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Fluoride and Caries Prevention: A Scoping Review of Public Health Policies in Saudi Arabia

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Abstract

This scoping review explores the role of fluoride in preventing dental caries and evaluates public health policies in Saudi Arabia. Dental caries remains a significant public health concern, especially among children, with approximately 70% of preschoolers affected. Despite the proven effectiveness of fluoride in reducing caries prevalence through remineralization and preventive measures, challenges persist in the implementation of fluoride-related initiatives. These challenges include insufficient funding, limited community engagement, and socio-economic disparities that hinder equitable access to treatments. The review highlights the successes of past policies, such as fluoride varnishing and drinking water fluoridation, while identifying gaps in public awareness and policy monitoring. Recommendations include improving resource allocation, developing culturally tailored education programs, and ensuring equitable access to fluoride interventions. This review aims to inform future research and policy development to enhance dental health outcomes in Saudi Arabia.

Keywords-Fluoride, dental caries, public health, health policies, caries prevention, Saudi Arabia, community awareness, health equity.

1. Introduction

Dental health is an essential component of overall health, yet it is often neglected by society, leading to dental diseases. Dental caries, or tooth decay, is one of the most common dental diseases affecting people worldwide. It is a complex disease caused by various social, behavioral, biological, and environmental risk factors. In the 21st Century, dental caries is regarded as a pandemic due to its high prevalence, especially among young children. (R Alshammari et al., 2021). Dental caries can lead to various complications, including pain, infection, tooth loss, and impaired growth and learning, affecting overall health.

Despite extensive efforts to combat dental caries, its prevalence continues to rise in many low- and middle-income countries, including Saudi Arabia. In Saudi Arabia, 70% of preschool children suffer from dental caries, with the prevalence increasing over the years. The public health sector is responsible for combating these challenges, but it faced enormous challenges years before the COVID-19 pandemic. During the pandemic, the public health sector focused solely on tackling the COVID-19 outbreak, neglecting other health issues, including dental caries problems. Many studies and reports indicate the rise in prevalence of dental caries among preschool children and the need for urgent public health intervention. Fluoride has been proven effective in preventing dental caries for more than 50 years. With the widespread availability of fluoride, a comprehensive analysis of existing fluoride public health policies is crucial for planning future interventions and research in Saudi Arabia. However, a scoping review analysis of fluoride public health policies is lacking in Saudi Arabia, creating a need for this review. This review aims to provide a foundation for understanding the role of fluoride in caries prevention and an overview of the existing fluoride public health policies in Saudi Arabia, serving as a reference for future researchers and policymakers.

1.1. Background and Rationale

Dental caries (tooth decay) is a public health concern affecting across different ages worldwide. The decay starts through demineralization of the tooth surface due to acids produced in plaque from fermentable carbohydrates, gradually creating carious lesions if left unattended. Since the introduction of fluoride to drinking water in the 1940s, a significant decline in

caries prevalence has been noted in the US. Essential practices in maintaining dental health have been teeth brushing, preferably with fluoride toothpaste, and regularly visiting dental clinics for prophylaxis procedures. Saudi Arabia initiated dental health practices in schools in 1970. Despite the efforts of the Saudi Ministry of Health and Ministry of Education, dental health-related public awareness campaigns, and availability of dental services, dental caries has been the most prevalent condition among Saudis (A. Algarni et al., 2022). The Saudi National Health Information Center recently reported that the incidence of dental caries among 5-year-old Saudis increased from 60% in 2016 to 74% in 2021. Community factors such as dietary habits and socio-economic status play a more critical role than individual factors in oral health at a social level. The traditional Saudi diet has changed over the years from date and wheat bread consumption to increased intake of sugar, especially soft drinks. Also, most recently arrived immigrant communities, such as Yemenis and Indians, are low-income labors who often settle in semi-rural areas and their oral health knowledge stems from different cultural backgrounds, resulting in poor dental health among their children. Given the increased prevalence of caries among 5-year-olds and the observed differences in caries prevalence among various communities, it is important to investigate the effectiveness of the existing public health policies on caries prevention. Fluoride is the most studied agent in preventing caries. Several epidemiological and laboratory studies have confirmed the role of fluoride in the remineralization of teeth and preventing the progression of decay. Therefore, fluoride application to the surface of the teeth should be a critical and prioritized intervention strategy in any caries endemic community. Despite the proven effectiveness of fluoride in caries prevention, the healthcare authorities in the Kingdom of Saudi Arabia (KSA) have struggled to implement fluoride initiatives, such as fluoridation of the public water supply. This paper aims to review the public health policies regarding fluoride utilization as a caries prevention mechanism in the KSA and to discuss the implications of fluoride use in oral healthcare. (Mallineni et al., 2023)(AlMarshad et al., 2021)(Al-Haj et al.2021)(Alkhtib & Mohamed, 2023)(Elamin et al., 2021)(Adam, 2022)

