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Contextual socioeconomic determinants of tooth loss in adults and elderly: a systematic review

Determinantes socioeconômicos contextuais das perdas dentárias em adultos e idosos: uma revisão sistemática da literatura

Paulo Roberto Barbato[I], Karen Glazer Peres[I,II]

ABSTRACT: *Objective:* To perform a systematic review regarding studies that investigated the association between contextual socioeconomic factors and tooth loss. *Methods:* MEDLINE, Embase, and LILACS databases were searched and no language or date restrictions were applied for this research. The search was also carried out at the Brazilian Library of Theses and Dissertations (BDTD), with the objective of seeking unpublished studies. We evaluated the bibliographical and methodological characteristics of the studies, as well as the findings. *Results:* We found 348 articles, out of which only 6 were included in this study after revision by 2 independent researchers. We also identified an unpublished thesis. In general, these results show that the socioeconomic context interferes in tooth loss. We found an association between the highest number of missing teeth with less favorable contextual variables, despite the weak evidence, due to the fact that all selected studies had a cross-sectional design. *Conclusion:* We suggest the standardization of outcome formats and exposures in order to favor the comparison between studies and their quantitative analysis.

Keywords: Tooth loss. Socioeconomic factors. Social conditions. Health inequalities. Oral health. Review.

[I]Graduate Program in Public Health, Center of Health Sciences, *Universidade Federal de Santa Catarina* – Florianópolis (SC), Brazil.
[II]Australian Research Centre for Population Oral Health, Dental School, University of Adelaide – Adelaide, Australia.
Corresponding author: Karen Glazer Peres – Australian Research Centre for Population Oral Health, School of Dentistry, The University of Adelaide, 122, Frome Street, Postal code 5000, Adelaide, Australia. E-mail: karen.peres@adelaide.edu.au

RESUMO: *Objetivo:* Realizar revisão sistemática de estudos que investigaram a associação entre os determinantes socioeconômicos contextuais e as perdas dentárias. *Métodos:* Foram pesquisadas as bases MEDLINE, Embase e LILACS, sem restrição ao tempo de publicação e ao idioma. Também foi realizada busca na Biblioteca Brasileira de Teses e Dissertações (BDTD), com o objetivo de buscar estudos não publicados. Foram avaliadas as características bibliográficas e metodológicas dos estudos, além dos resultados encontrados. *Resultados:* Foram identificados 348 artigos. Após avaliação por dois pesquisadores independentes restaram seis artigos incluídos na revisão, além de uma tese com resultados não publicados. Os resultados da revisão indicam que o contexto socioeconômico do local de moradia interfere nas perdas dentárias dos indivíduos, de maneira geral, associando-se ao maior número de dentes perdidos quando as variáveis contextuais são menos favoráveis aos moradores, apesar da fraca evidência, uma vez que todos os estudos selecionados tinham delineamento transversal. *Conclusão:* Sugere-se a padronização das formas de apresentação do desfecho e exposições, favorecendo a comparação entre os estudos e a análise quantitativa dos mesmos.

Palavras-chave: Perda de dente. Fatores socioeconômicos. Condições sociais. Desigualdades em saúde. Saúde bucal. Revisão.

INTRODUCTION

Tooth loss is caused by the aggravation of some oral conditions. The dental caries, its main cause, affects the adult[1,2] and the elderly population[3], including root lesions[4]. Periodontal disease is also an important cause of tooth loss among elderly men and women[1,2,5].

Despite the decreasing prevalence and severity of cavities, in many situations the extraction is still the main alternative of treatment, in extreme cases representing 100% of the procedures offered by the public network[6]. Thus, the overtreatment effect[7] and the accumulation of cavities during the life cycle[8] may also contribute to the occurrence of tooth loss.

Tooth loss is an outcome resulting directly from oral diseases, for it may also be influenced by individual social and behavioral factors[9], including the use of dental care services[10], habits such as smoking, oral hygiene, inadequate nutrition, as well as psychosocial factors[11]. Therefore, tooth loss is a marker of oral conditions, representing a complex interaction between social and biological factors[12].

