Systematic Review
Social/Community Dentistry

Assessment of the contextual effects on the prevalence of periodontitis: a systematic review

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Abstract: This study reviews the influence of contextual factors on periodontitis based on a systematic search of studies recorded in the PubMed, Scopus, Web of Science, and EMBASE databases. Periodontitis was assessed by clinical attachment loss and probing depth for studies with data on the socioeconomic status (SES) of a specific area (area-level SES) or dental care service (service-level) in a catchment area among individuals aged 18 and over. Two independent reviewers performed study selection, data extraction, and assessment of methodological quality. Of the 646 articles identified, 13 were included in the systematic review, representing 101,362 individuals from five countries (USA, UK, Brazil, China, and Uruguay). A higher prevalence of periodontitis was described in lower SES neighborhoods, more deprived postcodes, and poorer provinces. Gini Index results were mixed and inconclusive. Three studies showed that higher coverage of primary dental care at the municipal level was associated with a lower prevalence of periodontitis. Contextual factors at the area-level SES and dental care service might influence periodontitis, but the existing evidence is unclear. The contextual effect is important for periodontal health and may contribute to the prevalence of periodontitis, independent of well-known risk factors and individual levels.

Keywords: Periodontitis; Residence Characteristics; Dental Care; Social Class.

Introduction

Periodontitis is a destructive disease that affects the supporting structures of teeth, characterized by cumulative inflammatory processes induced by bacterial biofilm.[1] It is highly prevalent and the second most frequent cause of tooth loss, and the second leading oral health problem worldwide.[2,3] Periodontitis presents a varied pattern in different populations with a complex diagnosis. Among other factors, its prevalence is influenced by the case definition and dental examination protocols.[4]

Periodontitis affects mixed-age strata around the world. The World Health Organization (WHO) reports that the severe manifestation of the disease affects 5 to 20% of the global adult population, and at least 80% of adolescents show signs of gingivitis.[5,6] In Brazil, data from the Oral Health National Survey 2010 shows that periodontitis assessed by the community periodontal index (CPI) is concentrated in adults

between 35–44 years old, where 15% and 7% are affected when its moderate and severe forms are assessed, respectively.[7,8] In the United States, it was estimated that 46% of adults aged 30 years and over have periodontitis, with 37.1% presenting a moderate form and 8.9% a severe form of the disease.[9] Studies conducted in the United Kingdom showed that 48% of Scottish adults are affected by periodontitis,[10] and in Germany, 44% of individuals aged 20 to 70 years have moderate or severe periodontitis.[11]

Risk assessment studies have focused on factors attributed to characteristics at the individual level.[12,13,14] However, some studies have shown the importance of including contextual factors in assessing oral health conditions in populations, of which periodontitis stands out as one of the main outcomes.[15,16,17]

Context factors are a combination of elements, ranging from physical, social, and environmental aspects of the living environment such as leisure areas, adequate housing, health service availability, neighborhood social cohesion, and air and water quality. Elements in a context can expose individuals to conditions of stress and coping mechanisms affecting their health.[18-20] The context results from economic, cultural, structural, and geographical conditions, and the relationship between these elements and characteristics affects individual health status via chronic stress mechanisms either through long term hormonal effects or health-related behaviors.[21- 24]

There is evidence that contextual factors have some role in periodontal diseases. The relationship of contextual factors with periodontal disease can be understood as an association of an area variable that influences individual-level risk factors for periodontal diseases such as smoking, oral hygiene, and stress, and it may help identify interventions at the area level to improve oral health.[16] The literature shows that socioeconomic context, such as area deprivation and low income, has received more attention regarding the association with periodontal disease.[9,10,24,25] However, some studies have described inconsistent effects of other factors on periodontitis, including the exposure to environmental tobacco smoke,[26] lack of basic sanitation,[17] income inequality,[7,15,27,28] public health expenditure, poor distribution of dentists, and reduced access to oral health care.[16]

Despite some original studies, there is no systematic compilation of what contextual factors have been studied and what effects they have on periodontitis. This study fills this knowledge gap by systematically assessing the association of contextual factors with periodontitis.