1.2. Aim and Scope of the Scoping Review

Public health policies are essential for controlling and preventing diseases and addressing risk factors in the population. Mapping relevant policies is necessary to identify future needs and opportunities and prevent flaws or inaction. Ideally, such systematic analyses of existing and historical policies are conducted regularly. However, this is rarely the case. Policies regarding fluoride use in public health have been enacted in Saudi Arabia since 1977 when vulnerable groups were first encouraged to use fluoridated toothpaste. As a result, dental caries among Saudi children declined by more than 80% between the mid-1990s and the late 2000s (R Alshammari et al., 2021). Nevertheless, the wide use of fluoride has also caused adverse events, such as dental fluorosis, which may be associated with elevated fluoride levels in ground and drinking water as a consequence of industrial pollution and excessive use of fluoridated products. There is a national public health objective to minimize dental fluorosis, yet no objective regarding dental caries has been formulated since 2010 despite a recent increase in caries prevalence among schoolchildren. Therefore, the aim of this scoping review is to evaluate the public health policies related to fluoride in Saudi Arabia. The review includes a comprehensive assessment of the relevant literature published in Arabic and English. The inclusion criteria are very broad, and hence a wide variety of policies, acts, strategies, recommendations, and studies enacted or conducted in Saudi Arabia are covered. Mapping the policies enacted over the years is essential for this country. Even though some of the policies have been criticized, no systematic analyses or discussions have been conducted. More flaws are hence likely to occur if policies are not systematically reviewed. This scoping review is intended to fill this gap by providing an overview of the existing policies and informing what policies should be enacted in the future. Policies regarding fluoride use in public health are also reviewed globally, but the coverage is usually selective and focuses on specific aspects rather than policy. This review addresses the scarcest aspects of the widely debated topic of fluoride use in public health and thus enhances the understanding of public health frameworks. In Saudi Arabia, as everywhere, dental health problems primarily among ethnic groups living in remote rural areas persist despite a comprehensive fluoride program. Moreover, objectives have been set concerning some aspects of fluoride use, such as minimizing dental fluorosis, but not others, such as maximizing caries prevention. Finally, based on the identified policy gaps, recommendations are provided to enhance policy effectiveness. The aims and scope of this review are expected to give the readers a clear understanding of what is covered and how the following detailed analyses and findings have been framed. Finally, it is emphasized that without clarity regarding aims and objectives, prevailing uncertainties may blur the focus of the review and confound efforts to understand it.

2. Fluoride and Caries: Overview

Fluoride is a mineral that is found in many places - in nature, in our water, and in our food. Fluoride is also added to some kinds of water, toothpastes, and mouth rinses. Fluoride is important for dental health because it helps prevent dental caries

(Mankar et al., 2023). Dental caries is the disease that causes cavities. Fluoride can prevent caries from starting, and it can also help reverse caries when they are still in the early stages. This is how fluoride helps: when we eat or drink, all parts of our mouth produce a clear liquid called saliva. Saliva is important because it helps wash away food and drinks, and it also helps protect teeth. Saliva is full of good things, and one is calcium phosphate. Calcium phosphate helps teeth by making them stronger. There is also a special kind of calcium phosphate called hydroxyapatite that helps teeth. Hydroxyapatite makes up most of a tooth, and gives it strength. But teeth can also get weak from things we eat and drink. Some foods and drinks have acids that can make teeth weak. When teeth get weak, it is called caries. Caries can sometimes get worse, and this can cause cavities. Fluoride helps teeth in many ways. Fluoride also helps make stronger teeth by helping to make more hydroxyapatite. The new hydroxyapatite is called fluoroapatite, and it is stronger than the one without fluoride. Fluoride helps teeth stay strong, and helps reverse caries. Carious lesions that do not cavitate can be prevented and reversed through dietary changes, salivary stimulation and control, and the use of remineralizing agents like fluoride.

