Review

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Socioeconomic factors associated with xylitol use as a behavior related to oral health: a literature review

Fatores socioeconômicos associados ao uso de xilitol como comportamento relacionado à saúde bucal: uma revisão de literatura

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ABSTRACT

Identify in literature the influence of socioeconomic factors in the access to xylitol and find the effects of this sugar with regards dental caries; verify its potential as a behavior related to oral health. Searches were conducted in database Pubmed, between March and June in 2023, with MeSH terms “Epidemiology” and “Socioeconomic Factors” articulated with each other by means of boolean operator “OR”. These terms were articulated with the MeSH term “Xylitol” through boolean operator “AND”. Filters

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artigo alinhado ao objetivo Boa saúde e Bem-estar dos Objetivos de Desenvolvimento Sustentável (ODS)

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weren't applied. 86 results were evaluated on this narrative review of which 14 were included after steps of selection. The xylitol benefit effects to control of dental caries were reported in so many studies, through mechanisms such as the salivary stimulation and reduction of Streptococcus mutans levels. The xylitol access is limited to the socioeconomically advantaged people, specially to its high cost. The chewing gum was the main way to use xylitol in popularization strategies of this product. Xylitol access facilitation in an economic view is basal to this product will not act as an aggravating of oral health iniquities. Xylitol must be a tool able to reduce dental caries problems and the health system overload.

Indexing terms: Xylitol. Oral health. Socioeconomic factors.

RESUMO

Identificar na literatura a influência dos fatores socioeconômicos no acesso ao xilitol, constatar os efeitos desse açúcar no que tange à doença cárie; verificar o seu potencial enquanto hábito associado à saúde bucal. Foram feitas buscas na base de dados PubMed, entre os meses de março a julho de 2023, com a utilização dos descritores MeSH "Epidemiology" e "Socioeconomic Factors", articulados entre si pelo operador booleano "OR" e, simultaneamente, esses dois termos foram relacionados com o descritor "Xylitol" através do operador booleano "AND". Filtros de busca não foram aplicados. Obteve-se 86 resultados para serem avaliados nesta revisão narrativa, dos quais 14 foram incluídos após as etapas de seleção. Os efeitos benéficos do xilitol para o controle da cárie dentária foram relatados em vários estudos, mediante mecanismos como a estimulação da salivação e a redução dos níveis de Streptococcus mutans. O acesso a esse item fica restrito às pessoas socioeconomicamente favorecidas, especialmente pelo seu custo elevado. A goma de mascar foi o principal veículo de utilização do xilitol em estratégias de popularização desse produto. A facilitação do acesso ao xilitol do ponto de vista econômico é fundamental para que ele não atue como um agravante das iniquidades em saúde bucal e sim como uma ferramenta capaz de auxiliar na redução das mazelas relativas à cárie dentária e à sobrecarga dos sistemas de saúde.

Termos de indexação: Xilitol. Saúde bucal. Fatores socioeconômicos.

INTRODUCTION

Dental caries is a multifactorial disease that occurs through the interaction of microorganisms organized in the form of dental biofilm and the availability of fermentable sugars [1] for a certain period of time [2]. It consists of a dynamic process, characterized by periods of demineralization and remineralization of hard dental tissues, which culminates in the carious lesion, the clinical sign of the disease [3,4]. In this context, especially due to undisciplined sugar consumption, changes occur in the biofilm microbiota, characterizing an imbalance and consequent net loss of minerals [5,6]. Although dental caries is a totally controllable disease through preventive and interventional approaches [6], it has a high prevalence and is considered eradicable, being the second most common disease according to WHO data from 2017 [7].

Drawing a historical context, since the 1960s there has been a continuous decline in caries levels [8], mainly due to the fluoridation of public water supplies and the large-scale use of fluoridated toothpastes [9]. According to the latest data published by SB Brasil, a national survey, the disease affects more than half of Brazilian children up to the age of 5, 76% of adolescents aged between 15 and 19 and almost all adults [10]. According to data from the World Health Organization (WHO), it is the most common chronic non-communicable disease globally, responsible for consuming between 5 and 10% of the health budget

in industrialized countries [7]. In this scenario, it should be noted that other risk factors are also related to dental caries, such as genetics, lifestyle, as well as socioeconomic and cultural aspects [11], which makes the distribution of the disease uneven across the territory, with a higher prevalence in more socioeconomically vulnerable populations [10].