Methodology

This systematic review was conducted in compliance with the preferred reporting items for systematic review and meta-analysis (Prisma) 2020 guidelines and is registered with Prospero (protocol number: CRD42020136634).

Eligibility criteria

The following inclusion criteria were considered for studies to be eligible for the systematic review: (a) ecological studies; (b) cohort or cross-sectional studies that use multilevel analysis. Articles using any index of periodontitis were accepted for the diagnosis of the outcome, and no restriction to language or year of publication was used. However, case reports, narrative reviews, nonhuman studies, and studies evaluating children were excluded.

Search strategy and study selection

The focused question that guided the search strategy was: *"Do contextual factors affect the prevalence of periodontitis?"* The question was broad to identify contextual factors in the current literature and to summarize their association with periodontitis. An electronic search was performed in four databases: a) PubMed, b) Scopus, c) Web of Science, and d) EMBASE. The search strategy was based on patient/population, intervention, comparison, and outcomes (PICO) and used the following terms:

a. Population: adult and older individuals
b. Intervention/exposure: any contextual factors, any level of aggregation
c. Study design: multilevel analysis or ecological studies
d. Outcome: periodontitis
e. (#1 AND #2 OR #3 AND #4)

The strategy was updated, including publications up to November 2019, and is presented in Figure. A broad search strategy was undertaken to maximize the identification of relevant studies. Mendeley library and Rayyan were used to integrate and store all retrieved titles and abstracts from different databases. Studies with potential information were selected for full-text reading and data extraction. Reference lists of included studies were searched manually to identify studies until no new titles were identified.

Outcome and exposure variable

For this review, the outcome was the occurrence of periodontitis assessed by clinical attachment loss (CAL) or periodontal probing depth (PPD). Exposure was comprised of variables assessing area-level factors such as (a) socioeconomic status (SES) or deprivation indices, (b) Gini index, (c) human developed index (HDI), (d) coverage of primary dental care, and (e) overall coverage of dentist/population ratio. We included factors measured at the neighborhood, municipal, province, or country levels.

Data extraction and risk of bias

Two reviewers (LVF and WK) independently selected studies based on title and abstracts to verify if they met the inclusion criteria for full-text reading. The complete text was read in case of insufficient information in titles and abstracts. A previously tested form was used for data extraction that included the following information: Title of the study, authors, publication year, country, language, study type, population group, age group, periodontal diagnosis, contextual exposure, contextual level, sample size at the contextual and individual level, covariables used for adjustment, and effect measure. Disagreements were resolved by discussion between LVF and WK and including RKC in those where an accord could not be reached.

No meta-analysis was performed because different exposures cannot be collapsed. Nonetheless, a measure of association was extracted from each study. A qualitative analysis considered the magnitude of association, linear effect gradient in ordered categories, and statistical significance.