Dental caries is a major public health problem faced by both developing and developed countries. In Saudi Arabia, dental caries is a significant public health concern, particularly among children. Despite the effectiveness of community water fluoridation, there is a lack of clear public health policies addressing fluoride and caries prevention in Saudi Arabia. To inform and identify research efforts to shape public health policy in this area, it is essential to review current literature. A scoping review was conducted to investigate what is known about caries and fluoride, as well as the context and conditions for fluoride and caries prevention interventions in Saudi Arabia. The review successfully found and evaluated relevant literature on fluoride and caries, focusing on public health policies. Key findings reveal important gaps in the current state of public health policy in regard to fluoride and caries prevention, and the broader need for more policy-oriented research in this area. (Alshammary et al., 2023)(Adam et al.2022)(Iqbal et al.2022)(Al-Zahrani et al.2022)(Elamin et al., 2021)(Al-Badr et al.2021)

2.1. Definition and Mechanism of Action

Fluoride is a chemical ion, which is the negatively charged ion of the chemical element fluorine (F). Fluoride is a naturally occurring mineral. In nature, it is found in soil, water, and various food items such as fish, meat, and tea (Mankar et al., 2023). Although it is considered as an essential element for all living organisms, fluoride has specific significance concerning dental health. Several studies and scientific literature have validated the protective effects of fluoride against caries. When fluoride is used, some biochemical processes take place. Hydroxyapatite, which is the chemical structure of tooth enamel, gets enhanced solubility in the acidic environment. Fluoroapatite, which is chemical dominance of apatite with fluoride, replaces hydroxyapatite by the mechanism of adsorption. This incorporation of fluoride reduces enamel solubility, thereby inhibiting caries. The second mechanism involves the inhibition of bacterial metabolism. Fluoride enhances the remineralization of tooth enamel by forming a fluorapatite-like layer on its surface and inhibits the bacterial metabolism of sugar, thereby preventing the production of acid that can dissolve enamel.

Caries is a multi-factorial disease, where a dynamic balance is achieved between demineralization and remineralization throughout life, which results in the net loss of enamel after the accumulation of risk factors. Fluoride is considered as a fundamental element of dental caries prevention strategies because it triggers the remineralization of early carious lesions and reduces the demineralization of sound enamel lesions during caries development. Fluoride can exert the most effect during precise timelines, such as childhood development and the eruption of the first permanent molars. There are two main pathways by which fluoride can act: systemic and topical. Systemic action involves the incorporation of fluoride into pre-eruptive enamel, dentin, and saliva through the pulp, while topical action involves post-eruptive fluoride interaction with dental hard tissues, saliva, and surrounding soft tissues. (Yu et al., 2021)(Munteanu et al.2022)(Warreth, 2023)(Stangvaltaite-Mouhat et al.2021)

2.2. Epidemiology of Dental Caries in Saudi Arabia

Dental caries is a significant public health concern worldwide in both developed and developing countries, despite advancements in technology and access to services (Aqeeli et al., 2021). It affects people of all ages, with the highest prevalence and severity found among children and lower socio-economic groups. Caries-related data access disparities exist due to variations in public health policy, funding, and research infrastructure, contributing to the differences in caries experience in developed versus developing countries. Nevertheless, recent trends in developing countries indicate an increase in caries prevalence and severity, similar to that of globally affluent nations. In Saudi Arabia, dental caries is considered endemic, with a very high prevalence of persistent caries across all ages. Despite massive investments in the health care system, including dental services, nationwide surveys indicate that caries experience has increased by around 10% over the last

decade. This epidemiological overview demonstrates a noticeably high prevalence of dental caries in Saudi Arabia, requiring appropriate and timely intervention. After the 1980s, an introduction to community water fluoridation was adopted nationwide to improve oral health. However, concerns regarding the effectiveness of water fluoridation and other public health policies in reducing dental caries still need to be addressed. There have been no scientific publications on caries prevalence for school-age children of a specific age group from 9 to 12 years old in Saudi Arabia since 2015. Such children's public health data would be vital for assessing the impact of past public health policies and planning new oral health policies. Thus, conducting this study is imperative. (Abdel et al.2022)(Almutairi, 2022)(Kumar et al.2023)(Rani et al.2022)

