized as the leading journals focused on preventive measures and oral health education. Journals such as the British Dental Journal, the European Archives of Paediatric Dentistry, and the International Dental Journal are distributed in other clusters, reflecting the breadth of research topics and scientific interactions among different journals in this field.

Table 4- Top 10 total citations of journals

Journal Name	Total Citations
Community Dentistry and Oral Epidemiology	619
Journal of Public Health Dentistry	370
International Journal of Paediatric Dentistry	202
British Dental Journal	138
BMC Oral Health	138
Caries Research	138
Community Dental Health	102
Journal of Dentistry	86
Journal of International Society of Preventive and Community Dentistry	68
International Journal of Dental Hygiene	52

5. Most active countries

Among the 16 countries active in oral health education research, the top 10 countries have been recognized in terms of the number of articles, number of citations, and strength of scientific communication. These countries have played a key role in knowledge construction in this field due to the publication of high-quality articles and large number of citations.

The United States of America is on top of the list of active countries with 43 articles and 606 citations. This is followed by India with 42 articles and 573 citations and Canada with 11 articles and 431 citations ranking second and third. Countries such as Denmark and Brazil are

also very influential due to the high strength of communication links and scientific interaction.

The United States (largely driven by high-quality, theory-informed school-based and behavioral intervention studies) and India (particularly in low-cost, community- and school-oriented programs suitable for large underserved populations) were recognized as the leading countries in oral health, which indicates their high level of scientific production and global impact. Canada and Denmark, despite a smaller number of articles, have high citation rates, which indicates the high quality of their research. However, developing countries such as Brazil and Iran have also managed to establish their position in this field, to prove their scientific growth in oral health research **(Table 5).**

The map of country communication network shows that scientific interactions are mainly carried out in the form of regional clusters or international collaborations. The clustering of countries includes the following:

• Cluster 1: American and European countries such as the United States, Canada, and the United Kingdom

• Cluster 2: Northern European countries such as Denmark and the Netherlands

• Cluster 3: Asian countries including India and Indonesia

• Cluster 4: Middle Eastern countries such as Iran and Saudi Arabia

• Cluster 5: East Asian countries including China, Hong Kong, and South Korea

This analysis shows that different countries, depending on their geographical location and scientific capacity, have different roles in the development of oral health-related research. International collaboration, especially between developed and developing countries, can greatly contribute to the strengthening of global knowledge in this area.

Table 5 below shows the top 10 countries in scientific activity in oral health education:

Table 5- Top 10 highly cited countries

Country	Documents	Citations	Total Link Strength
United States	43	606	25
India	42	573	33
Canada	11	431	16
Denmark	8	364	30
United Kingdom	23	322	21
Brazil	27	264	26
China	27	211	19

Hong Kong	8	141	7
Iran	20	129	20
Finland	5	116	11

6. Analysis of active institutions

The analysis of research institutions active in oral health shows that only a few organizations have been involved in this field sustainably and effectively. As the key centers for knowledge construction and publication of scientific articles, these institutions play an important role in the further development of this field.

The extracted data show that 10 organizations met the criteria of at least two articles with two citations. These universities and institutes are among the most influential research centers, known for constructing scientific knowledge and strengthening international links in oral health.

The Department of Cariology and Endodontics at the University of Copenhagen, Denmark, is on top of the list of highly cited institutions with two articles and 187 citations, showing the great effect of their research on oral health. This is followed by the Public Dental Service in Sweden and the Western Australian Dental Service, recognized as important centers due to their high citation rates and scientific connections.

Moreover, Brazilian universities such as the Federal University of Rio Grande do Sul and Asian research centers such as King Saud University in Saudi Arabia and Universitas Indonesia play an important role in the geographical distribution of research in this field. These results show the extensive scientific collaborations and global impact of oral health research.

In addition, major European universities such as the University of Helsinki in Finland and the University of Hong Kong are emerging as leading academic centers in this field by presenting the main highly cited articles. In the UK, the University of Leeds also shows extensive research activity and international collaborations through participating in cluster analysis.