In this context, the etiology of caries has also considered broader factors than the proximal ones, the so-called distal factors. Despite the need to disorganize bacterial plaque and reduce the intake of fermentable carbohydrates, light has been shed on the factors that predispose individuals to these behaviors, in other words, the causes of the causes [6]. Thus, aspects such as social status are also important [9], so that the aforementioned decline in caries levels is accompanied by the polarization of the disease in less privileged groups [12]. In this scenario, it is important to look for complementary alternatives to the health promotion strategies already in place, in order to achieve greater control of caries disease in the population.

In light of this, there is interest in the study of xylitol (C5H12O5), a natural sweetener that has a molecule made up of five oxyhydriles, each linked to a carbon atom, giving this compound the name of acyclic polyhydroxyalcohol or pentiol [13]. According to the literature, in addition to xylitol being a substitute for sucrose because it has important anticariogenic mechanisms, it also has a positive systemic impact on other conditions such as kidney and parenteral lesions, hemolytic anemia, acute otitis media, osteoporosis, respiratory infections, inflammatory processes and even diabetes [14]. However, obtaining xylitol is difficult because it is found in minute quantities in nature in vegetables, fruit and mushrooms, making its extraction unfeasible [15]. Thus, although biotechnological processes are being researched, xylitol is obtained on a large scale through industrial chemical processes, which generates a high-cost product [16] and makes it impossible to popularize.

It is therefore necessary to understand the dynamics of the use of this compound, which, precisely because it is expensive, ends up being related to socio-economic factors, which should be investigated in order to popularize this product. Therefore, this study aims to identify in the literature the influence of socioeconomic factors on access to xylitol, in order to verify the effects of this sugar not only in terms of caries disease, but also as a habit associated with oral health.

METHODS

The method adopted was a narrative literature review. To this end, searches were carried out in the PubMed database between March and July 2023, using the Mesh descriptors “Epidemiology” and “Socioeconomic Factors”, linked together by the Boolean Operator “OR” and, simultaneously, these two terms were related to the descriptor “Xylitol” using the Boolean operator “AND”. No search filters were used.

The inclusion criteria adopted consisted of articles that explored the use of xylitol- whether related to the prevention of dental caries or not- and the presence of considerations about socioeconomic aspects or other epidemiological determinants - as a way of broadening the search - associated with access to xylitol. At the same time, review-type studies and the lack of attention to the association between the determinants visualized by epidemiological data and access to xylitol were the exclusion criteria used. In addition, a manual search was carried out for references based on the articles selected and in the Scielo, Lilacs and Google Scholar databases.

RESULTS

It obtained 86 results to be evaluated on this literature review. The studies were selected according to title and abstract analysis, such that 29 articles were eligibles to full reading, after exclusion of deviations from the objectives of the research. Of these, 6 had the text unavailable; of the remaining 23, 14 were included in the review.

In view of this, 6 studies [17-22]2 focused on evaluating chewing gum as a mechanism for the use of xylitol and discussed the positive effects on salivation stimulation and the reduction of Streptococcus mutans levels in preschool-aged children, as well as providing descriptive statistics on changes in caries disease associated with its use. Similarly, 5 articles [23-27] evaluated alternative methods of xylitol administration- especially aimed at the pediatric population- such as lozenges, oral syrup, candies, and milk. Finally, the remaining 3 articles [28-30] addressed, respectively, health-related behaviors of unemployed and employed individuals and the differences in xylitol consumption between these groups, root caries in the context of xylitol use, and the effectiveness of an oral health promotion program- based on the use of xylitol- in Finland.

In order to present the results clearly and succinctly, the selected articles were synthesized through the table below.

Table 1. Main results obtained in the review.

Authors; Title	Objectives	Results/Conclusion
Mäkinen et al. [17]; Polyol chewing gums and caries rates in primary dentition: a 24-month cohort study	Obtaining information on the effect of using chewing gums with xylitol and sorbitol on caries rates.	The study participants were divided into groups in order to test sorbitol and xylitol against a control group. The individuals who used the xylitol chewing gum had a high caries experience, low fluoride availability, and difficulties accessing dental care. Although data on the characteristics of the portion of the sample that did not receive xylitol or sorbitol chewing gum were not collected, it is believed they were people with better conditions. Nevertheless, the groups that received these interventions showed lower levels of dental caries.
Mäkinen et al. [18]; Xylitol chewing gums and caries rates: a 40-month cohort study	Investigating longitudinally the effect of chewing gum use on dental caries levels in individuals initially 10 years old living in Belize.	Chewing gums with mixtures of xylitol and sorbitol were less effective when compared to the use of xylitol alone. The systemic use of polyol-based chewing gums reduces caries rates in young individuals. The group that showed the best results was the one that used xylitol gum 5 times a day. In this sense, xylitol is a good option even when the consumption of sugary foods is high and access to preventive and restorative dental treatments is limited.