Tooth loss becomes a matter of concern when considering the inequalities in the distribution among the different segments of society[13]. Inequality in oral health is a universal phenomenon, considering that the highest levels of severity are found in poorer areas, regardless of the development of socioeconomic status[14]. It is also of great relevance to understand that the causes of health inequalities are complex and multifactorial, and that the

effect of the socioeconomic condition is mediated by environmental exposure, psychosocial and behavioral factors and availability of health services[15].

As a result, it is necessary to recognize and distinguish which effects on health are a result of where people live in, the so-called contextual effects, and those which are characteristics of individuals living in different places, that is, the compositional effects[16]. The context where people live in represents much more than just a physical location. It is a result from socioeconomic, cultural and geographic conditions, resulting in risks or benefits to these people's health. In this logic, the interrelationship between the household and the neighborhood becomes the synthesis of the combination between different social, economic, structural, demographic and geographic factors, which may affect the life and health of people[17].

Assuming that tooth loss is a reflex of socioeconomic inequality, which is very clear in the individual level[1,18-24], it is important to know the contextual influences on this loss, which has been a theme of studies found in the literature. However, there is no systematic review that provides a qualitative and quantitative synthesis on the subject. The objective of this study was to review the scientific literature, in order to answer to the question of the research: are the contextual socioeconomic factors associated to dental loss among the adult and elderly population?

METHODS

STUDY DESIGN

It is a systematic review consisting of "a method to locate, evaluate and synthesize the evidence from relevant and valid primary studies in order to obtain safe answers to specific questions"[25].

OUTCOME

In the scientific literature, we searched for studies presenting partial or total tooth loss as outcomes and approaching the association between these contextual socioeconomic variables.

SEARCH STRATEGY AND SELECTION CRITERIA

In order to carry out this review, we performed a search through the scientific literature, in June 2013, in the electronic databases of MEDLINE (by PubMed), Embase and LILACS (*Literatura Latino-Americana e do Caribe em Ciências da Saúde*). Initially, a search strategy was defined for articles indexed in MEDLINE using controlled terms (MeSH – *Medical Subject Headings*). When the terms were not included in the MeSH, the expression (TIAB) was used to restrict the research to terms found in the title or abstract of the selected references.

According to these criteria, the search key was: *(("adult"[mesh] OR "aged"[mesh]) AND ("residence characteristics"[mesh] OR "neighborhood"[TIAB] OR "environment"[TIAB] OR "contextual"[TIAB] OR "contextual factors"[TIAB]) AND ("tooth loss"[mesh] OR "mouth, edentulous"[mesh] OR "edentulism"[TIAB] OR "edentulousness"[TIAB])).* For the advanced search in Embase, search limits were included in the basis itself, once it also performs searches in MEDLINE; in humans and focus fields, restricted to public health, the following format remained: *'adult' OR 'aged' AND ('residence characteristics' OR 'neighborhood' OR 'environment' OR 'contextual' OR 'contextual factors') AND ('tooth loss' OR 'mouth, edentulous' OR 'edentulism' OR 'edentulousness') AND [public health]/lim AND [human]/lim AND [embase]/lim.* For LILACS the search strategy followed the pattern: *("adult" OR "aged" AND "residence characteristics" OR "neighborhood" OR "environment" OR "contextual" OR "contextual factors" AND "tooth loss" OR "mouth, edentulous" OR "edentulism" OR "edentulousness") AND db:("LILACS").* There was no restriction of time or language of publication for any of the analyzed bases. After the search, results were stored in the EndNote X5 (Thomson Reuters) software, where a tool to identify Double references was used.

INCLUSION AND EXCLUSION CRITERIA

Inclusion criteria of the studies were: they had to be observational epidemiologic, cross-sectional or longitudinal studies; use the multilevel modeling for data analysis; the researched subjects had to be adults and/or elderly and the study had to approach the relationship between contextual socioeconomic factors and tooth loss. The excluded studies did not use the previewed modeling for data analysis and had dental cavities or DMFT as an outcome.