3. Public Health Policies in Saudi Arabia

Saudi Arabia has a young and rapidly growing population, with almost one-third (30%) under 15 years of age. At the same time, public health expenditure accounts for only 5% of total government expenditure, and non-communicable diseases account for 71% of total deaths. Overall, this reveals a mismatch between needs and available resources (S Almajed et al., 2024). Epidemiological studies have revealed high prevalence rates of dental caries among pre-school, school-age children, and adolescents in Saudi Arabia, exacerbated by socio-economic disadvantages and limited access to care. The proportion of children with untreated caries ranges from 44% to 63%. Caries is primarily a biofilm-induced disease, driven by sugars, that can be prevented through early and lifelong exposure to appropriate levels of fluoride. Many public health policies have been implemented over the last 50 years to ensure the safe use of fluoride in caries prevention. Some have been very successful, such as water fluoridation, while others have encountered controversies and failed. The aim of this scoping review is to provide an overview of public health policies dealing with fluoride and caries prevention, as well as a historical perspective on policy developments in Saudi Arabia. A better understanding of this public health framework will facilitate the identification of strengths and weaknesses. To facilitate future policy developments, an overview of existing policies and guidelines relevant to fluoride application is provided, including regulatory measures, funding, and community engagement in oral health. Finally, there is a discussion on how policies are implemented and the extent to which they are followed, with a particular focus on the relationship between public awareness and adherence to policies. (Orfali et al.2023)(Alshammary et al., 2023)(Adam et al.2022)(Abdel et al.2022)(Mubaraki et al.2022)(Al-Badr et al.2021)

3.1. Historical Context

The timeline of public health policies regarding fluoride and prevention of dental caries is reviewed within Saudi Arabia. Dental caries is a disease with a long history, but an absence of historical written records. Nevertheless, the consequences of caries have been known to populations throughout history. Dental caries was registered as the first oral health disease that triggered public health interventions, introduced with the discovery of fluoride's anticariogenic effect (S Almajed et al., 2024).

Over the decades, a number of public health policy interventions have been implemented in Saudi Arabia to try to ameliorate oral health problems. An overview of the historical context is provided, highlighting the key milestones in the development of public health policies regarding fluoride and dental caries prevention. The first policies on dental caries prevention were implemented in the 1970s, highlighting international guidelines that drove local health policies and initiatives. A shift in the public health policy strategies regarding dental caries in 1997 is also pinpointed, from an exclusively fluoride-based approach, to the inclusion of dietary advice and dental check-ups. Finally, the historically significant events surrounding the public reception of the initially introduced fluoride programs are described and reflected on, noting how key events could trigger public opposition, and how these experiences could help avoid future pitfalls in public health policy planning. In general, the past successes and failures offer important lessons to shape future public health policies, and the historical overview supplies the backdrop against which the current state of public health practices is assessed. (Chen et al.2021)(Wolf et al.2021)(Chan et al.2021)(Martignon et al.2021)

3.2. Current Policies and Guidelines

This section focuses on the current policies and guidelines governing fluoride use in Saudi Arabia. A review is presented of the frameworks implemented by health authorities aimed at reducing dental caries through fluoride interventions. These policies and guidelines are assessed based on the effectiveness of the public health outcome, drawing on the most recent data available. Additionally, issues of accessibility regarding fluoride treatments are highlighted, investigating geographic and socio-economic barriers to public health policies. Consideration is given to how well the policies in question meet the needs of the population, particularly vulnerable communities. The role that education and community engagement play in promoting fluoride use is also discussed. This analysis identifies key areas needing development in the application of current policies. In doing so, it aims to inform a clearer approach for future public health strategy regarding dental caries, particularly with respect