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Authors; Title	Objectives	Results/Conclusion
Mäkinen et al. [19]; A descriptive report of the effects of a 16-month xylitol chewing-gum programme subsequent to a 40-month sucrose gum programme	Providing descriptive statistics of Belize City regarding the changes in dental caries rates observed after a period (16 months) of extensive use of xylitol chewing gum (up to 14 grams daily per child).	There was a reduction in the DMFT index, resulting in a significant change, mainly in component D (of decayed teeth), which reflected the stabilization of the carious process, making the carious lesions non-progressive.
Seki et al. [20]; Effect of xylitol gum on the level of oral mutans streptococci of preschoolers: block-randomised trial	Evaluating the influence of chewing gum consumption with xylitol on *Streptococcus mutans* levels in Japanese preschoolers aged 3 to 4 years.	Until 1997, xylitol was not permitted to be used as a sugar substitute in Japan. The popularization of this product is occurring gradually. In the context of the study, fluoride availability was limited. The consumption of chewing gum over a 3-month period is effective in controlling *Streptococcus mutans* in dental plaque in 3- and 4-year-old children. Interestingly, in this study, 10% of the children in the xylitol group had diarrhea as a side effect, a proportion much higher than what is described in the literature.
Kandelman et al. [21]; A 24-month Clinical Study of the Incidence and Progression of Dental Caries in Relation to Consumption of Chewing Gum Containing Xylitol in School Preventive Programs	Investigating whether the daily consumption of xylitol chewing gum can be easily integrated and if it provides an additional benefit in existing oral health prevention programs.	Chewing xylitol gum has shown to provide a beneficial effect on the carious process on all types of dental surfaces, especially on buccal-lingual surfaces. In this way, the study demonstrated a significant reduction in the incidence of caries disease with the additional use of xylitol chewing gum in a school prevention program in Montreal, Canada.
Honkala et al. [22]; Chewing of xylitol gum--a well adopted practice among finnish adolescents	Describing the changes in Finland regarding the use of xylitol chewing gum, as well as other types of gum, between the years 1977 and 1991, using comparable and nationally representative surveys. Additionally, to identify the subgroups that adopted xylitol gum more extensively.	The daily use of xylitol chewing gum did not vary according to socioeconomic level or degree of urbanization. The growth in xylitol gum use proved to be an example of the positive effect of health education, which was provided by a comprehensive and preventive dental healthcare system aligned with commercial interests. It is concluded that, in the past, the habit of chewing gum was considered harmful due to the cariogenic effect of sucrose present in gum, in addition to being regarded as an improper habit in many regions. However, it is noted that the inclusion of xylitol in chewing gum redefined the act of 'chewing gum' as a healthy choice and as a preventive measure against carious lesions, given that

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Authors; Title	Objectives	Results/Conclusion
	Furthermore, to study the possible side effects of xylitol.	many teenagers already chew gum routinely, thus combining the habit with health prevention.
Chi et al. [23]; Milk sweetened with xylitol: proof-of-principle caries prevention randomized clinical trial	Evaluating the effectiveness of xylitol-sweetened milk as a preventive strategy for caries among school-aged children.	The participants were at high risk for caries, making fluoride and the availability of dental care as complements to xylitol indispensable. Risk factors require adequate public policies for the implementation of these strategies. Xylitol-sweetened milk reduced *Streptococcus mutans* levels but did not decrease caries rates compared to sorbitol or sucrose-sweetened milk. Nevertheless, it is a promising strategy for comprehensive dental caries prevention in school-aged children.
Olak et al. [24]; Caries prevention with xylitol lozenges in children related to maternal anxiety. A demonstration project	Comparing the effect of a dental caries prevention program with xylitol lozenges between children of mothers with anxiety and those without anxiety.	More anxious mothers had more decayed teeth, higher smoking rates, lower education levels, worse hygiene habits, and visited the dentist less frequently. No significant differences were found in dental caries between the children of anxious and non-anxious mothers who used xylitol; however, the number of caries-free children in the intervention group was higher than in the control group (which did not use xylitol). All high-risk children benefited from the use of xylitol, regardless of maternal anxiety.
Milgrom et al. [25]; Xylitol pediatric topical oral syrup to prevent dental caries: a double blind, randomized clinical trial of efficacy	Evaluating the effectiveness of a pediatric topical oral xylitol syrup in reducing the incidence of dental caries in young children and to observe the effect of xylitol on reducing acute otitis media in a subsequent study.	Xylitol is effective for the prevention of caries in deciduous teeth. However, caution should be exercised when using xylitol in children, as it may exacerbate the innate preference for sweet taste, which is already more common in individuals from low socioeconomic backgrounds. Nevertheless, xylitol is very important for the prevention of dental caries, and strategies are needed to enable its application at the population level, especially in social groups with high caries rates, where these interventions are likely to be cost-effective.
Alanen et al. [26]; Xylitol candies in caries prevention: results of a field study in Estonian children	Testing xylitol candies as preventive agents for caries in schoolchildren with erupting permanent teeth.	The occurrence of dental caries is related to socioeconomic factors. In this sense, the use of xylitol in schools for a period of 2 to 3 years was able to equalize the annual increase in dental caries between the groups that initially had higher and lower caries rates. The doses of xylitol used were lower than those in other studies and demonstrated excellent effectiveness. The best timing and duration of xylitol use should also be further investigated. Xylitol chewing gums and candies are effective in preventing dental caries. School distribution systems can be a practical way to control and use xylitol products, and a 3-month break for the summer holidays did not eliminate the