DATA EXTRACTION AND SYNTHESIS

Data selection was performed by two independent researchers, initially by reading the titles of the studies selected; when the title was not sufficient for the inclusion criteria, the abstract was read. The disagreemens in selection was discussed between the researchers, after the full articles were read, and their inclusion or exclusion was defined by consensus.

Additionally, all references of the selected articles were read, in search for possible studies to be included in the review. A search in the Brazilian Library of Theses and Dissertations (BDTD) (http://bdtd.ibct.br) was carried out to find theses or dissertations whose product had not been published. Using the advanced search tool in the portal, in the subject 'field' the following search criteria was inserted: *"perda de dente" OR "tooth loss"*.

After the studies were selected, they were fully read with the same objective of extracting information for the review. For such, we elaborated a chart in Microsoft Excel 2010 (Microsoft),

where we registered: the authors, the institution the first author was from, the journal that published it, the year of publication, the place and the year of the study. There were also data on the type of study, type of sample, size of the sample, age of the participants, studied outcome, contextual variables, type of statistical analysis, associations found and main conclusions. The information was organized in tables.

From the data extracted, we organized a database with the information, which was analyzed by the software Stata 11.2 (Stata Corp) and presented in frequency and proportion. In a table, we also collected and registered the associations found with the different contextual exposures, the association measure, according to the variables selected for each study. The directions of the associations were classified as positive (when directly proportional) and negative (when inversely proportional). When there was no association, the information was also registered.

EVALUATION OF THE QUALITY OF STUDIES

To verify the quality of the selected studies, the evaluation criteria of Downs and Black[26] were used, adapted for cross-sectional studies[27], from where the specific criteria for clinical trials were extracted, totaling 23 adequacy criteria. Thus, the studies got scores for each criterion, varying from 0 to 1, except for criterion 5, which varied from 0 to 2, with the possibility of receiving the maximum of 24 points.

RESULTS

The search in the databases identified 348 articles that met the criteria on the search key. There was a consensus between researchers for the exclusion of 340 articles and the inclusion of 5 articles[28-32]. There was no agreement regarding the inclusion of two articles. Each research proposed the inclusion of one article, and after the reading of their abstracts and considerations, they decided for the inclusion of a new article[33] and consequently the exclusion of another one[34]. After the selection by researchers, six articles meeting the inclusion criteria remained. All references of the articles were verified in search of possible studies that could be eligible. After the abstracts were read, no other studies were included. Also, a search in the database of theses and dissertations was performed, and a thesis with unpublished results was identified and included in the review[35]. The search details are presented in Figure 1.

According to the quality criteria, the scores of the analyzed studies ranged from 11 to 23, with mean of 20.4 and standard deviation (SD) 4.4. Table 1 presents the proportions and adequacy of the studies, according to the criteria of Downs and Black[26].

Table 2 presents the bibliographic characteristics of the studies. Publications on dental loss and contextual factors in literature are recent (from 2007 onward), considering that 42.8% were published in 2009. As the country of origin of the study, considering the institution the first author was from, Brazil concentrates most of them (57.1%). The mean of the studied samples was 9,158.1 (SD 8,450.4). Considering the age of the participants, for the 7 studies included in the review, the medians of the minimum and maximum ages were 40 and 44 years of age, respectively.

All the studies were cross-sectional and the most common form of outcome presentation was number of teeth reported by the participants. Three studies were populational-based, two for Brazil as a whole and one for the state of Rio Grande do Sul; two others included adults living in Adelaide, Australia. The contextual variables presented great diversity, which were characteristic for each study (Table 3).