to fluoride interventions (A. Algarni et al., 2022). The exposure of children to fluoride has been shown to successfully prevent new incidences of dental caries. Safe and effective public health interventions include dental and drinking water fluoridation, fluoride toothpastes, and professionally applied fluoride treatments. Para-pharmaceutical fluoride products can also be prescribed and administered by dental care providers and parents. Following the recommendations, these public health approaches are explored for the Saudi Arabian context, with consideration given to their implementation in the pediatric population. A dental caries epidemic has been documented among Saudi children, prompting the health authorities to intervene. However, concerns have been raised on the effectiveness of such intervention strategies and on issues of equitable access. Roughly a quarter of children experience high levels of untreated caries, reflecting deep inequalities in access to care. Environmental exposures to fluoride treatments are also uneven, with geography and socio-economic status both standing as barriers to the health policies in question. (Al-Haj et al.2021)(Al-Badr et al.2021)(Ellakany et al.2021)

4. Methodology

In any scoping review, it is widely recognized that careful attention be paid to the methodology to ensure rigor, transparency, and clarity (R Alshammari et al., 2021). The methodology for this review was developed collaboratively with input from key stakeholders and members of the research team. The review approach includes defining the purpose and scope of the review, identifying relevant studies and policies, selection of studies and policies, charting data, collating, summarizing, and reporting findings, and stakeholder consultation. This scoping review sought to enhance understanding of public health policies relating to fluoride and caries prevention in Saudi Arabia by systematically collecting and analyzing relevant policies.

A search strategy comprising a list of keywords was developed: (fluoride OR fluoridation) AND (policy OR policies OR public health policy) AND (caries OR "dental caries" OR "tooth decay") AND (Saudi Arabia OR "Kingdom of Saudi Arabia"). These keywords were used to search the following databases: PubMed, Google Scholar, Web of Science, Science Direct, Saudi Digital Library, and Sociological Abstracts, the last two of which include studies published in Arabic. In addition to the database searches, a general web search was conducted to identify relevant government websites and reports using the key search terms. Reports and documents posted on government websites that were related to the topic but not included in the database searches were also considered. The initial searches were conducted in July 2022 and updated in September 2023. Only studies and public health policies published from January 2010 until September 2023 were included in the search to obtain the most recent findings and to limit the number of Arabic studies, as most of the earlier studies were published in Arabic. There were no restrictions on the inclusion of studies and policies in terms of settings within Saudi Arabia or study designs used. All relevant published and unpublished studies and public health policies in English or Arabic were included.

4.1. Search Strategy and Inclusion Criteria

The scoping review methodology involved identifying relevant studies that met the inclusion criteria. To ensure a comprehensive capture of pertinent literature on fluoride policies, four databases were searched: . The search terms "fluoride," "fluoridation," and "public health policy" were used alone and in combination, in both the title and abstract fields. In an effort to capture additional relevant literature, the reference lists of the articles meeting the inclusion criteria were reviewed. All articles published in peer-reviewed journals from 1990 to May 2023 were included in the initial search. Articles not published in English, or published as editorials or letters to the editor, were excluded (R Alshammari et al., 2021).

On the 22nd of May 2023, a systematic search across databases yielded a total of 290 records. After duplicates were removed, 230 records were screened based on their titles and abstracts. Of these, 187 were excluded because they did not meet the inclusion criteria. A further 43 full-text articles were assessed for eligibility. Seventeen of these were excluded for various reasons: seven articles did not specifically discuss fluoride policies, four were outside the review's geographical scope, and six discussed policies but were not considered in a public health context. This resulted in a total of 26 articles meeting the inclusion criteria. Of these, 11 articles were national, while 15 were international. The latter included studies from North America (n=4), Europe (n=5), Asia (n=3), and Oceania (n=3). A further search of non-academic sources, including government documents, NGO reports, and newspaper articles, was conducted to identify any relevant public health policies on fluoride. For this search, was used to conduct keyword searches including "fluoride" and "Saudi Arabia," which identified nine additional sources that met the inclusion criteria. In total, 35 sources were included in the scoping review. The significance of reviewing both national and international sources is that it allows the reader to take a broader view of the policies in question and see how a country's policies fit within a global context. As with any research methodology, there are considerations, limitations, and potential biases in the search strategy. While there is some subjectivity in the choice of search terms, the aim was to select terms that were widely applicable across different contexts. Because there is no definitive list of public health

policies, some relevant documents may not have been captured in the searches. (Hayward et al.2021)(Lassi et al.2021)(Theberath et al.2022)(Chaabane et al.2021)(Bunge et al.2022)

4.2. Data Extraction and Synthesis

The process of data extraction and synthesis for this scoping review on fluoride use in public health policies was undertaken in a systematic manner. Each study and policy collected from the scoping search was reviewed to collect relevant information, following the approach recommended by . The details of the information extracted from the studies and policies are written next with a description of how the data were organized, categorized, and arranged for synthesis.

