Implementation strategies for integration of evidence-based caries management approach in dental education: A scoping review

Bahareh Amir Hosseini

Faculty of Dental Medicine and Oral Health Sciences

McGill University, Montreal

August 2024

A thesis submitted to McGill University in partial fulfillment of the requirements of the degree of master.

Table of Content

Abstract

Introduction:

Despite the introduction of the Evidence-Based Caries Management (EBCM) approach over two decades ago, its integration into dental education and practice has been slow and inconsistent. For instance, a significant proportion of dental schools still adhere to outdated clinical practices, with surveys indicating only a minority of institutions have fully adopted EBCM principles. The lack of up-to-date dental education has been identified as a significant barrier to EBCM's implementation among dental practitioners. While there is existing literature related to the implementation of the EBCM approach in dental education, there is a lack of a comprehensive knowledge synthesis review on this topic. This scoping review aims to fill this gap by mapping and summarizing the evidence on implementation strategies of EBCM in dental education and identifying knowledge gaps.

Objectives:

This scoping review aims to map and summarize the evidence on implementation strategies of EBCM in dental education and to identify knowledge gaps.

Methodology:

Following the Joanna Briggs Institute manual and Arksey and O'Malley framework, an experienced librarian developed a comprehensive search strategy covering four databases, including MEDLINE (Ovid) and Scopus. Grey literature and hand searches through relevant journals and websites supplemented the retrieval. All study designs from 1990 to the present, excluding those conducted in private practices or focused on dental practitioners outside of educational settings, were included to focus on educational impacts. No language restrictions were applied. Two independent reviewers performed data screening, selection, and extraction.

Qualitative content analysis was adopted for data analysis, and Proctor's framework and ERIC taxonomy were used for data synthesis. Findings were reported following PRISMA-ScR guidelines, with most presented in tabular format.

Results:

Following the review of 1463 titles and abstracts and 50 full-text sources, 27 studies were included in this scoping review. These studies were published between 2007 and 2022 and were conducted at dental faculties in North and South America, Europe and Asia. Study designs included case studies, randomized control trials, non-randomized experimental studies, observational and mixed-method studies. Key findings indicated that caries detection and risk assessment were the most prevalent components of EBCM integration. According to the ERIC taxonomy, twelve implementation strategies were identified, including 'local consensus discussions', 'continuous and dynamic training', 'informing local opinions', 'ongoing supervision', 'training the trainers', 'changing record systems'. Only 15 out of 27 included studies reported the implementation outcomes. These outcomes were related to the acceptance and adoptability of the EBCM implementation (e.g., consensus on cariology curricula; participants' enhancement in the knowledge, decision-making and performance; participants' satisfaction, perceptions, reaction, and readiness).

Conclusions:

This review indicates that the integration of the EBCM approach into undergraduate dental education is in its early stages. The studies reporting the implementation of the full EBCM approach are limited. Various strategies, including local consensus discussions, continuous and dynamic training, and continuous supervision have been used to implement the approach. Future studies should focus on evaluating implementation outcomes; including fidelity, patient-related

outcomes, and sustainability to better understand the impact of integrating the EBCM in dental education.

RÉSUMÉ

Introduction :

Bien que l'approche de la gestion des caries fondée sur les données probantes ait été introduite il y a plus de deux décennies, son intégration dans la formation des futurs dentistes, y compris la pratique dentaire a été lente et incohérente. Par exemple, une proportion significative des écoles dentaires continue à adopter des pratiques cliniques obsolètes, avec peu d'établissements qui ont intégralement adopté les principes de de la gestion des caries fondée sur les données probantes. L'absence de mise à jour des programmes d'enseignement dentaire a été identifiée comme un obstacle majeur à la mise en œuvre de cette approche parmi les praticiens dentaires. Bien qu'il existe une littérature sur la mise en œuvre de la gestion des caries fondée sur les données probantes dans l'enseignement dentaire, il manque une synthèse complète des connaissances sur ce sujet. En identifiant et en synthétisant les évidences sur les stratégies de mise en œuvre de la gestion des caries fondées sur les données probantes dans les milieux d'éducation dentaire

Objectifs :

Cette revue vise à cartographier et à résumer les données probantes sur les stratégies de mise en œuvre de la gestion des caries fondées sur les données probantes dans les milieux d'éducation dentaire et d'identifier les lacunes dans les connaissances à ce sujet.

Méthodologie :

En suivant le manuel de l'Institut Joanna Briggs et le cadre d'Arksey et O'Malley, un bibliothécaire expérimenté a élaboré une stratégie de recherche exhaustive couvrant quatre bases de données, dont MEDLINE (Ovid) et Scopus. La littérature grise et des recherches manuelles dans des revues et sites web pertinents ont complété la recherche. La recherche a été réalisée dans les bases de données depuis l'origine en 1990 jusqu'à nos jours, à l'exclusion de celles menées en cabinets

privés ou centrées sur des praticiens dentaires hors du cadre éducatif, ont été inclus pour se concentrer sur les impacts éducatifs. Aucune restriction linguistique n'a été appliquée. Deux examinateurs indépendants ont effectué le dépistage, la sélection et l'extraction des données. Une analyse qualitative de contenu a été adoptée pour l'analyse des données Nous avons synthétisé les données en suivant le cadre conceptuel de Proctor ainsi que la taxonomie d'ERIC. Les résultats sont rapportés sous la forme des tableaux et selon les lignes directrices PRISMA-ScR des revues de portée.

Résultats :

Après l'examen de 1463 titres et résumés, ainsi que de 50 sources en texte intégral, 27 études ont été incluses dans cette revue exploratoire. Ces études, publiées entre 2007 et 2022, ont été menées dans des facultés dentaires en Amérique du Nord et du Sud, en Europe et en Asie. Les types d'études comprenaient des études de cas, des essais randomisés contrôlés, des études expérimentales non randomisées, des études observationnelles et des études mixtes. Les principales conclusions indiquent que la détection des caries et l'évaluation des risques étaient les composantes les plus répandues de l'intégration de la gestion des caries fondée sur les données probantes. Selon la taxonomie ERIC, douze stratégies de mise en œuvre ont été identifiées, dont 'les discussions de consensus local', 'la formation continue et dynamique', 'l'information des opinions locales', 'la supervision continue', 'la formation des formateurs' , 'le changement des systèmes de dossiers'. Seules 15 des 27 études incluses ont rapporté les résultats de la mise en œuvre. Ces résultats concernaient l'acceptation et l'adoptabilité de la mise en œuvre de la gestion des caries fondée sur les données probantes (par exemple, consensus sur les programmes de cariologie ; amélioration des connaissances, de la prise de décision et des performances des participants ; satisfaction, perceptions, réactions et préparation des participants).

Conclusions :

Cette revue indique que l'intégration de l'approche de gestion des caries fondée sur les données probantes dans l'enseignement dentaire de premier cycle est à ses débuts. Les études rapportant la mise en œuvre complète de cette approche sont limitées. Diverses stratégies, y compris les discussions de consensus local, la formation continue et dynamique, et la supervision continue ont été utilisées pour mettre en œuvre cette approche. Les études futures devraient se concentrer sur l'évaluation des résultats de la mise en œuvre, y compris la fidélité, les résultats liés aux patients, et la durabilité, pour mieux comprendre l'impact de l'intégration de la gestion des caries fondée sur les données probantes dans l'enseignement dentaire.

Mots-clés : Enseignement dentaire, Éducation en cariologie, Gestion des caries, Dentisterie fondée sur des preuves, Science de la mise en œuvre.

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to my supervisors, Dr. Svetlana Tikhonova and Dr. Pascaline Kengne Talla, for their invaluable guidance, unwavering support, and encouragement throughout the entire process of writing this thesis. Their expertise in cariology and Implementation science, patience, and constructive feedback have been instrumental in shaping this research project and enhancing its quality.

I am also grateful to the members of my thesis committee, Dr. Nora Makansi, and Dr. Nathalie Morin for their insightful comments, valuable suggestions, and scholarly input. Their expertise in scoping reviews, cariology and dental education has enriched my understanding of the subject matter and strengthened the academic rigor of this thesis.

I am thankful to Martin Morris, the dedicated librarian, was particularly helpful in developing the search strategy and navigating the various databases and Joon Kwon who helped us in data selection and extraction.

I extend my appreciation to the faculty of dental medicine and oral health sciences at McGill university for providing me with access to resources, scholarships, facilities, and research opportunities that have facilitated the completion of this thesis.

My heartfelt thanks go to my family, my parents, and my sister, for their unwavering love, encouragement, and understanding throughout this journey. Their constant support and

encouragement have been a source of motivation and inspiration, and I am deeply grateful for their sacrifices and beliefs in my abilities.

Lastly, I would like to express my appreciation to all my friends, colleagues, and peers who have provided moral support, encouragement, and camaraderie during challenging times. Their friendship and companionship have made this academic endeavor a more fulfilling and enriching experience.

DEDICATION

To my parents, Amir Amirhosseini and Farzaneh Moslemizadeh, your unconditional love and motivation have shaped me into the person I am today, and I dedicate this thesis to you as a token of my deepest appreciation and love. Your guidance, wisdom, and encouragement have been instrumental in helping me navigate the challenges and celebrate the successes along the way.

To my sister, Atiyeh Amirhosseini, may this thesis serve as a tribute to your unwavering support and belief in my dreams, and may it be a remark to the profound impact you have had on my life's journey. Thank you for being my rock, my confidant, and my greatest cheerleader. This achievement is as much yours as it is mine.

CONTRIBUTION OF AUTHORS

Bahareh Amir Hosseini: MSc candidate, developed the aims, wrote the research protocol, screened, and extracted the data, performed the content analysis, and wrote the thesis.

Svetlana Tikhonova: Faculty lecturer, McGill University, involved in research question development, protocol development, management, and supervision of the project, guiding the data screening and extraction, data analysis, data interpretation and reviewing thesis writing.

Pascaline Kengne Talla: Assistant Professor, McGill University, involved in the design of this thesis including research question and protocol development. She has guided the data screening, extraction, analysis, and interpretation, she has critically reviewed the thesis writing.

Martin Morris: Librarian, McGill university, involved in running searches in appropriate bibliographic databases, designing the search strategies, providing citations for all search results, and providing guidance on searching the grey literature.

Joon Kwon: Undergrade dental student, McGill university, involved in abstracts and titles screening and full text reviewing.

LIST OF FIGURES AND TABLES

LIST OF ABBREVIATIONS

Core Cariology Curriculum (CCC)

Consolidated Framework for Implementation Research (CFIR)

Evidence-Based Caries Management (EBCM)

Expert Recommendations for Implementing Change (ERIC)

Implementation Science (IS)

Plan-Do-Study-Act (PDSA)

Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA)

Scoping Review (ScR)

World Health Organisation (WHO)

1. Introduction

For many years, oral diseases have remained a significant public health concern, resulting in various disparities in oral health that have significant personal, societal, and economic impacts (1, 2). Numerous individuals worldwide and in Canada suffer from oral diseases, with untreated permanent tooth caries disease being the most common (1, 3). These oral diseases are more common and disproportionately impact marginalized groups (3-5). The World Health Organization (WHO) estimates that dental caries incur total costs of around 700 billion USD worldwide, covering both direct and indirect expenses (4).

A new perspective has emerged, defining dental caries as a non-communicable, multifactorial, and dynamic disease related to the dysbiosis in tooth biofilm, replacing the traditional view of it as an infectious disease (6). Due to improved knowledge and understanding of the caries disease process and its causes, new innovative methods have replaced traditional techniques for detecting and treating dental caries (7). Modern and generally non-invasive Evidence-Based Caries Management (EBCM) has been proven effective in controlling dental caries (8). This approach focuses on early detection of caries lesions and uses strategies based on assessing individual risk factors for managing the disease (9). The main goal of this approach is to control the caries disease process, maintain tooth structure integrity, promote dentin and pulp health, and preserve tooth function and appearance, all without causing harm. Although there is compelling data endorsing preventive and non-invasive methods for managing caries (10), there exists a notable variation between the guidelines and the current practices operated by dentists in clinical settings (11).

Future dentists must prioritize the development of effective caries management methods and skills to bridge the gap between research findings and clinical practice (12). During their undergraduate dentistry curriculum, dental students need to gain evidence-informed knowledge and skills for

caries diagnosis and treatment to apply them in their future clinical practices (12). However, many dental schools still prioritize training dental students to excel in surgical caries treatment procedures (13, 14). As a result, dental students graduate without sufficient knowledge and abilities to effectively handle the caries disease, adopting a philosophy of minimal intervention. Thus, effective implementation strategies are crucial to successfully introduce EBCM into dental education and clinical practice.

There is some evidence available about the application of the EBCM in dental education settings. For example, at Indiana University, the teaching of cariology underwent a significant change (11). Instead of a few scattered lectures, a comprehensive caries management program was implemented. In addition, there are instances where caries risk assessment tools (15) and modern caries diagnostic criteria have been employed in different dental schools (16, 17). However, this evidence often focuses on a single aspect of EBCM or the experience of a particular university. In general, there is insufficient evidence available that maps and summarizes the strategies used to overcome obstacles and focus on facilitators in order to improve the success of implementing of EBCM approach in dental educational settings.