Variations in the contextual level of aggregation of participants were found. With some very specific characteristics, such as in the study by Aida et al.[30], who used their own spacial unit: the Kyuuson. The studies in Australia[28,29] used postal codes as reference for the neighborhood (Table 4).
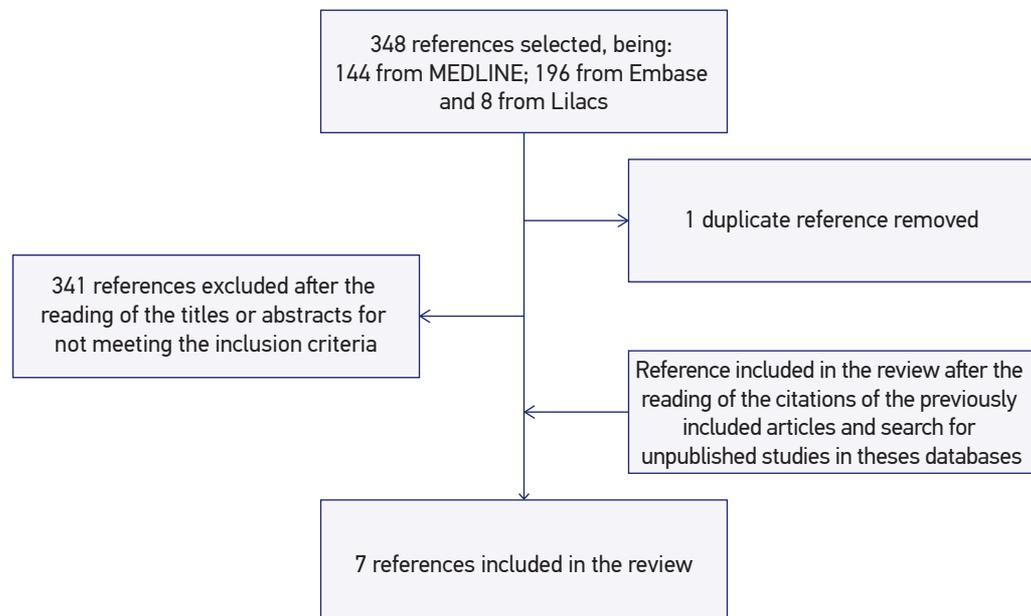
Analysis of the factors associated with tooth loss among the adults in eastern São Paulo. PhD thesis by Julie Silvia Martins. Dental School. Universidade de São Paulo, 2009.

Figure 1. Flowchart of study selection.

Table 1. Proportion of adequacy of the selected study (n = 7) to the quality evaluation criteria, proposed by Downs and Black.

Criterion	% of adequacy
Description of the study	
Is the hypothesis/objective described with clarity?	100.0
Are the main results to be measured described clearly in the Methods or Introduction section?	85.7
Well defined inclusion criteria?	71.4
Is the intervention of interest described clearly?	100.0
Are the confounding factors described clearly?	85.7
Are the main conclusions of the study described clearly?	85.7
Does the study provide estimates on the random variability of the data for the main results?	100.0
Is there description of loss?	71.4
Were the values of real probability reported for the main results?	100.0
External validity	
Are the subjects selected for the study representative of the whole population from which they were selected?	71.4
Are the subjects selected for the study representative of the whole population from which they were selected?	71.4
Internal validity	
Was there an attempt to blind the subjects of the study for the intervention they have undergone?	100.0
Was there an attempt to blind the evaluators?	100.0
If any of the results of the study was based in "data dredging ", was it clear?	100.0
Was there adjustment for the follow-up time?	100.0
The statistical tests used to evaluate the main results appropriate?	
Was the fulfilling of the intervention reliable?	85.7
Were the measures used for the main outcomes accurate (valid and reliable)?	85.7
Selection bias	
Were the patients from the different intervention groups (trials and cohort studies) or the case and control groups (case-control studies) selected in the same population?	100.0
Were the subjects from the different intervention groups (trials and cohort studies) or the case and control groups (case-control studies) selected in the same period of time?	100.0
Was there appropriate adjustment for the confounding factor in the analysis from which the main findings were taken?	85.7
Were the losses of patients in follow-up taken into account?	57.1
Power of the study	
Was the power of the study presented?	–

Table 2. Bibliographic characteristics of the studies included in the review, size of the sample and age of the participants.