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		preventive effects. It is an alternative especially for populations with limited access to dental services but with well-functioning schools. However, cost-effectiveness calculations depend on longer follow-up periods than those conducted in studies so far.
Meurman et al. [27]; Oral health programme for preschool children: a prospective, controlled study	Evaluating the preventive effect of a risk-based oral health program (OHP) versus a traditional OHP focused on the occurrence of dental caries in Finnish preschool children. The program established for children with *Streptococcus mutans* colonization consisted of repeated motivation, oral health education, and at-home use of xylitol lozenges.	In the studied population, *Streptococcus mutans* colonization in dental biofilm and the occupation of the caregiver or guardians were strongly associated with dental caries in children up to 5 years old. The risk-based oral health program, which even included the use of xylitol lozenges, appeared to have a better preventive effect in white-collar families than in blue-collar families. Thus, it was concluded that additional support and different methods for promoting oral health are necessary for families with blue-collar workers.
Ritter et al. [28]; Risk indicators for the presence and extent of root caries among caries-active adults enrolled in the Xylitol for Adult Caries Trial (X-ACT)	Identifying associations between baseline data and two different dependent variables: the presence of any root caries and the extent of root caries.	Further studies on the subject are needed to develop and validate risk models with large samples in longitudinal follow-ups of high-caries-risk participants, in order to obtain more effective results regarding the efficacy of daily xylitol lozenge use in reducing the increment of coronal and root caries in caries-active adults and children. In this regard, several determinants must be taken into consideration.
Al-Sudani et al. [29]; Association of current employment status with oral health-related behaviors: findings from the Finnish Health 2000 Survey	Comparing the oral health-related behaviors (OHRBs) of unemployed individuals with those of employed individuals. Additionally, to assess whether OHRBs differed according	Current unemployment indicated irregular dental attendance among individuals, infrequent use of xylitol, daily smoking, risky alcohol use, and less beneficial OHRBs. Thus, it was concluded that unemployed individuals may constitute a risk group for oral health problems and associated health behaviors. Therefore, further research and oral health promotion programs should be conducted with a focus on this population group.

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Authors; Title	Objectives	Results/Conclusion
	to the duration of unemployment, considering demographic and socioeconomic factors.	
Tolvanen et al. [30]; Children's oral health-related behaviors: individual stability and stage transitions	Between 2001 and 2005, a community-level oral health promotion program was targeted at all 11- to 12-year-old children residing in Pori, a city in Finland. Thus, the study aimed to describe individual stability and transition stages concerning behaviors among the children of Pori exposed to this program.	Behaviors are quite stable in childhood, especially positive ones, and it is evident that individuals who learned healthy behaviors at a young age are likely to maintain them during adolescence. Furthermore, any lapses into inappropriate behaviors during adolescence tend to be temporary in children who previously learned healthy behaviors. Regarding the use of xylitol products, the percentages for this behavior were not as strong, as the recommendation to use it three times daily is quite demanding and relatively recent. Additionally, improving xylitol use requires parents or children to purchase the product, which makes maintaining this habit more challenging.

DISCUSSION

This narrative literature review aimed to evaluate access to and use of xylitol according to socioeconomic variables. According to the studies reviewed, it was generally observed that individuals with higher socioeconomic status have greater access to and use of this sugar.

The use of xylitol in oral health promotion is not recent in some regions of Europe, such as Finland, a nation with a high Human Development Index (HDI) and one of the most developed economies in the world, according to the United Nations (UN) [31]. A study [32] conducted in the country demonstrated that the use of this sugar alcohol in a school program was equivalent to a sealant application program on pits and fissures in preventing carious lesions. Additionally, xylitol-based chewing gum has long been one of the primary forms of utilizing this compound among the young Finnish population. A nationally representative survey from 1998 revealed that approximately 45% of boys and 63% of girls aged 11, 13, and 15 had a daily habit of chewing xylitol gum [22].