To our knowledge, no reviews or review protocols published on the Open Science Framework (OSF) or the International Prospective Register of Systematic Reviews (PROSPERO) related to the EBCM implementation in dental schools. Hence, this study aimed to address this knowledge gap and to determine the strategies to enhance the implementation of EBCM in dental educational settings. Moreover, the study will describe the individuals involved in EBCM implementation, the actions taken, target populations, and measured outcomes.

2. COMPREHENSIVE REVIEW OF THE RELEVANT LITERATURE

2.1 Dental caries disease and its burden

Oral disorders have remained the most prevalent conditions worldwide (1, 4, 18-20). Globally, chronic oral diseases impact almost 3.5 billion people, with three out of every four people who are affected living in middle-income nations (4). Among the major oral disorders, untreated dental caries of permanent teeth is the most widespread, with around 2 billion instances worldwide (4). In Canada, the prevalence of caries disease reaches about 60% in children and adolescents and rises to 100% in adults and elderly people. The mean number of caries, missing, or filled permanent teeth (DMFT) progressively increases across different age groups: from 2.5 (12-19 years old), to 6.9 (20-39 years old), to 12.3 (40-59 years old), and to 15.7 DMFT at the age of 60-79 years (21, 22).

Dental caries as the other non-communicable diseases imposes an unequal burden on different demographic backgrounds (23). It is more prevalent and affects disproportionally marginalized groups of population including people with a low-income, disabled, elderly, children, refugees, indigenous people, and new immigrants, resulting in a huge health and economic burden, and affecting people's quality of life and well-being (3-5). These disparities in oral health status are unfair and unavoidable. They are generated by a complex network of interconnected social determinants such as income, social status, employment, working conditions, education, and literacy. Many of these factors are largely beyond people's direct control (4).

Dental caries, as a chronic and preventable disease, progresses with a slow rate in most contemporary populations and this is attributed to the availability of fluoride products (e.g., toothpastes, fluoridated water, etc.) (2, 24). Nevertheless, all teeth once erupted are prone to caries throughout an individual's lifetime which not only involve the primary teeth but also can affect the crowns and roots of the permanent teeth (25).

The primary attempt to explain the etiology of caries disease was undertaken more than a century ago when the "Chemoparasitic Theory" was presented by Miller in 1881 (25). By following this theory dental caries was perceived and categorized as an infectious disease the presence of which necessitated removal of all infected or affected hard tissues. This was called 'specific plaque hypothesis' (26). This understanding of caries created the basis for surgical approaches in the 19th - 20th centuries dictating the management of carious lesions (25). However, this concept was superseded by the fact that the sole existence of dental biofilm is not sufficient to cause dental caries (26).

Nowadays, multiple other factors such as diet, saliva, exposure to fluoride, oral hygiene behaviours and genetics have been determined to influence this dynamic disease process along with several demographic and psycho-social factors (2, 25). Therefore, dental caries is now considered as "a biofilm-mediated, diet modulated, multifactorial, non-communicable, dynamic disease resulting in net mineral loss of dental hard tissues. It is determined by biological, behavioural, psychosocial, commercial, and environmental factors" (6).

Various bacteria with different physiological characteristics inhabit dental biofilm and form a 'micro-ecosystem'. The composition of the initial dental biofilm is determined by a set of hereditary and environmental factors, but type and proportion of the microorganisms are modified by environmental parameters (26). Bacteria in tooth biofilm make acid by breaking down carbohydrates in food. This lowers the pH of the area, which makes the tooth substance less mineralized (demineralization). At the same time compensatory mechanisms related to saliva and presence of fluoride can lead to the tooth minerals gain (remineralization) (24). It is important to note that demineralization and remineralization processes are in equilibrium when there is a balance between the protective factors such as fluoride, appropriate salivary flow, oral hygiene,

etc. and the pathologic factors such as cariogenic bacteria, fermentable carbohydrates, lack of fluoride exposure, etc. (27, 28).

Frequent consumption of fermentable dietary carbohydrates fosters the growth of an acidogenic and aciduric microflora within the tooth biofilm, disrupting the equilibrium of commensal microorganisms in the areas where biofilm stagnates on the tooth surfaces for extended periods of time. This process in a tooth biofilm names bacterial dysbiosis. (9). The acidogenic bacteria are highly competitive and could dominate on other species in the biofilm providing that the conditions are optimal (29). The dental caries disease process is initiated when the physiological equilibrium between tooth substance and microbial biofilms is disrupted, and demineralisation process prevails.

When in a long run the compensatory mechanisms causing remineralization are unable to reverse the demineralization process, the net result would be formation of carious lesions (9, 12).

The caries lesions are the consequence of the disease process and is an implication of caries disease progression. Based on increasing severity and the extent of tooth destruction, dental caries is considered as a continuum with presentations ranging from sub-clinical changes to dentinal frank cavitated lesions (2). In fact, further development of the carious lesion causes a non-cavitated lesion to progress into a cavitated one if left untreated (30). The caries disease process can be controlled if protective factors related to caries (e.g., plaque control, fluoride exposure, low frequency of sugars consumption, normal saliva secretion) prevail on the pathological factors. This process shows the importance of patient classification based on their caries risk which allows the implementation of better management approaches (31).

As discussed earlier, dental caries cannot be considered as a classical infectious disease but is a multifactorial and dynamic process (32). Thus, caries is not eradicated by removing the associated

pathogens unless the contributing factors are addressed. The focus for caries management has drifted towards less aggressive procedures, emphasizing the disease prevention (33). Last, dental caries is not an infectious disease, and could be best managed by the novelle approaches including behavior modifications as an integral part (9).

2.2 Caries management approaches: from history to present time

Historically, dentists operating as surgeons administered restorative dental care by means of symptomatic treatment, excision of diseased tissue and 'extension for prevention' approach (7). Traditional restorative care included removing all carious tissue, including demineralized, discolored dentine, to get rid of microorganisms, stop the progression of cavities, and make sure that restorative materials like dental amalgam would stay in place (9). This outdated approach was based on the notion that caries is solely an infectious illness which requires invasive treatment through complete removal of all demineralized 'contaminated' tissues (26, 34). The lack of understanding that led to this misconception was two-fold: first, the failure to recognize that the caries process and carious lesions are distinct yet interconnected; and second, the incorrect belief that once a lesion had formed and the tooth was "infected," it was necessary to completely eliminate the bacteria in order to stop the process (26, 35).

In contrast, contemporary management of caries disease focuses on the following principles: health maintenance, early detection, caries risk assessment, control of modifiable risk factors on a patient level, application of appropriate non-invasive, micro-invasive and minimally invasive (as a last resort) procedures on a tooth surface level, and monitoring the disease based on patients' caries risk status. All these measures are aimed to control caries disease process, prevent lesion progression, protect the pulp-dentine complex, restore the tooth's function, form and esthetics if needed (7, 9). This contemporary paradigm is called *evidence-based caries management* which

emphasizes preventive and conservative approaches while employing patient-centered risk-based disease management strategies (28, 36, 37).

It is widely acknowledged that the most effective way to manage dental caries is by customizing the approach based on a thorough assessment of the individual's risk factors. This assessment provides detailed information about the specific factors that contribute to the patient's risk of developing future cavities. It also helps in creating a plan to encourage healthy habits through behaviour modification and determining the frequency of oral evaluations. Evaluating the likelihood of dental caries in each patient is a crucial foundation for addressing dental caries disease in patients of all age groups (27).

For active non-cavitated carious lesions, it is best to avoid minimally restorative procedures and instead opt for non- or micro-invasive strategies. Non-invasive treatments do not physically eliminate dental hard tissue but instead rely on measures such as managing dietary habits, biofilm reduction, application of topical fluorides to regulate mineral balance. Micro-invasive treatments involve the removal of the dental hard tissue at a microscopic level, typically through an etching process, as seen in sealing or infiltration methods. Minimally invasive restorative procedures involve the removal of a small quantity of dental hard tissues which are not mineralizable, preserving healthy and mineralizable tissues and achieving appropriate physical seal when placing restoration (38). Currently, restorative care is seen as the final resort particularly in cases where the tooth has cavities that cannot be effectively cleaned (29). Furthermore, after a tooth is restored, a continual process of replacing restorations begins, eventually resulting in tooth loss after a certain number of cycles. This phenomenon is referred to as the "re-restorative cycle" or "tooth death spiral" (39, 40).

2.3 The gap in research and practice

Clinical guidelines (28, 41) and strong evidence for preventive and non-invasive methods for treating caries (10, 42-48) are both available. However, there is a big difference between what dentists around the world actually do and what the guidelines say they should do (11, 49-53). Since the year of 1995, when evidence-based dentistry concept was introduced, dentists have not yet widely adopted the treatments for caries disease accordingly (25). The gap between evidence-based guidelines and daily dental practices may be attributed to various factors, including insufficient cariology education for dental students and an overemphasis on restorative procedures in dental schools (54). This could also be a result of difficulties in dissemination of information and communication across public health, practise, research, and education. One of the greatest obstacles for implementing non-operative and preventative therapies for caries management could be dentists who "Don't Know, Can't Do, or Won't Change" (25). It is crucial to bridge the gap between research and practise with an aim to bring the novel concepts into use to enhance patient care (11) It has been shown that the transition to evidence-based healthcare demands a more flexible attitude from medical personnel (7). Dentists require support in making the shift to an evidence-based, risk-informed, preventative strategy in caries management and dental schools must integrate evidence-based ideas into their curricula (12). The implementation of these changes involves a paradigm shift and requires practical strategies such as incentives, new reimbursement plans for non-restorative procedures, and training experienced clinical instructors (14). Ultimately, the data in favour of non-surgical therapies for dental caries and the significance of risk-based management should be made known to policymakers and other stakeholders (55).

2.4 Role of dental education

Dentistry currently emphasizes technical interventions over preventive and disease-controlling services. This is due to factors such as financial issues and the reimbursement systems, the way

dentistry is taught in pre-graduate education, and the public perspective, which is influenced by the emphasis of the craftsmanship approach in the dentistry field (12). It should be noted that caries scripts, which are 'mental images of different caries representations', mainly form during undergraduate dental education. These scripts take place automatically and without the aid of logical reasoning, concentrating instead on recognition of patterns and knowledge gained from previous situations (12). It is evident that the pre-graduate dental education is essential for the establishment for every dentist's distinct caries script. Consequently, the importance of dental schools playing a vital part in ensuring that their pre-graduate dental students have access to up-to-date, evidence-based caries scripts as well as an in-depth knowledge of the scientific principles underlying caries management decisions (12, 56).

2.5 Facilitators and barriers of implementation

Prior research has delineated the factors influencing positively or negatively the integration of Evidence-Based Caries Management approach in dental education.

2.5.1 Facilitators

The factors that contribute to the successful implementation of these approaches (12, 13, 57) include:

- endorsement from deans and other administrative staff of dental faculties

- existence of a written cariology curriculum

 - inclusion of non-invasive caries management credits in undergraduate dental clinical education

- the enthusiasm of students towards preventive treatments

 - the widespread use of technology and the availability of a global network in dentistry field.

2.5.2 Barriers

Conversely, various obstacles may arise on several levels which according to Consolidated Framework for Implementation Research (CFIR), can be described in different levels as outer, inner and individual contexts (58). The CFIR provides a realistic approach for conducting a systematic assessment of potential barriers and facilitators. Knowing this information can help guide implementation tactics and modifications, as well as explain outcomes (58).

The inconsistency in the use of clinical guidelines and terminology within caries management by dental practitioners and educators is an example of an outer context determinants (33). Inner context barriers, such as the dissemination of out-of-date ideas, variations in course content and grading systems, failure to place enough focus on non-surgical prevention and care, and a dearth of time and credits for cariology amplify this issue (12, 13, 34, 57). Lack of proper training and guidance of clinical instructors is another major obstacle on the individual level for the integration of EBCM in dental schools (12, 34).

2.6 Implementation science, definition, and main characteristics

2.6.1 Implementation science

The awareness about stakeholders, facilitators and obstacles and evaluation of the uptake strategies are the curtail elements of the implementation of any health-related innovation (59, 60). The implementation science (IS) is the area of research that focusing on this topic. Implementation science is defined by Eccles et al. as: "the scientific study of methods to promote the systematic uptake of research findings and other evidence-based practices into routine practice, and, hence, to improve the quality and effectiveness of health services and care" (61). In other words, to enhance the translation of EBCM into practice, there should be applied specific frameworks and scientific methods, awareness about stakeholders, facilitators and obstacles, and evaluation of the uptake strategies (59, 60).

2.6.2 Knowledge to action model

Given the complexity of translating knowledge into practice, several models have been proposed, one of which is the "Knowledge to Action" proposed by Dr. Ian Graham and his colleagues. This conceptual framework comprises two distinct components: the 'knowledge creation' and 'action cycle' which involves numerous steps (62). (Fig.1)

The first phase which resembles a funnel is a process that involves the creation of knowledge or research in healthcare. It consists of several phases, each with its own unique characteristics. The first phase is knowledge inquiry. This component will help to identify the knowledge gaps and the research questions for the next steps.

The second phase is knowledge synthesis, which involves the aggregation of existing knowledge. This process involves the identification, appraisal, and synthesis of relevant studies or information.

The third phase is to produce the knowledge tools or products, such as articles, practice guidelines, decision-aids, and care pathways. These tools aim to present knowledge in clear, concise, and user-friendly formats, providing explicit recommendations to influence stakeholders' actions. Knowledge producers can tailor their activities to the needs of potential users, tailoring research questions to address user problems, and customize the message for different audiences. They can also customize the method of dissemination to better reach the intended users (62, 63).