Characteristic	n	%
Year of publication		
2007 – 2008	2	28.6
2009	3	42.8
2010 – 2011	2	28.6
Institution of the first author		
Instituto Aggeu Magalhães	1	14.2
Queensland University of Technology	1	14.3
Tohoku University	1	14.3
Universidade Estadual do Rio de Janeiro	1	14.3
Universidade de São Paulo	1	14.3
Universidade do Vale do Rio dos Sinos	1	14.3
University of Michigan	1	14.3
Journal		
Acta Odontologica Scandinavica	1	14.3
Cadernos de Saúde Pública	1	14.3
Community Dentistry and Oral Epidemiology	1	14.3
Journal of Dental Research	1	14.3
Social Science & Medicine	2	28.5
Not published	1	14.3
Country of study		
Australia	1	14.3
Brazil	4	57.1
United States of America	1	14.3
Japan	1	14.3
Sample size		
Minimum – maximum	241 – 22,839	
Mean (standard deviation)	9158.1 (8450.4)	
Median	5560	
Age of the participants		
Minimum: mean (Standard deviation)	42.3 (10.6)	
Minimum: median	40	
Maximum: mean (stanrdar deviation)	53.3 (15.7)*	
Maximum: median	44*	

*The study by Aida et al.[30] presents 14 individuals aged 85 years old or older, however without identifying the maximum age. For this reason we used 85 years of age as the maximum age.

Table 3. Characteristics of the study included in the review.

Lastname of the first author	Year of publication	Location of the study	Minimum age	Maximum age	Size of the sample	Design of the study	Outcome	Contextual variable(s)
Aida et al.[30]	2009	Aichi	65	≥ 85	5,560	Cross-sectional	Number of self-referred teeth.	Vertical and horizontal social capital.
Celeste et al.[33]	2009	Brazil	35	44	22,839	Cross-sectional	Edentulism	Gini índex and inequality coefficient of municipal income
Koltermann et al.[32]	2011	Rio Grande do Sul	35	44	16,316	Cross-sectional	Presence of 20 or more teeth in the mouth.	Mean schooling of the municipality; fluoridated water availability time and location of the household.
Martins[35]	2009	São Paulo	40	40	241	Cross-sectional	Presence of 20 or more teeth in the mouth.	23 variables*
Moreira et al.[31]	2010	Brazil	35	44	13,431	Cross-sectional	Number of teeth lost.	Number of dentists per thousand inhabitants; rate of extractions performed by the public service and population size of the municipality.
Sanders et al.[29]	2008	Adelaide	43	58	2,860	Cross-sectional	Number of self-referred teeth.	IRSD (divided into 3 categories: wealthy, intermediate and poor neighborhoods).
Turrell et al.[28]	2007	Adelaide	43	58	2,860	Cross-sectional	Number of self-referred teeth.	IRSD (divided into deciles).

*23 variables classified into three groups: *Characteristics of the households* (building material of the houses; average number of rooms; density in the household; presence of houses without electricity; garbage collecting in all houses; tap water in every home; all houses connected to the sewage system; some houses use cesspools; some houses with open sewage); *socioeconomic and demographic characteristics* (proportion of families with health insurance; proportion of families participating in cooperatives; proportion of families which took part in some kind of religious group; proportion of families which took part in associations; proportion of families which took part in a social group; proportion of families which use just one car; proportion of children under 5 years of age; proportion of elderly (60 years of age or more); proportion of illiterate individuals with 15 years of age or more) and *characteristics regarding the health of registered individuals* (proportion of alcoholism in individuals with 15 years of age or more; proportion of individuals with 15 years of age or more who have physical disabilities; proportion of individuals with 15 years of age or more who have diabetes; proportion of individuals with 15 years of age or more who have hypertension and pregnant teenagers). IRSD: Index of Relative Socioeconomic Disadvantage.