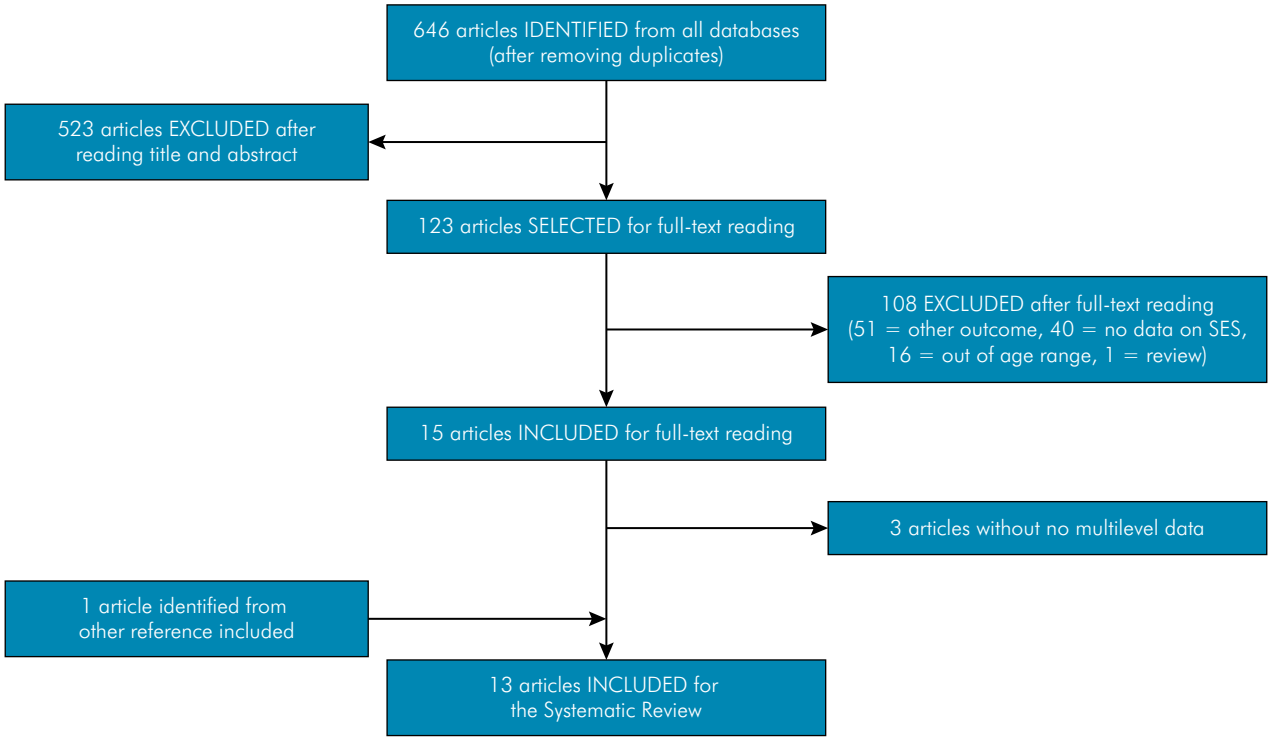

Figure 1. Flowchart outlining the search strategy and results along the step

Methodological assessments of each included study were performed as recommended by the Newcastle-Ottawa Scale (NOS) for observational studies. The following criteria were considered for each study: representativeness of the sample, sample size justified, response rate, exposure calibration, comparability in outcome groups (adjusted for confounders), and outcome (evaluated by the assessment of outcome tool and a statistical test). A percentage score was established for each study representing the number of items present (Table 1).

Results

A total of 1083 records were identified through the searching of electronic databases: PubMed (n = 353), Scopus (n = 159), Web of Science (n = 360), and EMBASE (n = 211). A total of 437 records were excluded as duplicates, leaving 646. After reviewing the titles and abstracts, 123 were selected for full-text reading, after which 13 were selected for inclusion in the systematic review. Details of the identification, selection, eligibility, and reasons for inclusion and exclusion are presented in Figure.

Characteristics of the study and quality assessment

The main methodological characteristics of the included studies are presented in Table 2. Their publication dates ranged from 2006 to 2018, and they included a total of 101,362 individuals. Most included individuals aged between 35-44 years, and two studies[7,29] used the same population sample and age group. The included studies were performed in five countries (Brazil, USA, UK, China, and Uruguay), and all defined periodontitis based only on PPD. The methodological quality of included studies varied from moderate (NOS score = 6) to high quality (NOS score = 10), with 84% of studies deemed of good quality, with NOS scores ≥ 7.