The knowledge action cycle part is a dynamic and ongoing process that encompasses the practical utilization or execution of knowledge. It comprises a sequence of stages, with each one being influenced by the phases of knowledge formation. These phases are derived from an analysis of planned-action theories, frameworks, and models (62, 63).

Planned action involves intentionally orchestrating change in groups of different sizes and contexts. More than 60 theories of this nature have been recognized, characterized by the following stages (62):

1. Identifying a problem that needs addressing

2. Identifying, reviewing, and selecting relevant knowledge or research (e.g., practice guidelines or research findings)

3. Adapting the knowledge or research to the local context

4. Assessing barriers to using the knowledge

5. Selecting, tailoring, and implementing interventions to promote the use of knowledge (implementation of the change)

6. Monitoring knowledge use or application

7. Evaluating the outcomes of using the knowledge

8. Sustaining ongoing knowledge use

The initial stage of the knowledge cycle entails the identification of a problem or issue that warrants attention, followed by a thorough search for pertinent research. The subsequent stage entails customizing the information to the specific local circumstances, evaluating any obstacles, strategizing, and implementing interventions, overseeing the utilization of knowledge, and ascertaining the effects of knowledge application (62, 63).
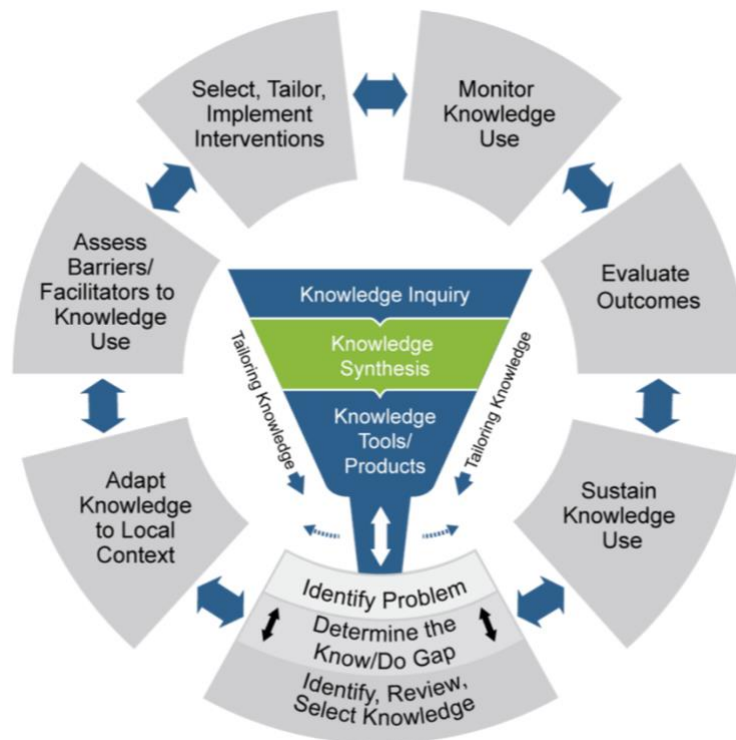
Figure 1. Knowledge to Action model

2.6.3 Implementation strategies

Proctor et al. define implementation strategies as 'approaches or procedures to enhance any innovation's adoption, sustainability, and dissemination' (64). The implementation strategies are social complex interventions, dealing with processes occurring in organizational, interpersonal, and community settings (65, 66). One of the primary obstacles to accurately describe, operationally define and quantifying implementation strategies is their notable complexity. Implementation strategies must be able to handle the uncertainties and specificities of different service systems, sectors, care practices, and contexts as well as the challenge of educating and supporting people. It was reported in the literature that implementation strategies informed by the barriers and enablers are more suitable to achieve the expected results and improve the success of the implementation

efforts (67), and the different characteristics of interventions that affect their feasibility should also be considered (68).

A wide variety of implementation options exist, each with its own unique characteristics. Discrete, multifaceted, and blended are some possible descriptions of them (69). *Discrete strategies* refer to specific and easily identifiable implementation steps such as reminders, instructional meetings, disseminating educational materials, notifying local opinion leaders, changing professional tasks, and reminding healthcare workers. These strategies entail a single procedure or activity (64, 69, 70). *Multifaceted implementation strategies* employ two or more discrete strategies as an optimal approach for effectively implementing clinical innovations (e.g., training combined with technical help and clinical reminders or audit and feedback) (71). The phrase "*blended strategy*" is used to describe situations when various distinct techniques are combined and presented as a standardized or branded implementation intervention, targeting numerous levels and obstacles to change (70).

By adapting implementation strategies to particular organizational attributes, one can efficiently mitigate the impact of influencing factors and enhance the adoption of evidence-based practices (72). Primarily in 2012, Powell et al. (70) composed a list of 68 distinct strategies and their definition which were organized into 6 different domain using systematic review approach. Later in 2015, the previous compilation was refined by a panel of stakeholders with expertise in implementation science and clinical practice using modified-Delphi process. This activity has produced Expert Recommendations for Implementing Change (ERIC) which offers a total of 73 distinct implementation strategies (73).

2.6.4 Proctor Framework

Several taxonomies about IS exist in the literature, including Cochrane EPOC (74), Behavioural change techniques (75) as well as Proctor et al. framework (64).

In order to investigate implementation strategies empirically, Proctor et al. explored key concepts for naming, defining, and specifying implementation strategies, which are prerequisites to measure them (64).

Here is a description of these concepts:

Name it: Implementation strategies must be named or labeled to be measured effectively preferably using language consistent with existing literature. However, issues such as homonymy, synonymy and instability can cause confusion in the social and health science lexicon. This complicates the process of conducting empirical literature searches, meta-analyses, and the development of evidence to support particular strategies in particular contexts (64, 70, 76).

Define it: Conceptually defining implementation strategies helps explain its components and ensures consistency with other publications. Each component of complex strategies must be conceptually distinguished in order to be defined. Pre-existing taxonomies provide conceptual definitions that facilitate comprehension (64, 70, 75, 77).

Specify it: To facilitate comparisons, rateability across multiple dimensions, and discussion at a common level of granularity, strategies must be described in a manner that ensures clarity. Essentially, operational definitions are required. This will facilitate the comparison and evaluation of implementation strategies, thereby reducing the burden on researchers and other stakeholders in the implementation process to determine which strategies are most suitable for their objectives (64). In order to better specify and identify the strategies we should know about the actors of the process, actions which were done, targets of the actions, temporality, and dosage of the action as well as the outcomes of the action. These terminologies will be defined bellow:

a*) The actor*: The term 'actor' refers to a stakeholder who delivers an implementation strategy, which can include payers, administrators, intervention developers, consultants, personnel, providers, clients, patients, and community stakeholders (64, 78).

b) *The action*: Implementation strategies involve active verb statements indicating actions, steps, and behavior sequences. These should be behaviorally defined beforehand to compare with actual actions. Examples include plan-do-study-act (PDSA) cycles, audit, and feedback, where the name indicates actions and definitions expand upon them (64, 79).

c) *The action's target*: Implementation strategies are sophisticated and impacted by the specific target they intend to affect. The majority of relevant conceptual models address many socioecological levels, including system, community, organisation, person, and policy levels, reflecting the complex nature of implementation strategies. It is essential to specify the target population in order to emphasise the application of the strategy and indicate where and how the results should be assessed (64, 80, 81).

d) *Temporality*: The order of strategy use can be crucial in some cases, such as boosting providers' motivation to learn new treatments. It was reported that strategy use should include start and stop dates, dosage changes, and address challenges of repeated data collection and analysis (64, 82).

e) *Dose:* Like the intervention or treatment literature discusses the concept of dose, implementation strategies can also vary greatly in terms of dosage or intensity. Research on the efficacy and comparative efficacy of implementation strategies should include the measurement of dosage. It is crucial to determine the minimum dosage needed to provide the most potent effect in this field. Therefore, it is important to establish and disclose in advance specific information regarding the dosage or intensity of implementation strategies, such as the duration of interaction with an

external facilitator, the timing and level of training, or the frequency of audit and feedback (64, 83).

f) *Implementation outcome* affected: Proctor et al. proposed a taxonomy of implementation outcomes, including acceptability (satisfaction with various aspects of the innovation), adoption (uptake; utilization; initial implementation; intention to try), appropriateness (perceived fit; relevance; compatibility; suitability; usefulness; practicability), feasibility (actual fit or utility; suitability for everyday use, practicability), fidelity (delivered as intended; adherence; integrity; quality of program deliver), implementation cost (marginal cost; cost-effectiveness; and cost-benefit), penetration (level of institutionalization; spread; service access), and sustainability (maintenance; continuation; durability; incorporation; integration; institutionalization; sustained use; routinization) with their definition. Training or educational strategies to promote fidelity, financial and policy strategies to ensure feasibility and acceptability, and consensus meetings to ensure stakeholder acceptance are all examples of strategies that may be designed to achieve these objectives (84).

g) *Justification*: Researchers should justify their intervention plans by identifying needs, challenges, and facilitators through assessments, theory, research literature, or informal brainstorming. They should justify their strategies with applicable theory, empirical facts, or pragmatic rationale. The relevance of theory is contested, although theoretical justification can illuminate change mechanisms, improving strategy effectiveness (64, 85, 86).

2.7 What is known in the literature about the EBCM implementation in dental education?

There is shortage of evidence available on the implementation and evaluation of the EBCM approach in dental schools in the macro-, meso- and micro-levels. Several surveys have been done regarding the current state of cariology teaching in different faculties (87-90). Authors discovered

that contemporary cariology principles are being used in dental education, although not in all schools. It was also found that cariology education is not appropriately integrated into clinical training.

Other study surveys were conducted on the knowledge, attitudes and behaviours of students regarding EBCM (91-93). According to these surveys, undergraduate dental students demonstrated an adequate theoretical knowledge of minimally invasive dentistry and positive attitudes toward its practice while dental clinical education did not show an appropriate adherence to guidelines or to the standardized processes. The majority of respondents agreed that more caries prevention training and practices should be provided in dental education settings. Positive reactions toward expanding preventive dental education suggests that students are receptive to modern caries treatment and prevention methods. However, these studies do not provide details on how the approach was implemented or how students' knowledge of minimally invasive dentistry was assessed.

The European Organisation for Caries Research (ORCA) and the Association for Dental Education in Europe (ADEE) collaborated to produce a standardised and evidence-based Core Curriculum in Cariology (CCC) starting in 2010 (94). The approach was meticulously designed to establish consensus and occurred following a Europe-wide survey of Dental Schools that confirmed both the necessity and the level of interest (95). A total of 75 dental academics from 28 countries participated in the workshop (96). These countries include Austria, Belgium, Croatia, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Ireland, Lithuania, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Spain, Sweden, Switzerland, Turkey, UK, Brazil, Colombia, and the USA (96). The ultimate curriculum that resulted from an extensive workshop in Berlin had 5 domains: The knowledge base; Risk

Assessment, Diagnosis and Synthesis; Decision Making & Preventive Non-Surgical Therapy; Decision Making & Surgical Therapy; and Evidence-based Cariology in Clinical & Public Health Practice. The CCC has been localised and adapted in other countries such as US, Canada, Colombia, Spain, and Caribbean region (97-101).

Moreover, there are several papers describing how certain dental faculties have implemented individual EBCM components (16, 17). One paper describes the implementation of the entire approach in undergraduate dental education settings (102). One systematic review paper aimed to investigate the undergraduate dental students' performance in detecting and staging caries and assessing activity using visual inspection (103). Additionally, there exists a scoping review on minimum intervention dentistry for children; however, this review does not encompass studies conducted in educational settings nor does it specifically address implementation methodologies (104).

2.8 Study rational

There are several research papers related to the implementation of EBCM approach in dental schools exist (16, 17, 102, 105). In addition, the adaption to the local context by developing CCC and identifying barriers and facilitators was carried out in several countries (96-101). At this moment, we are in the fifth stage of 'knowledge to action' model (62),where we should identify, review and select the knowledge related to the implementation strategies of the innovation. It is apparent that there is a lack of evidence mapping and summarizing implementation strategies to assist in overcoming barriers and leveraging facilitators for EBCM adoption in dental educational settings. Therefore, *the aim of this scoping review* is to address this gap and to consolidate and map the existing literature on the implementation of EBCM in dental education settings. This study will help to identify the most optimal implementation strategies and knowledge gaps to enhance

the adoption of EBCM in dental education. Moreover, this study will allow us to identify the existing EBCM implementation outcomes that have been used to promote change.

2.9 Study objectives

This study aimed four main objectives. Firstly, we aimed to identify the specific components of EBCM that have been integrated into dental education. *Secondly*, we investigated the implementation strategies utilized to enhance the adoption of EBCM within dental education programs. *Thirdly*, our focus extended to discerning the stakeholders involved in and targeted by the implementation of EBCM in dental education, shedding light on the individuals and groups engaged in this process. *Fourthly*, we sought to understand the outcomes associated with the implementation strategies of EBCM in dental education.