Table 4. Characteristics of the contextual level used in the studies associated with tooth loss.

Study	Contextual level	Contextual variable category	Direction of the association	Measure of association	Magnitude of the association	95%CI
Aida et al.[30]	Kyuuson*	Low vertical social capital	Not associated	–	–	–
		Low horizontal social capital	Positive	OR	1.25	1.03 – 1.52
Celeste et al.[33]	Municipality	Gini index	Not associated	–	–	–
Koltermann et al.[32]	Municipality	Average schooling level ≥ 5.2 years of study	Positive	OR	1.72	1.17 – 2.53
		Fluoridated water availability time ≥ 10 years	Positive		1.78	1.32 – 2.40
		Living in urban area	Positive		1.23	1.09 – 1.39
Martins[35]	Areas	≥ 4.5% illiterate with 15 or more years of age	Positive	OR	2.45	–
	Micro-areas	Prevalence of ≥ 1.25% of alcoholism in people older than 14 years of age	Positive		2.30	–
Moreira et al.[31]	Macro-region	Number of dentists per thousand inhabitants over the median (> 0.98)	Negative	Means ratio**	0.91	0.86 – 0.97
	State	3rd tertile of extraction rates	Positive		1.13	1.05 – 1.22
	Municipality	Municipality with more than 100 thousand inhabitants	Negative		0.87	0.82 – 0.93
Sanders et al.[29]	Postal Code ***	Poor neighborhood	Negative	Regression coefficient	-1.97	-2.75 – -1.18
Turrell et al.[28]	Postal Code ***	1st decile of IRSD	Negative	Regression coeficient	3.56	1.27 – 4.85

*Kyuuson is the second smallest measure of spacial unit in Japan. Usually, Kyuuson have common and temple sanctuaries, such as a church. **It is the measure of the resulting effect of the exponential negative binomial log-linear regression coefficient. ***They are geographic divisions with the objective of delivering mails, with sense and meaning of neighborhood to the residents. OR: *Odds ratio*; IRSD: Index of Relative Socioeconomic Disadvantage.

In general, all studies pointed out the association between worse conditions in the context with higher number of teeth lost, or even with the worst condition, edentulism, confirmed by the direction of outcome associations with the variables of contextual exposure.

DISCUSSION

The results in the review indicate that the socioeconomic outcome of the household may contribute with tooth loss of adults and the elderly, in general, associated to the higher number of teeth lost when contextual variables are less favorable to residents of the location.

The choice of conducting a systematic review on tooth loss and household context resulted in the possibility of accessing, in an orderly and summarized manner, the available evidence. It also constitutes an important tool for public health research[36], thus justifying its use. Another considered aspect was the possibility of identifying the possible generalization of the results between populations or specific groups[37].

Despite the coherence found in the results selected for the review, the quality of the evidence coming from these results is weak, once all studies are cross-sectional, not allowing a temporal evaluation of the sequence regarding how the events in the study occurred. This moderate evidence could be stronger with longitudinal studies presenting association of causes between the socioeconomic characteristics of the household and tooth loss. It is important to consider that the contextual influence of earlier ages on life[38], as well as the condition of family life[39,40], may have an impact on the outcomes of adult life. The possibility of changing households during their lives, or even changes in the socioeconomic and environmental characteristics of the place itself must be considered[41], once all household contexts are rather sensitive to economic and social policies[42]. Therefore, the impact of these situations on the cycle of life could be measured by longitudinal studies.

Studies using fewer variables follow the same premises on multilevel modeling, which is a parsimonious inclusion of variables in the models of analysis, by the need of explanatory hypothesis for each predictive variable, as well as possible cross-level interactions[43]. In the study by Martins[35] this postulate apparently was not considered, once many variables of the contextual level seem not to have an explanation. Besides, unlike the remaining studies, the Stepwise Forward Selection Procedure was used with the variables being ordered by statistical significance. A theoretical model was not created to define data entry, considering p-value < 0.20 for the univariate analysis and their inclusion in the final model.