Main findings

Tables 2 and 3 present the primary outcome of the included studies according to two categories of contextual exposures: area-level SES[7,10,15,16,24,28-35] and service level.[7,16,28,33,35] Studies that estimated area-level SES (Table 3) described a higher odds ratio (OR) of periodontitis to the lowest neighborhood SES[24] with OR=1.73 (95% confidence interval [CI]: 1.29–2.32), most deprived postcode with OR=7.60 (95%CI: 0.48–119.2),[10] and poorest province with OR=1.31 (95%CI: 1.21–1.42).[34] Eight studies addressed the impact of the Gini Index and HDI, showing that greater income inequality was inconsistently associated with periodontitis.[7,15,16,20,28,29,33,35] However, one study showed that countries with greater inequality had more frequent severe PPD (*P*earson's r = 0.510; p < 0.05).[32]

Three multilevel studies[7,28,35] observed that municipalities with a medium level of population coverage (25–50%) of primary dental care had lower probabilities of periodontitis with OR = 0.40 (95%CI: 0.20–0.80), OR = 0.62 (95%CI: 0.44–89), and OR=0.80 (95%CI: 0.39–1.63), respectively, in comparison to municipalities that had a lower level of coverage (< 25%; Table 4). Another multilevel study performed in China[16] reaffirmed the association between CAL and dental access among adults and older individuals, reporting OR = 0.81 (95%CI: 0.69–0.95) and OR = 0.86 (95%CI: 0.78–0.95), respectively.

Discussion

The current systematic review sheds light on two knowledge gaps. Firstly, it shows that only a few contextual factors have been studied. Secondly, it compiles the current associations between those factors and periodontitis. This study showed that area-level SES, including HDI, may be associated with periodontitis, given that the findings of the included studies were consistent. The contextual effect of access to dental care on periodontitis is small and unclear, but living in disadvantaged neighborhoods and deprived areas appears to increase the probability of having periodontitis. However, it is unknown which individual-level factors are confounders and mediators. Therefore, adequate control is unclear. Different adjustments have been used, and the SES effect of the area-level variable appears to remain.[10,24,31]

The findings of included studies suggest that middle to high coverage of primary dental care

Table 1. Quality assessment of included studies according to NOS.

Publication	Sample selection (5 stars)				Comparability (2 stars)	Outcome (3 stars)	Total
	1. Representativeness of the sample: a+, random or all subjects; b+, non-random; c, selected groups; d, no description.	2. Sample size: a+, justified and satisfactory; b, not-justified.	3. No respondents: a+, comparability and response rate satisfactory; b, comparability and/or response rate unsatisfactory; c, no description.	4. Ascertainment of the exposure (risk factor): a++, validated measurement tool; b+, non-validated measurement tool, but is available or described; c, no description of measurement tool.	Subjects in outcome groups comparable: a +, study controls for most important confounder; b +, study controls for any additional confounder; c, study did not control for any confounder; d, no comparison group.	Assessment of the outcome: a++, independent blind; b++, record linkage; c+, self-report; d, no description. Statistical Test: a+, clearly described and appropriate; b, not described, not appropriate, or incomplete.	
Borrell et al., 2006	a+	a+	a+	a++	a+ b+	a++ a+	10
Borrell et al., 2006	a+	a+	c	a++	a+ b+	b++ a+	9
Bower et al., 2007	a+	a+	a+	a++	a+ b+	b++ a+	10
Sabah et al., 2010	d	b	c	a++	a+	b++ a+	6
Hobdell et al., 2003	d	b	c	a++	a+	b++ a+	6
Celeste et al., 2011	a+	a+	a+	a++	a+ b+	a++ a+	10
Vettore et al., 2013	a+	a+	c	a++	a+ b+	a++a+	9
Chalub et al., 2016	a+	a+	c	a++	a+ b+	a++ a+	9
Dalazen et al., 2016	a+	a+	c	a++	a+ b+	a++a+	9
Sun et al., 2017	a+	a+	a+	a++	a+ b+	a++ a+	10
Valente et al., 2017	a+	a+	c	a++	a+ b+	a++a+	9
Bomfim et al., 2018	a+	a+	c	a++	a+ b+	a++a+	9
Lorenzo-Erro et al., 2018	a+	a+	a+	a++	a+ b+	a++ a+	10

Table 2. Descriptive characteristics of included studies.