3. BODY OF THE THESIS

3.1 Methodology

Manuscript

Implementation strategies for integration of evidence-based caries management approach in dental education: A scoping review protocol

Bahareh Amirhosseini1, Pascaline Kengne Talla*1, Svetlana Tikhonova1

1Faculty of Dental Medicine and Oral Health Sciences, McGill University, Montreal, Quebec, Canada

Corresponding author: Pascaline Kengne Talla

Email address: pascaline.kengnetalla@mcgill.ca

Registration link in OSF: https://doi.org/10.17605/OSF.IO/2F6MW

Abstract

Objective: To map and summarize the existing literature on implementation strategies of Evidence Based Caries Management approach in the context of dental education and identify knowledge gaps.

Introduction: Despite its introduction over 20 years ago, integration of the Evidence-Based Caries Management approach into dental education and practice remains slow. This situation can be explained by several barriers at different levels in the inner and outer contexts. In order to enhance the adoption, implementation, and sustainability of this approach in dental education, more effective strategies are needed.

Inclusion criteria: We will include all study designs on the implementation strategies of any components of evidence-based caries management approach. Publications dating from1990 to

present will be included. Studies conducted in non-educational settings will be excluded. There will be no language limitation applied.

Methods: The scoping review will be conducted based on the Joanna Bridge Institution manual for evidence synthesis and Arksey and O'Malley framework. A comprehensive search strategy will be developed by an expert librarian in several databases including Medline, Scopus, Embase and Eric. Gray literature and hand searching will be fulfilled. Consultation with the authors of primary studies will be conducted if needed. Two independent reviewers will screen, select and extract retrieved studies. Descriptive quantitative and qualitative data analysis will be performed. We will use tables and narrative summary approach to present the results.

Introduction

Dental caries is a global non-communicable disease that affects billions of individuals of all ages (1). According to the World Health Organisation, about 3.5 billion people suffer from oral diseases (2). Subsequently, around 700 billion US dollars are spent globally on direct and indirect dental caries-related care (2). Despite the decline in caries prevalence in the last decades worldwide, this disease remains a substantial public health problem resulting in several oral heath inequalities with significant personal, social, and economic consequences (1, 3).

The traditional paradigm of dental caries as an infectious disease has been replaced by an updated perspective which defines it as "a biofilm-mediated, diet modulated, multifactorial, non-communicable, dynamic disease resulting in net mineral loss of dental hard tissues. It is determined by biological, behavioural, psychosocial, and environmental factors" (4). Hence, the conventional methods of diagnosing and treating dental caries have been modified by novel and alternative approaches due to a better understanding of the caries disease process and its etiology (5). A substantial body of evidence have demonstrated that the contemporary and mostly non-invasive

Evidence-Based Caries Management (EBCM) is effective in controlling caries disease, rather than relying solely on surgical treatments (6). This approach is focusing on early caries detection and risk-based non-surgical and surgical (only when necessary) caries management. It aims to prevent caries and preserve the tooth structure longitudinally, ensuring dentine-pulp health, teeth function, and aesthetics without causing harm (7). While there is strong evidence supporting preventive and non-invasive approaches of caries management (8), there is a significant gap between evidence-based guidelines and how dentists operate in clinical practice (9).

It has been stated that undergraduate dental education is essential for the establishment of every future dentists' caries management practices to close the gap between research evidence and clinical practice (10). By receiving evidence-based knowledge and skills within undergraduate dental curriculum, dental students are gaining appropriate experience in caries diagnosis and treatment that they will be applying later in their real-life clinical practice (10). Nevertheless, it has been reported that many dental schools continue preparing dental students for being mostly proficient in surgical caries management (11, 12). Consequently, dental students graduate without adequate knowledge and skills to appropriately manage the caries disease using minimum intervention philosophy. Thus, there is a need for more efficient and effective implementation strategies to bring EBCM into dental education and later to clinical practice.

Previous studies have described the barriers and enablers for the implementation of EBCM in dental education. Among the facilitators to implementation of this approach are the support from deans and other administrative staff of dental faculties, presence of a written cariology curriculum, presence of non-invasive caries management competencies in clinical education, interest of students in preventive treatments, the ubiquity of technology and accessibility to global network (10). On the other hand, several barriers may occur at multiple levels such as the "outer" and

"inner" contexts, and the individual level. Example of outer context determinants is the lack of consistency in how dental professionals and educators use clinical guidelines and terminology across caries management. This problem is compounded by inner context barriers including teaching outdated concepts, lack of uniformity in education and classification systems, insufficient emphasis on non-surgical management and prevention, and lack of time and credits for Cariology (6, 13). Furthermore, inadequate education and training of clinical instructors has been identified as significant individual domain barrier to the implementation of EBCM in dental education (10, 13).

According to Proctor et al. (14) implementation strategies refer to methods or techniques to improve the implementation, sustainability and spread of any innovation. There is a heterogeneity of the implementation strategies in their nature and types. They can be discrete, multifaceted, active and passive (15). As per the Expert Recommendations for Implementing Change (ERIC) provides 73 unique implementation strategies categorized in 6 domains (16, 17). Among examples of discrete implementation strategies are the distribution of instructional materials, alerting local opinion leaders, modifying professional duties, or reminders for healthcare professionals (14, 15). It was suggested that for proper implementation of clinical innovations a combination of two or more discrete strategies should be applied which are called 'multifaceted strategies' (e.g., education, clinical reminders, audit and feedback) (14, 15). Customized implementation strategies tailored to specific organizational characteristics can effectively address factors influencing implementation and improve the utilization of evidence-based practices (18).

There is some evidence on the implementation of the EBCM approach in dental education settings. For example, at Indiana University in the US, the approach to teaching cariology was reportedly transformed from a few lectures scattered throughout the curriculum to a cariology management

program that is integrated into all four years of the curriculum, focusing on critical thinking and problem-solving, and including both didactic and clinical components (9). Another example is the reorientation of undergraduate curriculum in the University of Adelaide, Australia, to ensure that minimally invasive dentistry and patient centered care are taught to both students and instructors (19). Furthermore, there are some examples of the utilization of caries risk assessment tools (20) and contemporary caries diagnostic approaches at various dental schools (21, 22). However, these adaptations are often focused on a single component of EBCM or a single university's experience. Overall, there is a lack of evidence mapping and summarising the implementation strategies to help overcome barriers and leverage enablers to enhance the EBCM implementation success in dental educational settings. To our knowledge, to date, there are no reviews or review protocols published on this subject in Open Science Framework or Prospero. Therefore, the aim of this scoping review is to address this gap and to consolidate the existing literature on the implementation of EBCM in dental education settings. This study will help to identify the most optimal implementation approaches to enhance the adoption of EBCM in dental education. We will specifically examine EBCM approach, strategies and outcomes that were used to promote change.

Review questions:

1) Which components of EBCM have been incorporated in dental education settings?

2) Which implementation strategies were used to improve the adoption of EBCM in dental education?

3) Which stakeholders have been involved and targeted with the implementation of EBCM in dental education?

4) Which outcomes related to the adoption of the EBCM implementation strategies in dental education were reported?

Eligibility criteria

Participants

Studies will be considered for inclusion if they involve dental students, dental residents, dental hygiene students, dental school educators and clinical instructors. In addition, we will include studies involving other stakeholders such as researchers, curriculum planners and deans of dental schools. Studies in which the participants are only dental practitioners working in private practice will be excluded.

Concept

We will be looking for the implementation strategies of the EBCM approach in dental education. This approach includes detection and assessment of caries lesions from their early stages, assessment of individual's caries risk, patient-centred risk-based non-invasive and invasive caries management, risk-based follow-ups (23).

The invasive interventions such as restoration placement is the last option for the lesions that are cavitated and non-cleansable (24). There is a clear understanding that invasive treatments would enter the tooth in re-restoration cycle that eventually may lead to the tooth loss (25). In this review, the implementation strategies related to the main components of the EBCM approach, the type and the nature of EBCM-related outcomes will be included. We will consider single and multi-faceted implementation strategies.

Context

This review will consider studies which were conducted in any dental educational settings like dental schools/colleges/faculties (private and public) and there is no limitation for language.

Types of sources

This scoping review will include the following study designs: quantitative designs (e.g., randomized and non-randomized controlled trials, before and after studies, prospective and retrospective cohort studies, case-control studies, cross-sectional studies, case series and individual case reports), qualitative designs (e.g., descriptive interpretative, ethnography, phenomology, grounded theory, case study, etc.) and mixed-methods studies (e.g., concurrent, sequential, etc.). Moreover, any knowledge synthesis that meet the inclusion criteria will also be included. Gray literature materials such as white papers, dissertations, conference abstracts (International Association for Dental Research, American Association of Dental Education, European Organisation for Caries Research), conference presentations, dental organisations' websites' materials, course materials will also be considered for inclusion in this scoping review.

Methods

The proposed scoping review will be carried out in accordance with Arksey and O'Malley standard methods (26) and the Joanna Briggs Institute (JBI) manual for evidence synthesis (27). We have registered the protocol on Open Science Framework.

Search strategy

The search strategy will aim to locate both published and unpublished studies and it will be developed with the support of an experienced librarian. An initial limited search of Medline has been undertaken to identify articles in the topic. The text words contained in the titles and abstracts of relevant articles, and the index terms used to describe the articles will be used to develop a full search strategy for Medline (Appendix I). The search strategy, including all identified keywords

and MeSH terms, will be adapted for each included database and information source such as Medline, Scopus, Embase and Eric. Gray literature sources will include Grey matters and relevant websites. Peer Review of Electronic Search Strategies (PRESS) (28) criteria will be followed, and search strategy will be updated based on suggestions from the research team and the librarian.

The reference list of all included sources of evidence will be screened for additional studies. Also, hand search technique will be caried out in several relevant journals in the field such as Journal of Dental Education and Caries Research Journal. Studies published in any language will be included. Studies published since 1990 will be included as it is the date for introduction of evidence-based caries management.

Study/Source of Evidence selection

Following the search, we will collate and upload all identified papers into EndNote 20 (Clarivate Analytics, PA, USA) and duplicates will be removed. Following a pilot test, titles and abstracts will be then screened by two independent reviewers for assessment against the inclusion criteria for the review. Potentially relevant sources will be retrieved in full, and their citation details imported into Covidence. Two independent reviewers will screen and select the full text of selected studies against the inclusion criteria. We will record reasons for excluded studies, and we will report them in scoping review. Any disagreements between the reviewers at each stage of the selection process will be resolved through discussion, or with a consultation with a third reviewer. We will update the search during data synthesis to identify any new, relevant papers. The results of the search and the study inclusion process will be reported in the review following the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-analyses extension for scoping review (PRISMA-ScR) flow diagram (29).

Data Extraction

Two independent reviewers will extract data using a data extraction tool developed by the research team (Appendix II). This extraction grid is developed based on Proctor et al. (14) framework of categorizing implementation strategies based on actors, actions and target, and the standard template of data extraction in Covidence. We will extract some details including: i) characteristics of the included studies (year, country, study design); ii) attributes of the educational setting and their aim; iii) components of the caries management approach which were implemented; iv) specifications of the strategies for implementation; v) Outcome of the implementation vi) the impact of implementation from authors point of view and their conclusion. The data extraction tool will be revised during the process if necessary, and any deviation from the protocol will be presented in the scoping review. Any disagreements that arise between the reviewers will be resolved through discussion, or with an additional reviewer. If needed, authors of papers will be contacted to request missing or additional data.

Data Analysis and Presentation

A narrative synthesis will be carried out to summarize the data according to our research questions. At first, we will conduct descriptive quantitative data analysis (using frequencies, proportions). We will describe the characteristics of the studies including year of publication, country of origin, number, and roles of participants. Secondly, we will use a deductive approach to perform qualitative content analysis based on Proctor et al. framework (30). The following components of Proctor et al. (14) framework will be used to describe the implementation strategies: actors, actions, target, and implementation outcomes. In the case of the authors do not mention the name of the implementation strategy, we will match the strategy description with the ERIC classification (16, 17). The qualitative content analysis will follow 3 steps: a preparation phase from an inductive approach; the organizing phase where we will become more familiar with the data and develop an

open coding of data followed by Proctor framework; and, finally, the categorization phase aiming

to map the results to address the research questions. Further categorization will be done based on

components of EBCM. Tables and diagrams will be used to report the results.