In general, the associations found between tooth loss and contextual variables, regardless of the aggregation level of the context, maintained the focus when the outcome was more lost teeth or damage. All effect measures were adjusted for potential confounding factors.

Some studies tested cross-sectional interactions. Celeste et al.[33] tested the interactions between the municipal GINI index with the income in the same contextual level, as well

as the individual one. In a study with the Brazilian population[31] the interaction proved that residents with better socioeconomic conditions living in contexts with worse indicators presented more tooth loss when compared to those with similar socioeconomic conditions, living in places with betters indicators. In another study with the Australian population[29], the interactions point out to the poorer residents in wealthier contexts having fewer lost teeth than their similar ones in poorer contexts.

Even considering the quality of evidence in the studies incorporated in this review, it is noticeable that tooth loss is an indicator of health that is rather sensible to socioeconomic conditions, both individual and contextual ones. It is also worth to mention that the phenomenon occurs regardless of the aggregation level of the contextual information.

Some limitations must be considered for this study. The Brazilian analyses were based on data from the national survey of oral health, from 2003[31-33] with lack of sample weight; however, the use of multilevel modeling, when partitioning the variances, minimized this lack. Turrell et al.[28] informed a response rate of 69.4%, which may cause bias, affecting the inference of the results for the population in general. Low response rates were also observed in the studies of Martins[35] and Aida et al.[30], of 56.8 and 49.9%, respectively, considering that the first study also presented bias in the selection of the participants, once they were selected from the records of the Primary Health Care Information System (*Sistema de Informação da Atenção Básica* – SIAB) in the health units from the researched area. Another aspect that could contribute with selection bias would be possible errors in notifying household addresses. We also have to consider the amplitude of the definition of contexts, considering that we used large national macro-regions and areas equivalent to contexts that are smaller than neighborhoods, and this makes it difficult to standardize contextual characteristics.

Another limitation was the heterogeneity of variables, both for the characteristics of the context, since there are many ways of approaching socioeconomic status, and in the method used to measure tooth loss: self-reported, teeth counting or use of the functional dentition (more than 20 teeth). Despite being considered a limitation, all forms of tooth loss presented are found in the literature, including the validation of those self-referred ones[44-47] and functional dentition[9,48-50].

The cross-sectional design also has implications on the results of the review. However, it is important to observe that cross-sectional studies have a simpler design, require shorter execution time and the costs are lower when compared to other designs of epidemiologic studies, which, in some way, would justify their prevalence in the literature researched.

A possible limitation of this review could be the use of only three electronic research databases. Their use aimed at reducing possible publication biases, with the inclusion of Embase and LILACS as a strategy to identify studies in languages other than English, as well as the research of journals which are not indexed in MEDLINE. Another possible limitation may be the lack of quantitative data synthesis through meta-analysis. The lack of options is owed to the different forms to present the outcome and the measures of effect used, which made it impossible to execute this step[25].

Some positive aspects of the review may be highlighted, such as the search for unpublished references in databases of theses and the selection of studies by two independent researchers, with the objective of minimizing the possible exclusion of relevant analyses. There were no limitations regarding language, as well as time of publication, reducing the possibility of bias.

In order to qualify further studies on the theme of this review, it is suggested that standardization methods be used in the presentation of both the outcome and the exposure variables in the household context, allowing better comparisons between the studies and analyses that allow inference to other populations.

The results of the systematic review indicate that poorer socioeconomic status in the household is positively associated with the higher number of lost teeth by individuals living there. From the characteristics of the studies included in this review, it is important to mention the need for further longitudinal studies with the objective of identifying, in cause-and-effect relationships, if the socioeconomic characteristics of the household location interferes in the pattern of tooth loss, which may subsidize the public policies to modify the life context of the people and, similarly, their oral health conditions.

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