Author, year	Country	Population sample size	Age group	Main outcome	Blinded evaluation of outcome	Sample method	Contextual level	Covariates	Total of contextual units
Borrell et al., 2006[31]	USA	5677	45–64	Severe periodontitis (PPD > 5 mm + CAL > 6 mm)	Yes	Randomized	Neighborhood-level SES	Income, education	1000 residences
Borrell et al., 2006[24]	USA	13,09	≥1 8	Chronic periodontitis (2 sites with CAL > 4 and at least 1 site with PPD > 4 mm or more)	Yes	Randomized	Neighborhood-level SES	Race (ethnicity), income, and education	1126 census tract
Bower et al., 2007[10]	UK	632	≥ 16	PPD > 4 mm	Yes	Randomized	Deprivation-area level (index)[a]	Age, sex, income, and social class	346 household
Sabah et al., 2010[32]	UK	17	35–44	PPD> 6 mm	Yes	Randomized	Gini coefficient ratio between annual income of richest and poorest 20% of the population (20:20 ratio)	Gross domestic product (GDP) and national income (GNI)	17 countries
Hobdell et al., 2003[30]	UK	44	35–44	PPD > 6 mm	Not described	Not described	Gini Index (1990-1999) and HDI (1992)	Sugar, manufactured cigarettes, and civil strife/instability	44 countries
Celeste et al., 2011[15]	Brazil	13,405	35–44	CAL > 8 mm	Yes	Randomized	Gini index (2000)	Age, sex, place of residence, last dental visit, household income	250 municipalities
Vettore et al., 2013[7]	Brazil	9564	35–44	Severe periodontal disease [at least one sextant with PPD ≥ 4 mm (CPI > 2) and at least one sextant with CAL ≥ 6 mm (CAL >1)]	Yes	Randomized	MHDI, Gini index (2000), smokers (%), and OHT/PDC	Age, sex, race, family income, years of schooling	27 municipalities
Chalub et al., 2016[29]	Brazil	9564	35–44	Functional dentition (FD) in which FD class 6 corresponds to PPD or CAL >5 mm	Yes	Randomized	MHDI and fluoridation water supply	Gender, self-declared skin color, schooling, monthly household income, age group, self-rated treatment need, dental pain, dental appointment in the past 12 months, and dental services	177 municipalities
Dalazen et al., 2016[28]	Brazil	7619	65–74	PPD > 6mm	Yes	Randomized	MHDI, Gini, and SB/FHS	Sex, self-reported skin color, income, and need for treatment	32 municipalities
Sun et al., 2017[16]	China	Adults (20,204) and older individuals (9666)	35–44 65–74	PPD and CAL > 4 mm	Yes	Randomized	Gini, dentist to population ratio, and smokers (%)	Sex, ethnicity, place of residence, education level, equivalized income, toothbrushing frequency, last dental visit, and smoking status	31 provinces
Valente et al., 2017[33]	Brazil	Adults (6011) and older individuals (2369)	35–44 65–74	Accumulated attachment loss (AAL) using the following categories: 0-3 mm, 4-5 mm, 6-8 mm, 9-11 mm, ≥12 mm, and excluded sextant.	Yes	Randomized	Predisposing [b] (HDI and life expectancy) and Enabling b (OHT-PDC)	Age, sex, years of schooling, per capita monthly income, type of dental services, OIDP mean, dental treatment needs, time since last dental visit, and reason for last dental visit	27 municipalities
Bomfim et al., 2018[35]	Brazil	2332	> 65	PPD > 6 mm	Yes	Randomized	Gini, MHDI, and fluoridation	Gender, self-declare skin color, income, and age group	178 municipalities
Lorenzo-Erro et al., 2018[34]	Uruguay	Adults (223) and older individuals (455)	35–44 65–74	PPD and CAL > 4 mm	Yes	Randomized	Unsatisfied basic needs (UBN) [c]	Individual-SES (Sex, time since last visit), behavioral (heavy smoker, diet, drinking, and toothbrushing)	10 provinces