The top universities in this analysis, along with the number of documents, citations, and the strength of scientific links, are listed in **Table 6**:

Table 6- Top 10 organizations

Organization	Documents	Citations	Total Link Strength
Department of Cariology and Endodontics, Royal Dental College, Copenhagen, Denmark	2	187	4
Public Dental Service, Region Skåne, Malmö, Sweden	2	73	0
Department of Public Health, University of Helsinki, Helsinki, Finland	2	53	4

Dental Services, Health Dept. of Western Australia, Perth, WA, Australia	2	38	4
Graduate Program in Dentistry, Federal University of Rio Grande do Sul, Brazil	2	36	2
Faculty of Dentistry, The University of Hong Kong, Hong Kong	4	28	0
Department of Periodontics and Community Dentistry, King Saud University, Saudi Arabia	2	22	1
Denver Health and Hospital, Denver, CO, United States	2	21	0
School of Dentistry, University of Leeds, Leeds, United Kingdom	2	15	0
Department of Pediatric Dentistry, Faculty of Dentistry, Universitas Indonesia, Indonesia	4	12	0

7. Co-authorship analysis

Coauthorship analysis in this area shows that scientific collaborations among researchers are divided into two main clusters **(Figure 6).** This analysis includes eight authors divided into two groups with distinct intragroup connections.

The first cluster includes authors such as Fauziah, Eva, Indiarti, Ike Siti, Rizal, Mochammad Fahle and Sutadi, and Heriandi closely connected with each other. In this group, Indiarti, Ike Siti is recognized as the main hub of collaboration and plays a key role in establishing scientific links. This network indicates the implementation of joint projects or the publication of scientific articles on topics related to oral health and preventive interventions.

The second cluster includes authors such as Budiardjo, Sarworini, Indiarti, Ike, Suharsini, Margaretha and Widyagarini. In this group, Suharsini, Margaretha and Budiardjo, Sarworini play a key role and have an effective collaboration with the authors in this cluster. These interactions share a focus on specialized topics in oral health education.

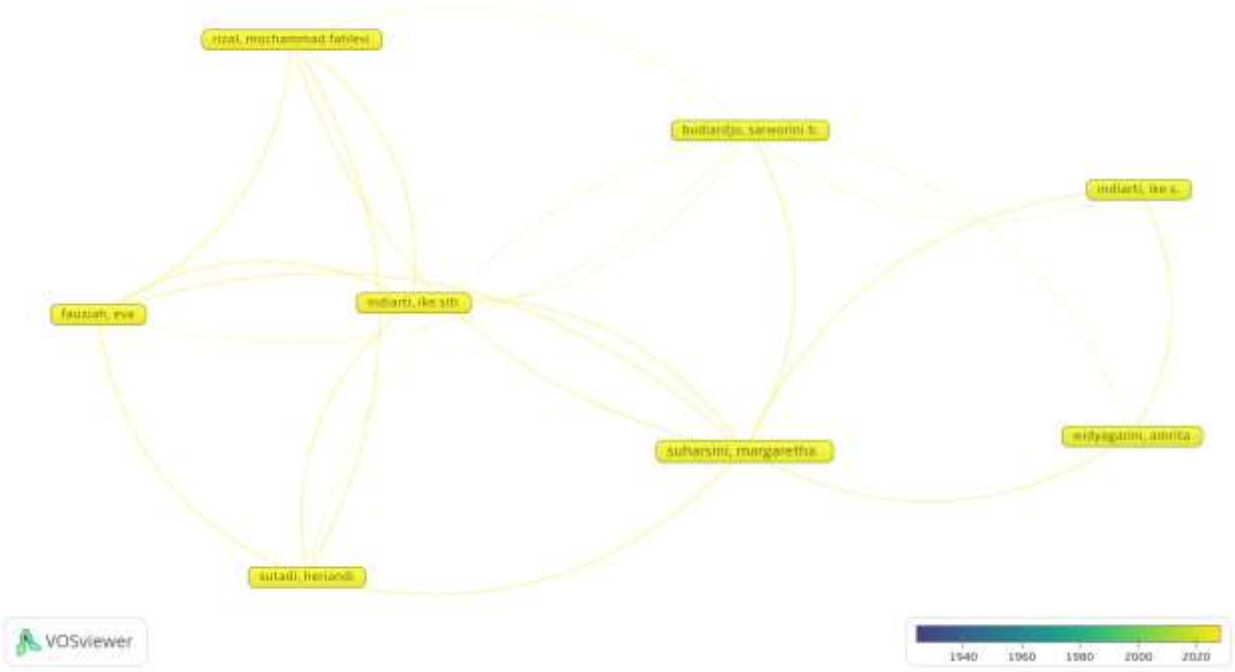

Figure 6. Co-authorship map (keyword threshold = 2; showing 100 out of 1,308 authors). Yellow colour indicates more collaborations in recent years

The coauthorship network as a whole shows that the two clusters are connected through Indiarti, Ike Siti. This author, as a connection of the two scientific clusters, has played a pivotal and influential role in connecting and strengthening scientific collaborations between the groups. The coauthorship network in this area mainly consists of small and focused groups with strong intra-group collaborations. With the help of pivotal authors, the links between the clusters has been established.