References

1.   Pitts NB, Mayne C. Making Cavities History: A Global Policy Consensus for Achieving a Dental Cavity-Free Future. JDR Clin Trans Res. 2021;6(3):264-7.
2.   Global oral health status report: towards universal health coverage for oral health by 2030. Geneva: World Health Organization; 2023.
3.   Selwitz RH, Ismail AI, Pitts NB. Dental caries. The Lancet. 2007;369(9555):51-9.
4.   Machiulskiene V, Campus G, Carvalho JC, Dige I, Ekstrand KR, Jablonski-Momeni A, et al. Terminology of Dental Caries and Dental Caries Management: Consensus Report of a Workshop Organized by ORCA and Cariology Research Group of IADR. Caries Res. 2020;54(1):7-14.
5.   Pitts NB. Are we ready to move from operative to non-operative/preventive treatment of dental caries in clinical practice? Caries Res. 2004;38(3):294-304.
6.   Schwendicke F, Doméjean S, Ricketts D, Peters M. Managing caries: the need to close the gap between the evidence base and current practice. Br Dent J. 2015;219(9):433-8.
7.   Banerjee A, Frencken JE, Schwendicke F, Innes NPT. Contemporary operative caries management: consensus recommendations on minimally invasive caries removal. Br Dent J. 2017;223(3):215-22.
8.   Urquhart O, Tampi MP, Pilcher L, Slayton RL, Araujo MWB, Fontana M, et al. Nonrestorative Treatments for Caries: Systematic Review and Network Meta-analysis. J Dent Res. 2019;98(1):14-26.
9.   Fontana M, Zero D. Bridging the gap in caries management between research and practice through education: the Indiana University experience. J Dent Educ. 2007;71(5):579-91.
10.   Baelum V. Caries management: technical solutions to biological problems or evidence-based care? J Oral Rehabil. 2008;35(2):135-51.
11.   Tikhonova S, Girard F, Fontana M. Cariology Education in Canadian Dental Schools: Where Are We? Where Do We Need to Go? J Dent Educ. 2018;82(1):39-46.
12.   Tikhonova S, Jessani AA, Girard F, Macdonald ME, Souza G, Tam L, et al. The Canadian Core Cariology Curriculum: Outcomes of a national symposium. J Dent Educ. 2020;84.
13.   Banerjee A. 'MI'opia or 20/20 vision? British Dental Journal. 2013;214(3):101-5.
14.   Proctor EK, Powell BJ, McMillen JC. Implementation strategies: recommendations for specifying and reporting. Implement Sci. 2013;8:139.
15.   Kirchner JE, Smith JL, Powell BJ, Waltz TJ, Proctor EK. Getting a clinical innovation into practice: An introduction to implementation strategies. Psychiatry Res. 2020;283:112467.
16.   Powell BJ, Waltz TJ, Chinman MJ, Damschroder LJ, Smith JL, Matthieu MM, et al. A refined compilation of implementation strategies: results from the Expert Recommendations for Implementing Change (ERIC) project. Implement Sci. 2015;10(1):21.

17.   Powell BJ, McMillen JC, Proctor EK, Carpenter CR, Griffey RT, Bunger AC, et al. A compilation of strategies for implementing clinical innovations in health and mental health. Med Care Res Rev. 2012;69(2):123-57.

18.   Waltz TJ, Powell BJ, Fernández ME, Abadie B, Damschroder LJ. Choosing implementation strategies to address contextual barriers: diversity in recommendations and future directions. Implement Sci. 2019;14(1):42.

19.   Kaidonis JA, Skinner VJ, Lekkas D, Winning TA, Townsend GC. Reorientating dental curricula to reflect a minimally invasive dentistry approach for patient-centred management. Aust Dent J. 2013 Jun;58 Suppl 1:70-5.

20.   Lee GHM, McGrath C, Yiu CKY. Evaluating the impact of caries prevention and management by caries risk assessment guidelines on clinical practice in a dental teaching hospital. BMC Oral Health. 2016;16(1):58.

21.   Escobar A, Rojas-Gualdrón DF, Velez LF, Santos-Pinto L. Developing diagnostic skills from preclinical dental education: Caries detection and assessment using e-learning assisted practice. J Dent Educ. 2022;86(10):1382-9.

22.   Luz PB, Stringhini CH, Otto BR, Port AL, Zaleski V, Oliveira RS, et al. Performance of undergraduate dental students on ICDAS clinical caries detection after different learning strategies. Eur J Dent Educ. 2015;19(4):235-41.

23.   Fontana M, Zero DT. Assessing patients' caries risk. J Am Dent Assoc. 2006;137(9):1231-9.

24.   Schwendicke F, Frencken J, Innes N. Clinical Recommendations on Carious Tissue Removal in Cavitated Lesions. Monogr Oral Sci. 2018;27:162-6.

25.   Brantley CF, Bader JD, Shugars DA, Nesbit SP. Does the cycle of rerestoration lead to larger restorations? J Am Dent Assoc. 1995;126(10):1407-13.

26.   Arksey H, O'Malley L. Scoping Studies: Towards a Methodological Framework. Int J Soc Res Methodol. 2005;8:19-32.

27.   Peters M, Godfrey C, McInerney P, Munn Z, Trico A, Khalil H. Chapter 11: Scoping Reviews. 2020.

28.   McGowan J, Sampson M, Salzwedel DM, Cogo E, Foerster V, Lefebvre C. PRESS Peer Review of Electronic Search Strategies: 2015 Guideline Statement. J Clin Epidemiol. 2016;75:40-6.

29.   Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. Ann Intern Med. 2018;169(7):467-73.

30.   Pollock D, Peters MDJ, Khalil H, McInerney P, Alexander L, Tricco AC, et al. Recommendations for the extraction, analysis, and presentation of results in scoping reviews. JBI Evid Synth. 2023;21(3):520-32.

3.2 Results

3.2.1 Search results

After conducting a search on MEDLINE (Ovid), Scopus, Embase (Ovid), and Eric databases, a total of 1455 relevant papers were found. Additionally, citations and hand searches yielded 21 articles. No results were found when searching the Grey Matters website. Moreover, we found 16 abstracts presented at the European Organization for Caries Research (ORCA) congresses and one webinar provided by the American Dental Education Association (ADEA) that discussed the implementation experiences of four dental schools in the context of Evidence-Based Caries Management. We obtained this information by searching the American Dental Education Association (ADEA) website, Journal of Dental Education and Caries Research Journal.

After eliminating 18 duplicate papers, we examined the titles and abstracts of 1458 articles and identified 50 relevant studies. Upon performing a thorough examination of the full text studies, a total of 23 research articles were identified for final inclusion. The results are shown in PRISMA Flow Diagram (Figure 1).
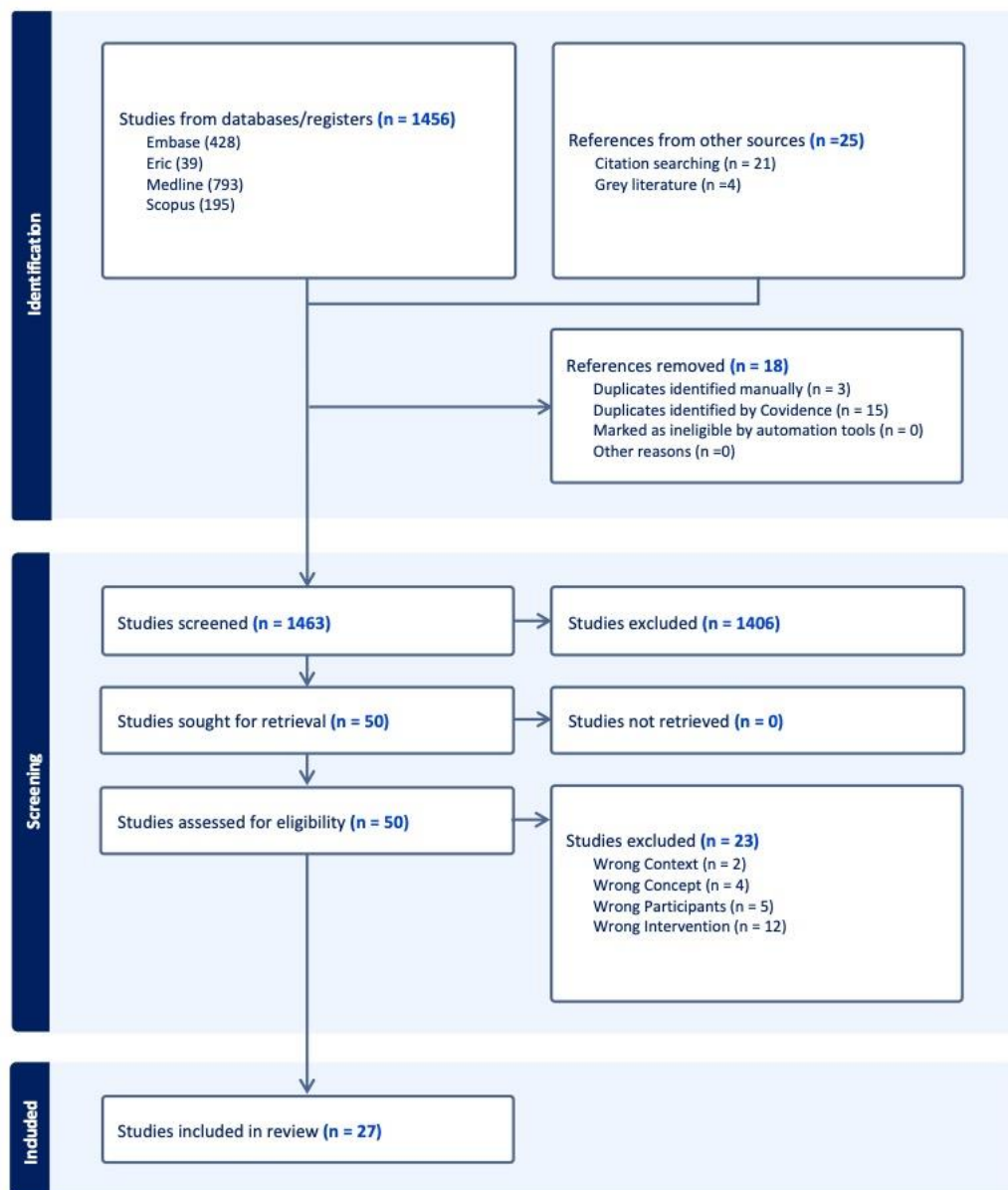
Figure 2. PRISMA Flow Diagram

3.2.2 Characteristics of the included studies (Table 1)

Included papers were published between 2007 to 2022 years. The studies' locations were: the United States [n=14; (99, 102, 106-112)], Brazil [n=3; (17, 113, 114)], Colombia [n=2; (16, 100)], Canada (101), Spain (98), Norway (115), Belgium (116), Malaysia (117), Caribbean countries (97) and European countries (96). In addition, one systematic review was undertaken in Brazil although

data sources included Egypt, Switzerland, Finland, the United Kingdom, Germany, and the United States (103).

The included study designs were case studies [n=6], non-randomized experimental studies [n=5], randomized control trials [n=3], systematic review [n=1], cohort study [n=1], quality assurance study [n=1], retrospective time series study [n=1], validation study [n=1], mixed-methods study [n=1] and cross-sectional [n=1] study. Regarding the consensus studies, we were not able to assign a study design to them as they cannot fit into traditional study designs [n=6; (96-101)]. Most studies were carries out at dental faculty settings.

Several included studies aimed to develop a comprehensive cariology curriculum that was customized to the specific circumstances of the country where the study was conducted (96-101). Conversely, the remaining studies sought to evaluate the implementation of the whole Evidence-Based Caries Management Approach or it's specific components (16, 17, 102, 103, 105-118).

Table 1. Characteristics of the included studies

Author	Year	Settings	Country	Study design
Fontana and Zero	2007	Indiana University	United States	Case study
Diniz et al.	2010	Araraquara Dentistry School	Brazil	Non-randomised experimental study
Schulte et al.	2011	Dental faculties	Europe	Consensus
Teich et al.	2012	Case Western Reserve University	United States	Cohort study
Jablonski-Momeni et al.	2012	Philipps University of Marburg	Germany	Randomised controlled trial
Luz et al.	2014	Federal University of Rio Grande do Sul	Brazil	Randomised controlled trial
Chaffee and Featherstone	2014	University of California student dental clinic	United States	Retrospective time series
Martignon et al.	2014	Colombian Dental Schools	Colombia	Consensus
Goolsby et al.	2016	Virginia Commonwealth University	United States	Quality assurance
Fontana et al	2016	Dental faculties	United States	Consensus
Young et al.	2017	University of the Pacific	United States	Validation study
Alves et al	2018	Federal University of Santa Mari	Brazil	Randomised controlled trial
Turchiello et al.	2018	Dental faculties	Brazil,Egypt,Switzerland,Finland, United Kingdom,Germany,USA	Systematic review
Abreu-Placeres et al.	2020	Dental faculties	Carribean region countries (Dominican Republic, Puerto Rico, Jamaica, Trinidad, Tobago)	Consensus
Ribeiro et al.	2020	University of Florida	United States	Case study
Tikhonova et al.	2020	Dental faculties	Canada	Consensus
Cortés-Martinicorena et al.	2021	Dental faculties	Spain	Consensus
Pishipati et al.	2021	Penang International Dental College	Malaysia	Non-randomised experimental study
Booth et al.	2021	University of Michigan	United States	Cross sectional study
Yount et al.	2022	Faculty of Dentistry, University of Oslo	Norway	Mixed-methods study
Carvalho et al.	2022	UCLouvain, dental faculty	Belgium	Non-randomised experimental study
Escobar et al.	2022	Dental faculties	Colombia	Non-randomised experimental study
DiLuigi et al.	2022	Tufts University School of Dental Medicine	United States	Non-randomised experimental study
Jan Mitchell	2022	The Dental College of Georgia System	United States	Case study
Fontana et al.	2022	University of Michigan	United States	Case study
Andrea Ferreira Zandona	2022	Tufts School of Dental Medicine	United States	Case study
Nascimento et al.	2022	University of Florida college of dentistry	United States	Case study

3.2.3 Evidence-based caries management approach

Studies focusing on Core Cariology Curriculum (CCC)

Six of the twenty-seven studies (22 %) were concerned with developing a CCC. One of them was focusing on the development of the European Core Cariology Curriculum (96) while five other studies were based on the European model but modified it to fit their particular country's needs (96-101). In Europe, Colombia, US, Spain and Caribbean region (96-100), there were workshops and meeting discussions while in Canada a national symposium was held (101). The participants worked in groups to review the 5 domains of the curriculum (knowledge base; risk assessment, diagnosis, and synthesis; treatment decision making, nonsurgical management; treatment decision making, surgical management; and evidence based Cariology in clinical and public health practice to determine major and supporting competences, and also to assign different levels such as being competent, having knowledge or being familiar to the competencies.