PPD: periodontal probing depth; CAL: clinical attachment loss. a) The deprivation-level index is based on four factors in the postcode sector: level of overcrowding in households; male unemployment; the proportion of social classes IV and V; and the proportion of persons in private households with no car. The index consists of seven categories (Depcat 1=least deprived to Depcat 7=most deprived). b) Predisposing was composed of HDI (human developed index) and life expectancy, while enabling was composed of population coverage by primary dental care and oral health care teams into primary care (OHT/PDC). In both dimensions of Anderson´s model, those contextual variables show a high correlation by Spearman´s and are tested by principal component analysis (PCA). c) Unsatisfied basic needs (UBN) was performed to measure socioeconomic deprivation using six dimensions as contextual variables: housing and minimum domestic, household equipment, sanitation facilities, access to education, electricity, and clean drinking water. The absence of one of these dimensions is considered a positive or lower case.

Table 3. Main outcomes [pooled odds ratio (OR) and confidence interval (95%CI)] for studies assessing the association between area SES-level and periodontitis.

Author, year	Country	Age group	Area-level SES	OR	95% CI	r	p-value
			Neighborhood-level SES				
Borrell et al., 2006[31]	USA	45–64	High	1			
			Medium	1.10	0.90-1.30*		
			Low	1.10	0.80-1.30*		
	USA	≥ 18	High	1			
			Medium	1.63	1.23-2.17*		
			Low	1.73	1.29-2.32*		
			Province-level SES				
Lorenzo-Erro et al., 2018[34]	Uruguay	35–44	Greater area-level (score1)	1			
			Lower area-level (score 2)	1.51	1.42-1.60		
		65–74	Greater area-level (score 1)	1			
			Lower area-level (score 2)	1.31	1.21-1.42		
			Postcode-level SES				
Bower et al., 2007[10]	UK	≥ 16	Least deprived area-level (score 1)	1			
			Most deprived area-level (score 7)	7.60	0.48-119.2*		
			Country-level SES (Gini/HDI)				
Sabah et al., 2010[32]	UK	35–44	Gini coefficient/GDP	-	-	0.55	0.03
			Gini coefficient/GNI	-	-	0.53	0.03
			20:20/GDP	-	-	0.62	0.01
			20:20/GNI	-	-	0.61	0.01
Hobdell et al., 2003[30]	UK	35–44	Gini Index (1990-1999)	-	-	0.25	<0.01
			HDI (1992)	-	-	0.23	<0.01
Celeste et al., 2011[15]	Brazil	35–44	Municipal- or province-level Gini/HDI				
			Gini (2000; every 10 points)	0.99	0.69-1.44		
Vettore et al., 2013[7]	Brazil	35–44	Gini (lower)	1			
			Gini (middle)	1.80	1.00-3.20		
			Gini (upper)	3.00	1.50-5.90		
Chalub et al., 2016[29]	Brazil	35–44	MHDI (<0.70)	1			
			MHDI (0.70-0.79)	1.16	0.99-1.37		
			MHDI (>0.80)	1.42	1.16-1.75		
Dalazen et al., 2016[28]	Brazil	65–74	Gini (lower)	1			
			Gini (middle)	1.02	0.68-1.55		
			Gini (upper)	0.64	0.41-1.00		
			MHDI (<0.7)	1			
			MHDI (>0.7)	1.09	0.64-1.88		
Sun et al., 2017[16]	China	35–44	Gini coefficient (%)	0.97	0.87-1.08		
		65–74	Gini coefficient (%)	0.98	0.92-1.05		
Valente et al., 2017[33]	Brazil	35–44 65–74	Predisposing (HDI/Life expectancy)	0.93[PR]	0.87-0.99		
Bomfim et al., 2018[35]	Brazil	> 65	Gini (lower)	1			
			Gini (middle)	0.75	0.39-1.40		
			Gini (upper)	0.90	0.50-1.65		
			MHDI (<0.7)	1			
			MHDI (0.70-0.79)	1.13	0.18-6.94		
			MHDI (>0.80)	0.53	0.07-1.91		

*p< 0.01; PR: prevalence ratio.