8. Co-citation analysis for Cited References

Co-citation analysis for sources with a threshold of at least 4 citations shows that out of 6,968 cited sources, only 14 were selected as major sources. These are grouped into three clusters, each indicating a close content relationship between articles and scientific sources **(Figure 7).**

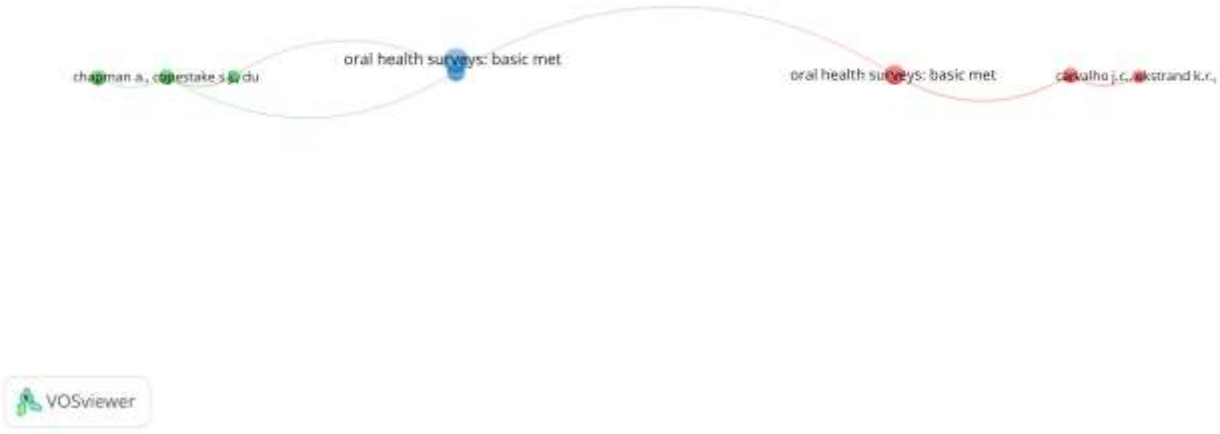

Figure 7. Co-citation map (threshold = 4; display of 14 of 6,968)

The first cluster evaluates the effectiveness of oral health education and includes sources that have examined educational interventions and health assessment indicators. Among these sources, mention can be made of Greene et al. (26) who introduced oral health indicators. Another study by Kwan et al. (27) explained the role of schools as a setting for health promotion and intervention studies. These sources have a special emphasis on intervention programs and the effectiveness of oral health education in different groups.

The second cluster includes prevention studies and standard oral health indicators. The source of this group is the study by Carvalho et al. on the prevention of dental caries and oral health related indicators (18). Another one is Oral Health Surveys: Basic Methods, published in two editions in 1997 and 2013. It is recognized as one of the main and global sources for the assessment of oral health. This cluster introduces preventive studies and the use of oral health indicators at the core of research.

In the third cluster, the article by Yalcinkaya and Atalay relates to the promotion of oral health knowledge in specific groups, such as specific problems (28). This cluster examines the treatment and prevention of gum diseases, as well as raising public awareness in different communities.

9. Bibliographic coupling in oral health education

The bibliographic analysis of articles on oral health education was done in VOSviewer. This analysis, through examining the shared references (Bibliographic Coupling), showed that the articles were divided into 10 clusters based on bibliographic links. Overall, out of 335 articles, 141 with at least 5 citations were selected as the key articles for analysis **(Figure 8).**