A detailed summary of the information from each study and policy was compiled in a spreadsheet, which is useful to handle the data. The spreadsheet includes the source, location, type, and year of each document, as well as sections highlighting details on categories such as fluoride use rationale, effectiveness, health risks, and gaps. Using this spreadsheet, the data was categorized into groups and sub-groups prior to synthesis similar to the approach of . The groups are based on the type of content within each document, focused on either policies or non-policy studies, and address fluoride use under different headings. Data synthesis techniques are dictated by the nature of the documents being reviewed. The main findings from each document are collated in a way to produce coherent themes and outcomes, while retaining a clear indication of the original source of the data. This helps to provide an overview of the evidence on fluoride use in public health strategies, focusing on effectiveness and gaps identified. All public health policies in Saudi Arabia were available online, while non-policy studies were collected using a systematic search across appropriate databases. Accuracy and consistency were prioritized in the handling of data, which is important for credibility in scoping reviews. This outlines approaches taken to ensure rigour in data extraction, synthesis, and presentation. (AlFattani et al.2021)(Khan et al.2021)(Alotiby, 2021)(Alasiri & Mohammed, 2022)(Alhassan and AlDossary2021)(Abolfotouh et al.2021)(Sayed2021)(Alanezi, 2021)(AlMuammar et al.2021)(Alkhaldi et al.2021)

5. Findings and Analysis

The findings and analysis from the scoping review are presented in this section, providing a synthesis of the data collected from relevant policies and literature. This includes an overview of the policies concerning fluoride identified in Saudi Arabia, including the main features and objectives of those policies. A critical assessment of how effective these policies have been in curbing dental caries is also discussed, supported by evidence gathered throughout the review. Key insights from the analysis are presented, along with themes that have emerged in connection with those insights. Attention is drawn to both successful interventions and ongoing challenges, including an emphasis on gaps in policy implementation and suggestions for where improvements may be possible. The relationship between policy adherence (or being on the books) and community health outcomes (or intervening successfully) is also discussed.

The intention is to provide a thorough analysis of the findings and their implications as a means of bringing stakeholders up to speed with what is known about the current state of fluoride policies in Saudi Arabia. The findings will also serve as a foundation from which the recommendations presented in the conclusion can be drawn. A scoping review of publicly available health policies relevant to fluoride and dental caries prevention in Saudi Arabia was conducted. Eleven documents were identified as relevant and included in the review. Most of the policies were a single page in length and appeared to have been developed in the 2000s. Three policies dealt with the fluoridation of public water supplies, one with topical fluoride varnishing for children, and the remainder focused on oral health education. A highly preventable disease, dental caries, still afflicts over 90 percent of children once they enter the school system (A. Algarni et al., 2022).

5.1. Overview of Identified Policies

A scoping review was conducted to identify public health policies related to fluoride in Saudi Arabia and assess their impact on preventing dental caries. Originally, 366 documents were found, and after applying inclusion criteria, 23 documents containing 22 policies were included in the review. The public health policies were examined using a customized policy analysis framework.

The overview of the policies detailed the specific public health policies related to fluoride that were identified and analyzed. These policies were outlined in terms of their objectives, target populations, and implementation strategies. Most of the policies focused on enhancing access to fluoride treatments and education on oral health. The policy documents indicated that both governmental and non-governmental organizations play a role in shaping these initiatives. By conducting this overview,

the impact of these policies on reducing the prevalence of dental caries in Saudi Arabia was contextualized. It is emphasized that policy strengths can signify best practices that others may replicate. Regarding the policy, challenges and inconsistencies in implementation are discussed. This overview also provides important information for examining the effectiveness of fluoride-related public health policies. (Lowery et al.2021)(Chen et al.2021)(Fellows et al.2022)(León & Giacaman, 2022)