Studies focusing on whole EBCM approach or its components

Seven included studies incorporated all of the components of EBCM, including caries detection and diagnosis, risk assessment, preventative and non-surgical therapies, surgical treatments, and follow-ups (102, 106, 110, 112, 115, 116). Seven studies focused solely on caries detection (16, 17, 103, 108, 113, 114, 117), whereas five studies focused exclusively on caries risk assessment (105, 107-109, 111). Two studies focused on the implementation of both caries detection and risk assessment (112).

3.2.4 Description of implementation strategies based on Proctor framework components

Actor

Regarding the individuals responsible for implementing the plan, all the studies featured cariology educators, lecturers, or faculty members in the departments of Cariology and/or Restorative dentistry.

Actions

The strategies deployed to improve the success of EBCM implementation are varied and described as followed: workshops and symposiums (96-101); lectures and didactic trainings (16, 103, 105, 106, 112, 118); PowerPoint presentations (110); simulated trainings (103, 112, 114); e-learning and digital learning tools (16, 103, 113, 114, 117); audience response rate (115); inverted classroom (116); teledentistry (108, 112); guidelines and articles (111); hands-on laboratories

(102); active learning strategies (102); providing a feedback (112); using electronic forms (16, 102, 112); faculty calibration (16, 102, 109).

By analyzing the actions in relation to the Expert Recommendations for Implementing Change (ERIC) list (70, 73), we can classify them into 12 distinct implementation strategies: 'conduct educational meetings'; 'develop educational materials'; 'create a learning collaborative'; 'conduct local consensus discussions'; 'continuous training'; 'dynamic training'; 'dissemination of educational materials'; 'informing local opinions'; 'ongoing supervision'; 'training the trainers'; 'changing record systems' and 'reminding clinicians'.

Target

Regarding the target population in the included papers, twelve studies exclusively focused on undergraduate students (16, 17, 103, 108, 110, 112-114, 116-118), seven papers focused on dental instructors (96-101, 109) and six papers included both students and faculty members (102, 105-107, 111, 112). There were two papers that examined dental students at the undergraduate level and dental hygiene students (112, 115).

Outcomes

The studies conducted with the goal of creating a CCC (96-101) resulted in a consensus documents tailored to their particular circumstances and requirements. For the other articles (16, 17, 102, 103, 105-118), the reported outcomes were: an enhancement in the knowledge, decision-making and performance of the target groups; the participants' satisfaction, perceptions, reaction, and readiness. We compared the outcomes provided in the selected studies with the Taxonomy of Implementation Outcomes proposed by Proctor (84). The implementation outcomes of the CCC studies can be classified as 'adoption' (96-101). In addition, the studies which identified the participants' satisfaction, perceptions, reaction, and readiness (108, 110, 114-117), the implementation strategy is determined as 'acceptability'. However, for the remaining studies (16, 17, 102, 103, 105-107, 109, 111-113, 118), no outcomes were provided on the implementation strategy itself. They just reported about the performance of target groups.

The categorization of the results data according to the EBCM approach or its components, Proctor framework and ERIC list is presented in Table 2.

Table 2. EBCM and Proctor framework

	Proctor Framework			Implementation strategy (ERIC)	Reported outcomes	Implementation outcomes (Proctor)
	Actors	**Target**	**Actions**			
Core Cariology Curriculum (n=6)	-Faculty members - Cariology and behavioural science experts -Dental researchers, curriculum implementation and health professions education experts	- Deans, clinic directors and cariology educators	- Workshops - Symposium	-Conduct educational meetings -Conduct local consensus discussions -Develop educational materials -Create a learning collaborative	- Consensus on Core Cariology Curriculum	Adoption
Whole EBCM approach (n=7)	-Cariology educators and faculty members	-Undergraduate dental and dental hygiene students - Full- and part-time faculty members	- Inverted classrooms -Fluoride and new instruments laboratories -In-house and workshop trainings for faculty members - Hands-on laboratories for visual caries detection -In-class analysis of problems and review cases -Switch to electronic forms for following up the students -Audience response rate	- Dynamic training - Ongoing trainings - Inform local opinions	-Students' performances, learning engagement, satisfaction, feedback, and timely approach	Acceptability
Caries detection (n=7)	-ICDAS experts and researchers -Cariology educators	-Undergraduate dental students	- E-learning and digital learning tools -Classroom lectures and training using dental images - Simulated lab trainings	- Ongoing supervision - Distribute educational materials	-Students' performances, readiness and reproducibility	

	-Supervisors with previous experience in ICDAS		- Providing feedback	-Train the trainers strategy -Change record systems		
Caries risk assessment (n=5)	-Faculty members -Cariology educators	-Undergraduate dental students -Faculty members	-Faculty calibration -Handing out guidelines - Group discussions - Teledentistry -PowerPoint presentations by students	-Remind clinicians	-Students' performance, perception, and compliance	
Caries detection & Caries Risk Assessment (n=2)	-Cariology instructors and educators	-Undergraduate dental students	-Using colored forms and electronic health records for caries risk -A course for hygiene students on ICDAS diagnosis -Caries detection classes in deferent departments (geriatric, pediatric and medically complex patients) -Case discussions and simulations	-Remind clinicians -Change the record systems -Make training dynamic -Conduct ongoing trainings	-Not reported	

4. Comprehensive scholarly discussion of all the findings

Our scoping review synthesized the literature on implementation strategies of evidence-based caries management approach in dental education. Through a comprehensive search, we identified 27 studies that addressed various aspects of EBCM implementation. Using the classification of data based on the EBCM approach and the examination of implementation strategies using the Proctor et al. framework, we obtained a thorough comprehension of the actions undertaken, actors who initiate the implementation, target groups, and reported outcomes. The results of the scoping review revealed a wide range of EBCM implementation activities applied in dental schools from 'conduct local consensus discussions' to 'continuous and dynamic training' and 'ongoing supervision'.

While there are other scoping reviews on implementation methods in oral health settings (119) or evidence-based practice in other areas (120), this study is the first scoping review explicitly focused on implementation strategies for evidence-based caries management approach in dental education.

In current scoping review out of the twenty-seven studies, six were dedicated to CCC. Five studies out of these six were adapting and customising of a CCC that adheres to the European model of CCC to meet the special requirements of individual countries and dental education systems (96-101). This underscores the significance of customising instructional resources to fit specific local circumstances, guaranteeing their pertinence and efficacy in dental education. Furthermore, the agreement established on CCC in various nations highlights the endeavours towards establishing uniformity and synchronisation of dental education on a global scale as well as access the competencies expected from students' during their education (31, 96, 121).

In relation to the EBCM approach, seven evidence sources encompassed all elements of the EBCM (102, 106, 110, 112, 115, 116). This evidence provides a unique and pertinent experience that can be considered by other dental schools while working on the adoption of EBCM approach. On the other hand, the limited number of such reports could be attributed to the complexity of

implementing the entire approach which necessitates additional resources, time, efforts, and dedication (31). Meanwhile, seven studies incorporated solely caries detection (16, 17, 103, 108, 113, 114, 117), while five evidence sources focused exclusively on caries risk evaluation (105, 107-109, 111). This might be read as a predominant emphasis on these two components within dental faculties, as these two stages were identified as the most crucial and challenging to accomplish (122, 123).

Regarding the frameworks used, a scoping review of Rommerskirch-Manietta et al. that examined evidence-based interventions for individuals with dementia (120) employed the ERIC list for identifying the implementation strategies and Proctor framework to assess the implementation process which is similar with our study. In addition, comparably with our study, they discovered that the majority of reported strategies included 'continual training', 'ongoing consultation', 'development of educational materials', and 'application of dynamic training methods'.

Similar to our study, Guerrero et al. (119) used the same framework for actors, actions, and targets in a project focusing on identifying effective implementation strategies in oral health settings. The effective strategies reported, which were 'education' and 'restructuring the system', were also consistent with our findings. Nevertheless, the majority of the actors were individuals in managerial positions (e.g., management supervisor, leading clinic staff, executive leadership) while the target group consisted of dentists, dental hygienists, and assistants affiliated with a large prepaid dental care delivery system. Overall, there were discrepancy in concept, setting, and population comparing to our study since they focused on oral health in general, not EBCM, and it was done in dental practice settings among dentists and hygienists.

The selection of undergraduate dentistry students and faculty members as the target population for the studies was expected, as we specifically focused on educational environments. Only two

studies were focusing on teaching of dental hygiene students (112, 115). This may ascertain the disparity or deficiency in dental hygienists' education in cariology field.

The measured outcomes of the implementation activities in the current scoping review ranged from the development of tailored curricular documents for specific situations to improvements in the understanding, decision-making and performance of the target group(s). Each study had a distinct definition of performance, as they utilised diverse methodologies. Overall, the reporting of the implementation outcomes in the included papers was limited and/or imprecise. When the outcomes were reported they primarily centred on the 'acceptability' of the strategies employed, as determined by students' feedback on one side and the 'adoption' of educational interventions in the studies that developed the new core cariology curriculum on the other side. In contrast, in the Rommerskirch-Manietta et al. scoping review the implementaion outcomes were reported in the magority of the included studies and comprised 'fidelity', 'acceptability', 'adoption' and 'sustainability' outcomes (120). This underscores the need of the assessment of other implementation outcomes in EBCM implementation field as they are essential prerequisites for achieving targeted improvements in clinical or service outcomes (84), a step that was neglected in the majority of the included studies.

Implications for practice and research:

The findings of this review will be disseminated to dentists, dental school deans, faculty members (particularly those specialising in cariology education), and dental school curriculum planners through publications in peer-reviewed journals, thesis publications, and local and national scientific conference presentations. This will provide an insight about the overview of implementation approaches used by different dental schools to integrate EBCM in dental education. This study also highlights crucial topics for future investigation, such as examining the

degree to which the program's graduates remain committed to the programme, as well as assessing the long-term viability of implementing these principles in practical settings and the efficacy of various implementation options. Additional investigation is needed to evaluate the enduring effects on patients and results when integrating EBCM principles into dentistry education.

Limitations and strengths:

The legitimacy and usefulness of this scoping review are enhanced by its unique strengths. These include being the first scoping review on the subject and employing rigorous searching techniques such as searching through several databases, manual searching in various journals, and conduction a grey literature search. Despite the strengthens, some limitations may have been identified across the research process. Through a comprehensive search of grey literature, we discovered multiple abstracts that were given during the European Organization for Caries Research (ORCA) conference. Unfortunately, there were no published numerical data available that provided the detailed information relevant to extract. There was no evaluation of the selected studies' quality, however the quality assessment is not necessarily attribute in the method of a scoping review.

While the findings may be applicable to educational context, caution is warranted in generalizing to private practice settings. Further research is needed to explore how EBCM approaches are implemented in both educational and non-educational settings.

5. Conclusion

In conclusion, this scoping study provides a comprehensive overview of the implementation strategies of Evidence-Based Caries Management approach applied in undergraduate dental education. The incorporation of the Core Cariology Curriculum by dental schools worldwide using local consensus discussions and educational meetings, as well as the provision of tailored and ongoing education for students and faculty members utilizing active learning approaches were reported as EBCM implementation strategies. As the only assessed implementation outcomes described were related to acceptability and adoption of the approach, the lack of the assessment of the other outcomes such as fidelity, feasibility, sustainability, etc. is one of the identified knowledge gaps. Furthermore, there is a need for more research in the area of practical implementation and evaluation of different strategies to examine their effectiveness in educational settings and evaluation of patient-related outcomes.

Overall, the integration of EBCM into undergraduate dental education is in its early stages. Despite some improvements, there is a need for a strong engagement of decision-makers to reinforce and build capacity of the future dental workforce in applying evidence-informed practice. The current scoping review is a first step to inform policy and decision-makers about the existing strategies and the outcomes respectively.