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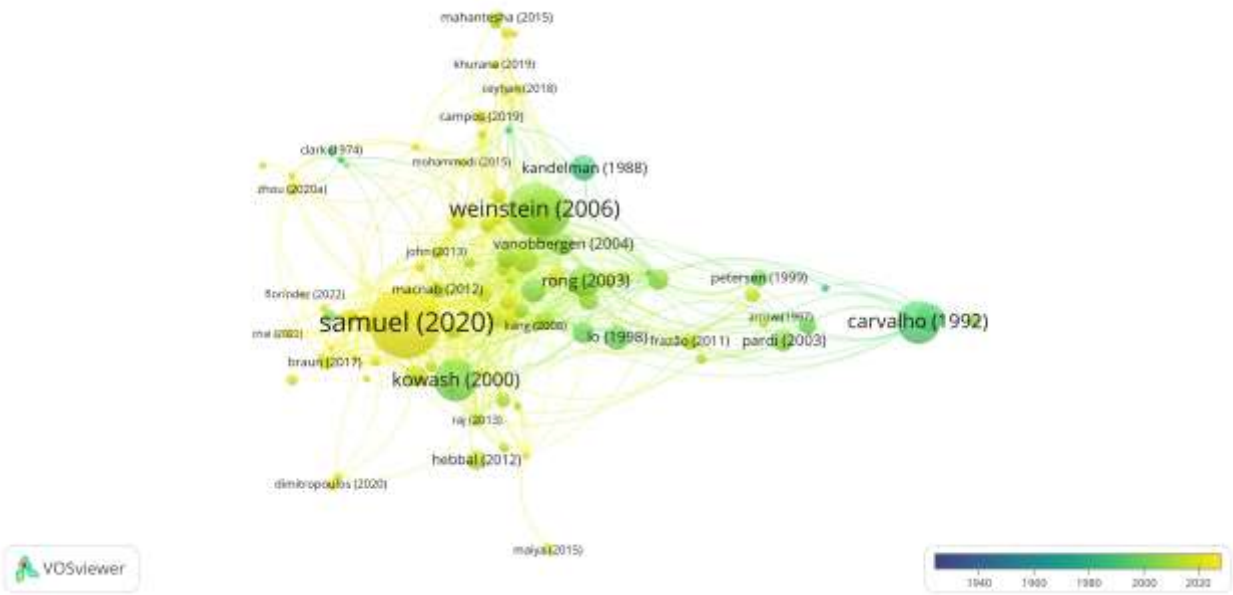

Figure 8. Bibliographic map (threshold = 5; showing 141 of 335)

The clusters were divided into several major groups in terms of common articles and references. For example, articles in cluster 1 emphasized preventive interventions and educational programs to improve oral health. Studies such as those by Kowash (2000) et al. (22) and Lo (1998) et al. (24) in this group evaluated oral health education programs and showed their effectiveness in reducing dental caries.

In cluster 2, several works of research such as Kandelman (1988) et al. (29) and Mohammadi (2015) et al. (30) focused on clinical and therapeutic interventions. These articles used experimental methods and public health interventions to promote oral health in different communities. The key articles in this cluster show that different countries have adopted different therapeutic interventions according to their cultural and social conditions.

Cluster 3 includes studies on health promotion and evaluation of oral health indicators. The article by Samuel (2020) et al. (19) was recognized as an important source in this cluster with a focus on the evaluation of oral health and design of health promotion programs. Articles in this group often use standard indicators such as DMFT to examine oral health status in different groups.

Cluster 4 includes studies on prevention of dental caries and use of methods based on oral health indicators such as fluoride and sealants. The articles by Carvalho et al. (1992) (18) in this group are known as seminal studies in preventing dental caries.

Cluster 5 consists of behavioral studies and the role of education in improving children's oral health. Articles by Weinstein et al. (2006) (20) and Rong et al. (2003) (31) in this cluster have examined the role of parents, schools, and focused education in changing children's health behaviors.

Cluster 6 focuses on clinical studies and evaluation of preventive interventions. Studies by Pienihäkkinen et al. (2002) (32) have examined the role of preventive interventions and their impact on reducing the prevalence of oral diseases.

Cluster 7 includes studies conducted in developing countries. For example, Saied-Moallemi (2009) et al. (33) addressed the challenges of promoting oral health in these countries and presented strategies to improve health status.

Clusters 9 and 10 contain limited articles that address specific topics such as small community health and local oral health interventions.

Discussion

The present bibliometric analysis provides a comprehensive mapping of global research trends in children's oral health education from 1929 to 2023, revealing a clear paradigm shift from clinical and treatment-focused studies (pre-1990s, dominated by DMFT indices and fluoride applications) to prevention-oriented, behavioral, and educational interventions (post-2010, with emphasis on school-based programs, parental involvement, and health behavior change). This evolution aligns with broader public health priorities, as evidenced by high-citation clusters around keywords such as "health education", "tooth brushing", "parents", "prevention", and "program evaluation". This bibliometric finding directly supports the growing body of scientific literature advocating for a proactive, rather than reactive, approach to oral health management. This shift reflects a growing global consensus, as emphasized in recent public health literature, that addressing the root causes of oral diseases requires moving beyond traditional restorative approaches toward integrated, population-level preventive strategies (34, 35).