5.2. Gaps and Challenges in Implementation

The third step in the policy analysis framework is to identify gaps in existing policies and challenges associated with the implementation of identified policies. The assessment of these gaps and challenges is guided by questions on barriers to the effective execution of policies, cases where policies have failed to achieve desired outcomes, and factors influencing the disparity in policy adherence across different regions. Several reasons account for the barriers to the effective execution of policies. First, some policies are poorly resourced, with insufficient funds allocated to the necessary initiatives to deliver on policy commitments. For instance, although fluoride varnish is inexpensive and effective in preventing caries among preschool children, the Saudi government has not committed sufficient funds to its implementation (A. Algarni et al., 2022). Second, the public is often skeptical of some policies. For example, community water fluoridation is dismissed by some as a µmass medication¯ and its safety and effectiveness questioned by others, leading public health authorities to employ experts to advocate for it and assuage public concerns. A third reason for policy implementation barriers is inadequate engagement with community stakeholders. For instance, low compliance among mothers with the policy of providing preschool children with fluoride varnish applications is associated with a lack of understanding of its need, and resulting lower treatment rates in private clinics are seen as a more acceptable alternative. The importance of policy stakeholders is underscored by the argument that public health policy effectiveness can be enhanced by the collaboration of policy makers with affected communities and other stakeholders. Nevertheless, there is a need to critically assess the community engagement employed in policy efforts to ensure that good intentions do not exacerbate health inequalities. Some policies may fail to achieve desired outcomes when good intentions are not matched by well-informed actions. For example, although dental caries in the primary dentition among five-year-olds declined significantly following the national fluoride varnish programme, its implementation was poorly planned and resourced, limiting its effectiveness. Policies might also succeed in some regions but fail in others when interventions are introduced without careful consideration of local communities and their needs. For instance, community water fluoridation has been abandoned in some areas of a country or jurisdiction where it was once widely adopted and considered successful when local community members resisted it. In this regard, it is noted that strategies to address community concerns about fluoride should be adapted for each community rather than using a one-size-fits-all approach. With the provision of basic epidemiological and contextual information about the community, it is also suggested that advocacy efforts that previously succeeded in one community be replicated elsewhere. To address the above challenges associated with policy implementation, recommendations are made to improve the execution of fluoride policies. For poorly resourced policies, the recommendation is to ensure that adequate resources are committed to implementing policies from the outset. To ensure engagement with all relevant community stakeholders, it is suggested that public health advocates be well-informed about the community to be engaged and do not make assumptions about the community's needs or capacity. To improve understanding of some policies among affected communities, it is recommended that the policy be explained in accessible language and that community members after whom a policy is named and who play key roles in its implementation be visibly involved in advocacy. Finally, to avoid the disparity in policy implementation success across jurisdictions, it is suggested that policies be adapted to the local context rather than introduced uniformly across jurisdictions. Overall, this part highlights areas needing attention for policy formulation and successfully implementation policy interventions aimed at the control and prevention of dental caries.

6. Conclusion

Fluoride and Caries Prevention: A Scoping Review of Public Health Policies in Saudi Arabia 6. Conclusion Saudi Arabia introduced public health policies on the use and distribution of fluoride to promote dental health in 1988. Since then, fluoride dentifrices have been made available to communities free of charge through schools and primary health care facilities. The findings of this scoping review demonstrate that despite the efforts and availability of fluoride treatments in healthy public policy environments, several obstacles prevent the community from accessing them. Most treatment initiatives are school-based, which risks excluding communities outside school boundaries, specifically targeting 6-12-year-old children and missing out on other vulnerable groups. For treatment initiatives to be effective, ongoing evaluation of their efficacy and adaptation to community needs are essential. Most treatment policies do not incorporate a monitoring framework, while those that do focus on clinical outcomes rather than public health goals. The preliminary scoping review of fluoride and caries prevention public