6. References

1.   Pitts NB, Mayne C. Making Cavities History: A Global Policy Consensus for Achieving a Dental Cavity-Free Future. JDR Clin Trans Res. 2021;6(3):264-7.
2.   Selwitz RH, Ismail AI, Pitts NB. Dental caries. The Lancet. 2007;369(9555):51-9.
3.   Allison PJ. Canada's oral health and dental care inequalities and the Canadian Dental Care Plan. Can J Public Health. 2023;114(4):530-3.
4.   Global oral health status report: towards universal health coverage for oral health by 2030. . Geneva: World Health Organization; 2023.
5.   Peres MA, Macpherson LMD, Weyant RJ, Daly B, Venturelli R, Mathur MR, et al. Oral diseases: a global public health challenge. The Lancet. 2019;394(10194):249-60.
6.   Machiulskiene V, Campus G, Carvalho JC, Dige I, Ekstrand KR, Jablonski-Momeni A, et al. Terminology of Dental Caries and Dental Caries Management: Consensus Report of a Workshop Organized by ORCA and Cariology Research Group of IADR. Caries Res. 2020;54(1):7-14.
7.   Pitts NB. Are we ready to move from operative to non-operative/preventive treatment of dental caries in clinical practice? Caries Res. 2004;38(3):294-304.
8.   Schwendicke F, Doméjean S, Ricketts D, Peters M. Managing caries: the need to close the gap between the evidence base and current practice. Br Dent J. 2015;219(9):433-8.
9.   Banerjee A, Frencken JE, Schwendicke F, Innes NPT. Contemporary operative caries management: consensus recommendations on minimally invasive caries removal. Br Dent J. 2017;223(3):215-22.
10.   Urquhart O, Tampi MP, Pilcher L, Slayton RL, Araujo MWB, Fontana M, et al. Nonrestorative Treatments for Caries: Systematic Review and Network Meta-analysis. J Dent Res. 2019;98(1):14-26.
11.   Fontana M, Zero D. Bridging the gap in caries management between research and practice through education: the Indiana University experience. J Dent Educ. 2007;71(5):579-91.
12.   Baelum V. Caries management: technical solutions to biological problems or evidence-based care? J Oral Rehabil. 2008;35(2):135-51.
13.   Tikhonova S, Girard F, Fontana M. Cariology Education in Canadian Dental Schools: Where Are We? Where Do We Need to Go? J Dent Educ. 2018;82(1):39-46.
14.   Tikhonova S, Jessani AA, Girard F, Macdonald ME, Souza G, Tam L, et al. The Canadian Core Cariology Curriculum: Outcomes of a national symposium. J Dent Educ. 2020;84.
15.   Lee GHM, McGrath C, Yiu CKY. Evaluating the impact of caries prevention and management by caries risk assessment guidelines on clinical practice in a dental teaching hospital. BMC Oral Health. 2016;16(1):58.
16.   Escobar A, Rojas-Gualdrón DF, Velez LF, Santos-Pinto L. Developing diagnostic skills from preclinical dental education: Caries detection and assessment using e-learning assisted practice. J Dent Educ. 2022;86(10):1382-9.
17.   Luz PB, Stringhini CH, Otto BR, Port AL, Zaleski V, Oliveira RS, et al. Performance of undergraduate dental students on ICDAS clinical caries detection after different learning strategies. Eur J Dent Educ. 2015;19(4):235-41.
18.   Kassebaum NJ, Bernabé E, Dahiya M, Bhandari B, Murray CJ, Marcenes W. Global burden of untreated caries: a systematic review and metaregression. J Dent Res. 2015;94(5):650-8.

19.   Listl S, Galloway J, Mossey PA, Marcenes W. Global Economic Impact of Dental Diseases. J Dent Res. 2015;94(10):1355-61.

20.   Marcenes W, Kassebaum NJ, Bernabé E, Flaxman A, Naghavi M, Lopez A, et al. Global burden of oral conditions in 1990-2010: a systematic analysis. J Dent Res. 2013;92(7):592-7.

21.   (CHMS) CHMS. Oral Health Report 2007 [Available from: http://www.caphd.ca/sites/default/files/CHMS-E-tech.pdf

22.   canada H. Summary Report on the Findings of the Oral Health Component of the Canadian Health Measures Survey 2007‑2009 2007-2009 [Available from: https://caphd.ca/wp-content/uploads/2022/06/CHMS-E-summ.pdf.

23.   Schwendicke F, Dörfer CE, Schlattmann P, Foster Page L, Thomson WM, Paris S. Socioeconomic inequality and caries: a systematic review and meta-analysis. J Dent Res. 2015;94(1):10-8.

24.   Takahashi N, Nyvad B. Caries ecology revisited: microbial dynamics and the caries process. Caries Res. 2008;42(6):409-18.

25.   Pitts N, Zero D. White Paper on Dental Caries Prevention and Management: FDI World Dental Press Ltd; 2016.

26.   Schwendicke F, Splieth C, Breschi L, Banerjee A, Fontana M, Paris S, et al. When to intervene in the caries process? An expert Delphi consensus statement. Clin Oral Investig. 2019;23(10):3691-703.

27.   Featherstone JDB, Crystal YO, Alston P, Chaffee BW, Doméjean S, Rechmann P, et al. Evidence-Based Caries Management for All Ages-Practical Guidelines. Front Oral Health. 2021;2.

28.   Slayton RL, Urquhart O, Araujo MWB, Fontana M, Guzmán-Armstrong S, Nascimento MM, et al. Evidence-based clinical practice guideline on nonrestorative treatments for carious lesions: A report from the American Dental Association. J Am Dent Assoc. 2018;149(10):837-49.e19.

29.   Schwendicke F, Frencken J, Innes N. Clinical Recommendations on Carious Tissue Removal in Cavitated Lesions. Monogr Oral Sci. 2018;27:162-6.

30.   Fontana M, Guzmán-Armstrong S, Schenkel AB, Allen KL, Featherstone J, Goolsby S, et al. Development of a Core Curriculum Framework in Cariology for U.S. Dental Schools. J Dent Educ. 2016;80(6):705-20.

31.   Pitts NB, Mazevet ME, Mayne C. Shaping the future of dental education: Caries as a case-study. Eur J Dent Educ. 2018;22 Suppl 1:30-7.

32.   Twetman S. Prevention of dental caries as a non-communicable disease. Eur J Oral Sci. 2018;126 Suppl 1:19-25.

33.   Innes N, Schwendicke F, Frencken J. An Agreed Terminology for Carious Tissue Removal.

34.   Banerjee A. 'MI'opia or 20/20 vision? Br Dent J. 2013;214(3):101-5.

35.   Schwendicke F, Göstemeyer G. Understanding dentists' management of deep carious lesions in permanent teeth: a systematic review and meta-analysis. Implement Sci. 2016;11(1):142.

36.   Fontana M, Gonzalez-Cabezas C. Evidence-Based Dentistry Caries Risk Assessment and Disease Management. Dent Clin North Am. 2019;63(1):119-28.

37.   Leal SC, Dame-Teixeira N, Barbosa CB, Kominami PAA, Raposo F, Nakagawa EMT, et al. Minimum intervention oral care: defining the future of caries management. Braz Oral Res. 2022;36:e135.

38.   Schwendicke F, Splieth CH, Bottenberg P, Breschi L, Campus G, Doméjean S, et al. How to intervene in the caries process in adults: proximal and secondary caries? An EFCD-ORCA-DGZ expert Delphi consensus statement. Clin Oral Investig. 2020;24(9):3315-21.

39.   Brantley CF, Bader JD, Shugars DA, Nesbit SP. DOES THE CYCLE OF RERESTORATION LEAD TO LARGER RESTORATIONS? J Am Dent Assoc. 1995;126(10):1407-13.

40.   Elderton RJ. Clinical Studies Concerning Re-Restoration of Teeth. Adv Dent Res. 1990;4(1):4-9.

41.   Dhar V, Pilcher L, Fontana M, González-Cabezas C, Keels MA, Mascarenhas AK, et al. Evidence-based clinical practice guideline on restorative treatments for caries lesions: A report from the American Dental Association. J Am Dent Assoc. 2023;154(7):551-66.e51.

42.   Ahovuo-Saloranta A, Forss H, Walsh T, Nordblad A, Mäkelä M, Worthington HV. Pit and fissure sealants for preventing dental decay in permanent teeth. Cochrane Database Syst Rev. 2017;7(7):Cd001830.

43.   Dorri M, Dunne SM, Walsh T, Schwendicke F. Micro-invasive interventions for managing proximal dental decay in primary and permanent teeth. Cochrane Database Syst Rev. 2015;2015(11):Cd010431.

44.   Marinho VC, Worthington HV, Walsh T, Clarkson JE. Fluoride varnishes for preventing dental caries in children and adolescents. Cochrane Database Syst Rev. 2013(7):Cd002279.

45.   Harris R, Gamboa A, Dailey Y, Ashcroft A. One-to-one dietary interventions undertaken in a dental setting to change dietary behaviour. Cochrane Database Syst Rev. 2012;2012(3):Cd006540.

46.   Marinho VC, Higgins JP, Logan S, Sheiham A. Topical fluoride (toothpastes, mouthrinses, gels or varnishes) for preventing dental caries in children and adolescents. Cochrane Database Syst Rev. 2003;2003(4):Cd002782.

47.   Marinho VC, Higgins JP, Sheiham A, Logan S. Fluoride toothpastes for preventing dental caries in children and adolescents. Cochrane Database Syst Rev. 2003;2003(1):Cd002278.

48.   Marinho VC, Worthington HV, Walsh T, Clarkson JE. Fluoride varnishes for preventing dental caries in children and adolescents. Cochrane Database Syst Rev. 2013;2013(7):Cd002279.

49.   Gordan VV, Bader JD, Garvan CW, Richman JS, Qvist V, Fellows JL, et al. Restorative treatment thresholds for occlusal primary caries among dentists in the dental practice-based research network. J Am Dent Assoc. 2010;141(2):171-84.

50.   Innes NPT, Schwendicke F. Restorative Thresholds for Carious Lesions: Systematic Review and Meta-analysis. J Dent Res. 2017;96(5):501-8.

51.   Rechmann P, Doméjean S, Rechmann BM, Kinsel R, Featherstone JD. Approximal and occlusal carious lesions: Restorative treatment decisions by California dentists. J Am Dent Assoc. 2016;147(5):328-38.

52.   Riley JL, 3rd, Gordan VV, Ajmo CT, Bockman H, Jackson MB, Gilbert GH. Dentists' use of caries risk assessment and individualized caries prevention for their adult patients: findings from The Dental Practice-Based Research Network. Community Dent Oral Epidemiol. 2011;39(6):564-73.

53.   Schwendicke F, Foster Page LA, Smith LA, Fontana M, Thomson WM, Baker SR. To fill or not to fill: a qualitative cross-country study on dentists' decisions in managing non-cavitated proximal caries lesions. Implement Sci. 2018;13(1):54.

54.   Pitts NB, Zero DT, Marsh PD, Ekstrand K, Weintraub JA, Ramos-Gomez F, et al. Dental caries. Nat Rev Dis Primers. 2017;3:17030.

55.   Pitts N, Mazevet M, Mayne C, Hinrichs S, Boulding H, Grant J. Towards a Cavity Free Future: The Policy Institute at King's; 2017.

56.   Baelum V. What is an appropriate caries diagnosis? Acta Odontol Scand. 2010;68:65-79.

57.   Banerjee A. 'Minimum intervention' ‑ MI inspiring future oral healthcare? Br Dent J. 2017;223(3):133-5.

58.   Damschroder LJ, Reardon CM, Lowery JC. The consolidated framework for implementation research (CFIR).   Handbook on implementation science: Edward Elgar Publishing; 2020. p. 88-113.

59.   Thomas A, Bussières A. Leveraging knowledge translation and implementation science in the pursuit of evidence informed health professions education. Adv Health Sci Educ. 2021;26(3):1157-71.

60.   Thomas A, Bussières A. Knowledge Translation and Implementation Science in Health Professions Education: Time for Clarity? Acad Med. 2016;91(12):e20.

61.   Eccles MP, Mittman BS. Welcome to Implementation Science. Implement Sci. 2006;1(1):1.

62.   Graham ID, Logan J, Harrison MB, Straus SE, Tetroe J, Caswell W, et al. Lost in knowledge translation: Time for a map? J Contin Educ Health Prof. 2006;26(1):13-24.

63.   Implementation TCf. Implementing the Knowledge to Action (KTA) Model to Pick Change   Strategies   2018   [Available   from: https://thecenterforimplementation.com/toolbox/knowledge-to-action-model.

64.   Proctor EK, Powell BJ, McMillen JC. Implementation strategies: recommendations for specifying and reporting. Implement Sci. 2013;8:139.

65.   Alexander JA, Hearld LR. Methods and metrics challenges of delivery-system research. Implement Sci. 2012;7(1):15.

66.   May C. Towards a general theory of implementation. Implement Sci. 2013;8:18.

67.   Cook JM, Biyanova T, Coyne JC. Barriers to adoption of new treatments: an internet study of practicing community psychotherapists. Adm Policy Ment Health. 2009;36(2):83-90.

68.   Grol RP, Bosch MC, Hulscher ME, Eccles MP, Wensing M. Planning and studying improvement in patient care: the use of theoretical perspectives. Milbank Q. 2007;85(1):93-138.

69.   Kirchner JE, Smith JL, Powell BJ, Waltz TJ, Proctor EK. Getting a clinical innovation into practice: An introduction to implementation strategies. Psychiatry Res. 2020;283:112467.

70.   Powell BJ, McMillen JC, Proctor EK, Carpenter CR, Griffey RT, Bunger AC, et al. A compilation of strategies for implementing clinical innovations in health and mental health. Med Care Res Rev. 2012;69(2):123-57.

71.   Grol R, Grimshaw J. From best evidence to best practice: effective implementation of change in patients' care. Lancet. 2003;362(9391):1225-30.

72.   Waltz TJ, Powell BJ, Fernández ME, Abadie B, Damschroder LJ. Choosing implementation strategies to address contextual barriers: diversity in recommendations and future directions. Implement Sci. 2019;14(1):42.

73.   Powell BJ, Waltz TJ, Chinman MJ, Damschroder LJ, Smith JL, Matthieu MM, et al. A refined compilation of implementation strategies: results from the Expert Recommendations for Implementing Change (ERIC) project. Implement Sci. 2015;10(1):21.