Countries such as the United States (43 publications, 606 citations) and India (42 publications, 573 citations) have led this transition through high-impact, theory-informed studies. For instance, Samuel et al. (2020) (19), now cited over 528 times (as of February 2026),demonstrated the long-term efficacy of school-based interventions (monitored brushing, sugar restriction, and education) in low-socioeconomic children, reflecting the

field's growing focus on scalable, equity-driven approaches. Similarly, contributions from Brazil, China, and Iran highlight culturally adapted, low-cost strategies suitable for resource-limited settings. The leadership of these nations in publishing high-impact studies is primarily driven by robust research funding, established academic infrastructure, and sustained governmental support—a constellation of factors identified in bibliometric literature as the principal determinants of both scientific output growth and global research influence (36).

Scientific evidence strongly supports this shift toward educational and theory-based interventions. Recent systematic reviews and meta-analyses confirm that programs grounded in behavioral theories (e.g., Health Belief Model, Theory of Planned Behavior, Social Cognitive Theory) yield superior outcomes compared to traditional knowledge-based education. Nazari et al. (2025) reported significant improvements in self-efficacy, oral health knowledge, attitudes, behaviors, dental plaque reduction, and periodontal health among children and adolescents (37). Likewise, Shirahmadi et al. (2024) found substantial increases in twice-daily toothbrushing, daily flossing, and OHI-S scores three months post-intervention in elementary students using theory-based programs (38). These empirical findings, extensively cited within the bibliometric landscape, underscore the critical role of theoretical frameworks in designing effective and sustainable oral health education programs, as they demonstrate how theory-driven interventions are more likely to produce enduring changes in knowledge, attitudes, and behaviors rather than short-term shifts in clinical indicators alone. By situating our bibliometric results within this theoretically informed perspective, our study highlights that the most influential contributions in the field are those that explicitly operationalize behavioral and educational models and translate them into practical, context-sensitive strategies for oral health promotion.

These empirical findings reinforce the thematic clusters identified in our analysis—specifically the prevalence of behavioral/educational approaches and preventive strategies—and highlight the persistent value of standardized indicators, such as DMFT and plaque index, in evaluating program impact. Our comparative review reveals a significant correlation between a region’s economic infrastructure and its research focus: high-income nations are increasingly utilizing advanced digital health tools, while low- and middle-income countries concentrate on pragmatic, community-based solutions and low-cost educational materials. To

address these disparities and bridge the gap between resource-constrained and high-resource environments, targeted international collaboration is essential. This requires not only the sharing of evidence-based tools and technologies but also conducting rigorous comparative studies to examine the cross-cultural effectiveness of these diverse interventions.

Ultimately, while current research trajectories are often dictated by national developmental levels and resource availability, this study underscores that global oral health promotion can be significantly elevated through knowledge exchange and wider access to scientific data. By fostering international interaction, the field can move toward a more standardized, yet context-sensitive, framework for designing effective oral health programs that address the unique needs of children across all economic settings.

Study Limitations and Strengths: The use of only one database (Scopus) may have limited access to all relevant articles and publications in different fields. In addition, the temporal focus of analysis was on articles up to 2023, and newer research or recently published articles may not have been included in this study. This study relied on bibliographic pairs and quantitative data and did not perform a deeper analysis of the content of articles. The language limitation is significant, as non-English articles, though available in the database, may have been less reviewed or not fully represented in the final analysis.

Conclusion

This bibliometric analysis unequivocally demonstrates a global paradigm shift towards prevention and education in children's oral health, a transition strongly supported by accumulating scientific evidence for theory-based interventions. Nevertheless, critical gaps persist, including limited long-term sustainability of behavioral improvements beyond 12–24 months, insufficient equity in access for underserved and low-socioeconomic populations, and underutilization of innovative digital tools (e.g., mobile apps and teledentistry) for scalable education. To advance the field and maximize real-world impact, future research should prioritize longitudinal studies to rigorously assess the durability of intervention effects over extended periods; systematic reporting and comparative evaluation of theoretical frameworks and validated measurement tools (e.g., DMFT/dmft, plaque/gingival indices, self-reported behavior scales); cross-cultural and socioeconomic comparative designs to identify adaptable, context-specific strategies; greater community and family engagement in program

co-design and implementation; and integration of emerging technologies to enhance reach, engagement, and cost-effectiveness. By addressing these priorities through enhanced international collaboration and evidence-based innovation, the field can more effectively contribute to reducing oral health inequities and supporting lifelong healthy behaviors in children worldwide.

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