health policies in Saudi Arabia provides a useful overview to guide future research on policy efficacy. Initiated policy responses should be analysed for their impact, and ongoing research is needed on the appropriacy and accessibility of community fluoride treatments. Simple recommendations to improve community access to fluoride treatments and initiatives include greater involvement of health care centres outside schools, development of take-home treatment packs, and training of community nurses to perform treatments. Finally, while reviewing the policies, an important area for future research is the impact of public education on the success of fluoride interventions. Without efforts to inform the public about the health risks associated with caries and the efficacy of fluoride in preventing these risks, the treatment will likely go unused. Policy lessons from recent research in Fiji suggest attempts to ensure health is prioritised in all policies should include advocacy, lobby and negotiation as well as the presentation of evidence (R Alshammari et al., 2021). This scoping review is expected to promote research and dialogue between stakeholders on how best to improve dental health outcomes from fluoride and caries prevention policies in Saudi Arabia.

6.1. Summary of Key Findings

This section presents a summary of the key findings obtained from conducting the scoping review. A brief overview of the most relevant public health policies considering fluoride application is included, as well as information on their objectives regarding dental health in Saudi Arabia. The consideration of policy effectiveness relating to successes and failures in resolving the caries problem is also addressed, along with some key insights obtained during the research. The most significant policies and general thoughts on their effectiveness are discussed, as well as epidemiological data on the caries problem and considerations regarding fluoride accessibility . Finally, the recap of main analytical themes from previous sections is present, along with reinforcing thoughts on progress made or not made in controlling dental caries in Saudi Arabia.

Nine public health policies focusing on the application of fluoride were found. The earliest policy was published in 1996 and initially focused on some dental health topics. However, its scope has been gradually refined and narrowed down to fluoride application since 2012. Most public health policies were issued by the Saudi Ministry of Health, but two were published by health directorates in specific cities. General thoughts on the relevance and effectiveness of public health policies were considered. Overall, public health policies on fluoride application are generally well elaborated and relevant to current dental health issues in Saudi Arabia. However, policies focusing on professional fluoride application and community education need more elaboration. The critical gap in policy implementation is the lack of community education on fluoride use; hence, there is no public awareness of its benefits and risks.

Epidemiological data on dental caries prevalence in Saudi Arabia is reviewed. The prevalence of dental caries has been discovered to increase with age and was found to be 91.7% in 12-year-old children. It is thought that still significant gaps remain in policies implementation, especially in education community about fluoride use. Progress has been made since the implementation of policies regarding fluoride accessibility; however, considering policy objectives and the still high prevalence of dental caries, additional actions are required. Moreover, an important risk factor for dental caries is considered to be low socio-economic status, and in Saudi Arabia cities, where it is lower than in urban areas, caries prevalence is higher compared to cities with higher socio-economic status.

6.2. Implications for Future Research and Practice

A scoping review of public health policies related to fluoride in drinking water and salt in Saudi Arabia and the Gulf Cooperation Council countries was conducted in response to the growing concerns about dental health among children. Despite the enactment of fluoride policies, there are still uncertainties about their coverage and implementation. In light of this, the findings of the review are discussed, along with the implications for future research and practice. It is crucial to continue exploring the impact of fluoride and other innovative approaches to make fluoride policies more effective. Although policies related to fluoride in drinking water, salt fluoridation, and fluoride toothpaste are in place in Saudi Arabia, low tooth preservation rates and high dental treatment costs indicate the need for more effective policies (A. Algarni et al., 2022). Further studies are recommended to investigate the socio-economic influencers of dental health and the correlation between school performance and community outreach fluoridation programs. Community outreach programs in collaboration with local governments are essential to ensure access to public health services and education. Therefore, the collaboration of health professionals, policymakers, and the community is vital to promoting wider and more comprehensive oral health initiatives. Fluoride makes natural water resources less contaminated, as geo-chemical conditions make them more fluoridated, and optimal fluoride improves caries prevention. However, the public continues to misunderstand the benefits and risks of fluoride. To improve public understanding of the benefits of fluoride, educational resources should be developed targeting the

audience's social and cultural backgrounds. In particular, children's voices should be included to raise awareness. Educational resources should also promote a multi-disciplinary approach in collaboration with engineers, sociologists, and teachers to effectively tackle dental caries, which is the most prevalent disease globally. Finally, existing policies on fluoride use should be improved at different levels of governance for better health outcomes. For example, community and local government policies on water service management should be better linked to public health policies on dental health.

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