74.   (EPOC) EPaOoC. EPOC   Taxonomy: Cochrane;   2015   [Available   from: epoc.cochrane.org/epoc-taxonomy

75.   Michie S, Richardson M, Johnston M, Abraham C, Francis J, Hardeman W, et al. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an

international consensus for the reporting of behavior change interventions. Ann Behav Med. 2013;46(1):81-95.

76.   Mazza D, Bairstow P, Buchan H, Chakraborty SP, Van Hecke O, Grech C, et al. Refining a taxonomy for guideline implementation: results of an exercise in abstract classification. Implemen Sci. 2013;8(1):32.

77.   Abraham C, Michie S. A taxonomy of behavior change techniques used in interventions. Health Psychol. 2008;27(3):379-87.

78.   Kauth MR, Sullivan G, Blevins D, Cully JA, Landes RD, Said Q, et al. Employing external facilitation to implement cognitive behavioral therapy in VA clinics: a pilot study. Implemen Sci. 2010;5(1):75.

79.   Rapp CA, Etzel-Wise D, Marty D, Coffman M, Carlson L, Asher D, et al. Evidence-based practice implementation strategies: results of a qualitative study. Community Ment Health J. 2008;44(3):213-24; discussion 25-6.

80.   Damschroder LJ, Aron DC, Keith RE, Kirsh SR, Alexander JA, Lowery JC. Fostering implementation of health services research findings into practice: a consolidated framework for advancing implementation science. Implement Sci. 2009;4:50.

81.   Tabak RG, Khoong EC, Chambers DA, Brownson RC. Bridging research and practice: models for dissemination and implementation research. Am J Prev Med. 2012;43(3):337-50.

82.   Magnabosco JL. Innovations in mental health services implementation: a report on state-level data from the U.S. Evidence-Based Practices Project. Implement Sci. 2006;1:13.

83.   Atkins MS, Frazier SL, Leathers SJ, Graczyk PA, Talbott E, Jakobsons L, et al. Teacher key opinion leaders and mental health consultation in low-income urban schools. J Consult Clin Psychol. 2008;76(5):905-8.

84.   Proctor E, Silmere H, Raghavan R, Hovmand P, Aarons G, Bunger A, et al. Outcomes for implementation research: conceptual distinctions, measurement challenges, and research agenda. Adm Policy Ment Health. 2011;38(2):65-76.

85.   Eccles M, Grimshaw J, Walker A, Johnston M, Pitts N. Changing the behavior of healthcare professionals: the use of theory in promoting the uptake of research findings. J Clin Epidemiol. 2005;58(2):107-12.

86.   Wensing M, Oxman A, Baker R, Godycki-Cwirko M, Flottorp S, Szecsenyi J, et al. Tailored Implementation For Chronic Diseases (TICD): a project protocol. Implement Sci. 2011;6:103.

87.   Ngoc CN, Mehta R, Donovan TE, Ferreira Zandona AG. Teaching Silver Diamine Fluoride in U.S. Dental Schools' Predoctoral Curricula. J Dent Educ. 2018;82(12):1305-9.

88.   Tikhonova S, Girard F, Fontana M. Cariology Education in Canadian Dental Schools: Where Are We? Where Do We Need to Go? J Dent Educ. 2018;82(1):39-46.

89.   Brown JP. A new curriculum framework for clinical prevention and population health, with a review of clinical caries prevention teaching in U.S. and Canadian dental schools. J Dent Educ. 2007;71(5):572-8.

90.   Splieth CH, Abudrya MH, Anandakrishna L, Cheng L, Al-Khalifa KS, Kim BI, et al. Teaching Cariology in Asia and Arabia. Caries Res. 2022;56(2):109-15.

91.   Alrasheedi HS, Mian RI, Ibne H, Alrashidi SO, Al Harbi TMA, Alrashedi AHJ, et al. Knowledge, attitude and practice of minimally invasive dentistry among dental graduates: A cross-sectional survey from saudi arabia. Int. J Pharm Sci Rev Res. 2020;62(1):192-8.

92.   Al-Sabri FA, Ba-Salamah M, El-Marakby AM, Okash S, Ghaleb IH, Abdulrab S. Tooth Decay Prevention: Knowledge and Practices Survey of Dental Students. Jaypee's int. 2019;12(2):92-5.

93.   Autio-Gold JT, Tomar SL. Dental students' opinions and knowledge about caries management and prevention. J Dent Educ. 2008;72(1):26-32.

94.   Schulte AG, Pitts NB. First Consensus Workshop on the Development of a European Curriculum in Cariology. Eur J Dent Educ. 2011;15 Suppl 1:1-2.

95.   Schulte AG, Buchalla W, Huysmans M-CDNJM, Amaechi BT, Sampaio F, Vougiouklakis G, et al. A survey on education in cariology for undergraduate dental students in Europe. Eur J Dent Educ. 2011;15(s1):3-8.

96.   Schulte AG, Pitts NB, Huysmans MC, Splieth C, Buchalla W. European Core Curriculum in Cariology for undergraduate dental students. Eur J Dent Educ. 2011;15 Suppl 1:9-17.

97.   Abreu-Placeres N, Grau-Grullón P, Naidu R, García-Godoy F, Newton JT, Ekstrand KR, et al. Cariology consensus for undergraduates at dental schools in the Caribbean region. Eur J Dent Educ. 2021;25(4):717-32.

98.   Cortés-Martinicorena FJ, Ceballos L, Martínez-Pérez E, Hernández-Juyol M, Schulte AG, Almerich-Silla JM, et al. Spanish Curriculum in Cariology for undergraduate dental students: Proceedings and consensus. European Journal of Dental Education. 2022;26(2):317-28.

99.   Fontana M, Guzman-Armstrong S, Schenkel AB, Allen KL, Featherstone J, Goolsby S, et al. Development of a Core Curriculum Framework in Cariology for U.S. Dental Schools. J Dent Educ. 2016;80(6):705-20.

100.   Martignon S, Marin LM, Pitts N, Jacome-Lievano S. Consensus on domains, formation objectives and contents in cariology for undergraduate dental students in Colombia. Eur J Dent Educ. 2014;18(4):222-33.

101.   Tikhonova S, Jessani A, Girard F, Macdonald ME, De Souza G, Tam L, et al. The Canadian Core Cariology Curriculum: Outcomes of a national symposium. J Dent Educ. 2020;84(11):1245-53.

102.   Fontana M, Zero D. Bridging the gap in caries management between research and practice through education: the Indiana University experience. J Dent Educ. 2007;71(5):579-91.

103.   Turchiello RZ, Pedrotti D, Braga MM, Rocha RO, Rodrigues JA, Lenzi TL. Do undergraduate dental students perform well detecting and staging caries and assessing activity by visual examination? A systematic review and meta-analysis. Int J Clin Pediatr Dent. 2019;29(3):281-93.

104.   Dawett B, Deery C, Banerjee A, Papaioannou D, Marshman Z. A scoping literature review on minimum intervention dentistry for children with dental caries. Br Dent J. 2022.

105.   Teich ST, Demko C, Al-Rawi W, Gutberg T. Assessment of implementation of a CAMBRA-based program in a dental school environment. J Dent Educ. 2013;77(4):438-47.

106.   Booth ET, Eckert GJ, Fontana M. Variability in caries management decision-making in a dental school setting. J Dent Educ. 2022;86(1):57-67.

107.   Chaffee BW, Featherstone JD. Long-term adoption of caries management by risk assessment among dental students in a university clinic. J Dent Educ. 2015;79(5):539-47.

108.   DiLuigi M, Hagel N, Finkelman M. Evaluating a student's performance in CAMBRA using teledentistry. J Dent Educ. 2023;87 Suppl 3:1773-5.

109.   Goolsby SP, Young DA, Chiang HK, Carrico CK, Jackson LV, Rechmann P. The Effects of Faculty Calibration on Caries Risk Assessment and Quality Assurance. J Dent Educ. 2016;80(11):1294-300.

110. Ribeiro APD, Dilbone DA, Delgado AJ. Virtual caries management competency. J Dent Educ. 2020;85(Suppl 1):1011-2.

111. Young DA, Alvear Fa B, Rogers N, Rechmann P. The Effect of Calibration on Caries Risk Assessment Performance by Students and Clinical Faculty. J Dent Educ. 2017;81(6):667-74.

112. Association ADE. Caries Management Competency: Implementation of This New CODA Requirement: American Dental Education Association; 2022 [Available from: https://elearn.adea.org/products/caries-management-competency-implementation-of-this-new-coda-requirement?

113. Alves LS, de Oliveira RS, Nora Â D, Cuozzo Lemos LF, Rodrigues JA, Zenkner JEA. Dental Students' Performance in Detecting In Vitro Occlusal Carious Lesions Using ICDAS with E-Learning and Digital Learning Strategies. J Dent Educ. 2018;82(10):1077-83.

114. Diniz MB, Lima LM, Santos-Pinto L, Eckert GJ, Zandoná AG, de Cássia Loiola Cordeiro R. Influence of the ICDAS e-learning program for occlusal caries detection on dental students. J Dent Educ. 2010;74(8):862-8.

115. Young A, Skudutyte-Rysstad R, Torgersen G, Giertsen E. Teaching Radiographic Caries Detection and Treatment Planning: A Seminar Using an Audience Response System. Caries Res. 2022;56(3):226-33.

116. Carvalho JC, Brabant A, Hara AT, Kanaan M. Teaching Tooth Wear Diagnosis, Risk Assessment, and Treatment Decisions Applying Inverted Classroom Combined with Case Presentation Model. Caries Res. 2022;56(3):206-14.

117. Pishipati KV, Telang L, Nerali JT, Telang A, Jaganathan S. Evaluating the Performance of Dental Students with Different Levels of Clinical Experience in Learning ICDAS. J Contemp Dent Pract. [Electronic Resource]. 2021;22(1):89-92.

118. Jablonski-Momeni A, Busche JF, Struwe C, Lange J, Heinzel-Gutenbrunner M, Frankenberger R, et al. Use of the international caries detection and assessment system two-digit coding method by predoctoral dental students at Philipps University of Marburg, Germany. J Dent Educ. 2012;76(12):1657-66.

119. Guerrero EG, Kaplan CD, Gruß I, Frantsve-Hawley J, Fellows JL, Yosuf N, et al. Applying a scoping review approach for identifying effective implementation strategies in oral health settings. J Clin Transl Sci. 2021;5(1):e187.

120. Rommerskirch-Manietta M, Manietta C, Purwins D, Braunwarth JI, Quasdorf T, Roes M. Mapping implementation strategies of evidence-based interventions for three preselected phenomena in people with dementia−a scoping review. Implement Sci. 2023;4(1):104.

121. Pitts N. Preventive and minimal intervention dentistry in the undergraduate curriculum. J Dent. 2011;39 Suppl 2:S41-8.

122. Featherstone JDB, Crystal YO, Alston P, Chaffee BW, Doméjean S, Rechmann P, et al. A Comparison of Four Caries Risk Assessment Methods. Front Oral Health. 2021;2.

123. Pitts N. Detection, assessment, diagnosis and monitoring of caries. Basel ; New York: Karger; 2009.

7. Appendices

7.1 Search strategy

1. exp Dental Caries/
2. (caries or carious or cariology* or DMT or DMFT or ICDAS).tw,kf.
3. ((tooth or teeth or dental or oral) and (decay* or cavit*)).tw,kf.
4. 1 or 2 or 3
5. exp Evidence-Based Practice/
6. exp Translational Research, Biomedical/
7. exp Information Dissemination/
8. exp Diffusion of Innovation/
9. (evidence adj3 (base? or informed)).tw,kf.
10. ("translational gap" or "research uptake" or "research adj3 practice" or "research into practice" or "research to practice" or "research uptake" or ((research or evidence) adj1 practice gap) or "evidence to practice" or "evidence into practice" or "systematic review evidence" or (implementation adj3 (strateg* OR approach* OR program* or science))).ti,ab.
11. ((knowledge or research or evidence) adj3 (translat* or transfer or implement* or utili#ation or disseminat* or adopt* or evaluat* or institutionali* or operationali* or communicat* or adhere* or compli*)).tw,kf.
12. ((information adj5 disseminat*) or ((modern or updated) adj5 (principles or practice?)) or (innovate* adj3 diffus*) OR early adopter* or (technolog* adj3 transfer)).tw,kf.
13. or/5-12
14. exp Education, Dental/
15. exp Schools, Health Occupations/
16. exp Students, Dental/
17. Schools/ or exp Universities/ or Clinical Clerkship/ or Education, Medical, Undergraduate/ or Health Education/
18. (student? or educat* or train* or curricul* or class* or facult* or college? or school? or universit* or didactic* or pedagog*).tw,kf.
19. or/14-18
20. 4 and 13 and 19

7.2 Data extraction table

Author/year		
Country		
Setting		
Aim		
Study design		
EBCM approach		
Actor		
Actions		
Target		
Outcome		
Justification		
Authors' Conclusion		
Limitations of the study		
Further research		
Funding		

7.3 PRISMA-ScR checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	Page 0
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	Page I-VI
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	Page 19
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	Page 20
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	Page 21
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	Page 26
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	Page 27
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Page XXI
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	Page 28
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	Page 29
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	Page XXI
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	-
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	Page 29
RESULTS			

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	Page 32
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	Page 33
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	-
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	Page 38-39
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	Page 36-37
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	Page 40
Limitations	20	Discuss the limitations of the scoping review process.	Page 43
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	Page 44
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	-