The production cost of xylitol can be up to 10 times higher than that of conventional sugar (sucrose), which limits the consumer market for this product [15]. In these cases, production occurs via the conventional chemical method, which requires a large amount of energy and, consequently, is a significantly costly process14. On the other hand, the biotechnological method uses microorganisms for xylitol synthesis,

requiring less energy and potentially becoming a more economically viable alternative. In this regard, raw materials such as sugarcane and cassava can be used to obtain xylitol [33,34]. However, further research is still needed regarding these techniques.

In Brazil, xylitol has been included in various products by exploring its anticariogenic action and refreshing taste in desserts, chewing gums, jellies, candies, chocolates, toothpaste, mouthwashes, in addition to being used in the pharmaceutical industry in syrups and vitamins, for example [14]. However, there is still a lack of educational programs and studies that demonstrate the application of xylitol in the prevention and promotion of oral health in Brazil, an emerging country, and even in first-world countries, making its research and discussion highly necessary.

The prevalence of dental caries is influenced by contextual inequalities in Brazilian children, which makes the implementation of prevention strategies in health important [35]. The use of daily doses of xylitol is a good alternative for the prevention of caries, especially in this age group [36], as it is essential for the incorporation of healthy habits, including dietary ones [37]. In this sense, the intake of small daily amounts of xylitol – approximately 0.8 g – is already sufficient to reduce the levels of Streptococcus mutans, with a higher concentration – around 3.4g – being able to enhance the beneficial effects regarding dental caries [38]. Due to being an easy-to-execute proposal, culturally accepted, and potentially widespread, the use of xylitol-based chewing gums, candies, or lozenges has been studied as a means of popularization to promote oral health and, consequently, prevent carious lesions by stimulating saliva production and promoting the remineralization of dental structure, as well as inhibiting dental biofilm accumulation [19,20,24,26,28,38]. Other methods are also being researched, such as xylitol-sweetened milk [23], pediatric oral syrup containing xylitol [25], and the incorporation of xylitol into toothpaste in sufficient quantity to achieve the beneficial effects of this sugar [39]. Thus, the school is an environment with potential for the establishment of oral health promotion strategies, including through xylitol, via its different forms.

However, the need for xylitol to be purchased and made available for use makes it difficult to achieve its beneficial effects at the population level [30]. Due to its high cost, its use ends up following the law of inverse care, which defines that the availability of beneficial resources is inversely proportional to the health needs of the population [40]. Thus, based on the results of the 2000 Finnish Health Survey, the study by Al-Sudani et al. [29] associated the current employment status of Finns with oral health and found that unemployment was linked to infrequent use of xylitol, constituting a risk group associated with oral health problems and health-related behaviors. Another study conducted with a population of Finnish children [27] linked the type of work of caregivers or guardians to the use of xylitol lozenges, as it was found that white-collar families (office workers) had a better preventive effect from the proposed health program compared to blue-collar families (individuals engaged in heavy manual labor), who require greater support for oral health promotion.

The main limitations of the research lie in the study type, as a literature review depends on already published materials; the lack of specific articles on the influence of socioeconomic conditions on access to xylitol, with most of the information being extracted from articles that focused more on other aspects of the product; the intrinsic differences in the locations of the articles' production, as the realities of Brazil and Finland, for example, are completely different regarding the use of xylitol; and finally, the need to evaluate older articles due to the scarcity of current scientific literature on the topic, in which even concepts related to the etiology of dental caries are outdated, with conclusions needing to be considered carefully during the review process. As a result, future research should more deeply examine the feasibility of using xylitol in the Brazilian context and also take into account the influence of distal determinants in this dynamic.

CONCLUSION

Xylitol can be implemented for the prevention of dental caries, since it has relevant beneficial results and is considered a behavior related to oral health. However, due to its high cost, its availability is often restricted to socioeconomically privileged people. In this sense, xylitol needs to be popularized so that it does not perpetuate itself as an agent that amplifies oral health inequalities between low and high-income individuals. More studies are needed to evaluate the cost-benefit ratio of using xylitol in its different dosages and use strategies, in order to consider socioeconomic issues in this analysis and obtain the best possible results in reducing dental caries and the burden on health systems.

Collaborators

MZ Scheuermann, project administration, conceptualization, writing, proofreading and editing, research. DO Almeida, writing, proofreading and editing, research. JK Knorst, supervision, visualization, research, writing.

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