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1 ("adult"[MeSH Terms] OR "young adult"[MeSH Terms] OR "middle aged"[MeSH Terms] OR "aged, 80 and over"[MeSH Terms] OR "aging"[MeSH Terms] OR "elderly"[Title/Abstract] OR "ageing"[Title/Abstract] OR "older people"[Title/Abstract])

2 ("Residence Characteristics"[Mesh] OR census block*[Title/Abstract] OR census tract*[Title/Abstract] OR census region*[Title/Abstract] OR contextual approach*[Title/Abstract] OR contextual characteristic*[Title/Abstract] OR "contextual data"[Title/Abstract] OR contextual determinant*[Title/Abstract] OR contextual effect*[Title/Abstract] OR contextual factor*[Title/Abstract] OR contextual analys*[Title/Abstract] OR contextual feature*[Title/Abstract] OR contextual issue*[Title/Abstract] OR contextual variable*[Title/Abstract] OR contextual level*[Title/Abstract] OR municipal level*[Title/Abstract] OR neighborhood*[Title/Abstract] OR Neighbourhood*[Title/Abstract] OR state level*[Title/Abstract] OR Group level*[Title/Abstract] OR city level*[Title/Abstract] OR "Area based"[Title/Abstract] OR electoral ward*[Title/Abstract] OR "state variable"[Title/Abstract])

3 ("multilevel analysis"[MeSH Terms] OR "Small-Area Analysis"[Mesh] OR Multilevel regression*[Title/Abstract] OR Multilevel Approach*[Title/Abstract] OR Multilevel Stud*[Title/Abstract] OR Multilevel Analys*[Title/Abstract] OR multilevel model*[Title/Abstract] OR "multilevel logistic"[Title/Abstract] OR mixed model*[Title/Abstract] OR Ecologic Approach*[Title/Abstract] OR Ecologic Stud*[Title/Abstract] OR Ecologic Analys*[Title/Abstract] OR Ecological Approach*[Title/Abstract] OR Ecological Stud*[Title/Abstract] OR Ecological Analys*[Title/Abstract])

4 (periodontal disease [MeSH Terms] OR periodontit*[Title/Abstract] OR Pyorrhea [Title/Abstract])

Scopus

1 TITLE-ABS-KEY ("adult" OR "young adult" OR "middle aged" OR "aged, 80 and over" OR "aging OR elderly" OR "ageing" OR "older people")

2 TITLE-ABS-KEY ("Residence Characteristics" OR "census block* OR census tract* OR census region* OR "contextual approach* OR contextual characteristic* OR" contextual data* OR contextual determinant* OR contextual effect* OR contextual factor* OR contextual analys* OR contextual feature* OR contextual issue* OR contextual variable* OR contextual level* OR "municipal level*" OR "neighborhood* OR neighbourhood*" OR "state level*" OR "group level*" OR "city level*" OR "area based*" OR "electoral ward*" OR "state variable")

#3 TITLE-ABS-KEY ("multilevel analys*" OR "Small-area analys*" OR "Multilevel regression OR "Multilevel approach* OR Multilevel stud* OR multilevel model* OR multilevel logistic OR "mixed model*" OR "Ecologic approach*OR Ecologic stud* OR Ecologic analys* OR Ecological approach* OR Ecological stud* OR Ecological analys*")

4 TITLE-ABS-KEY ("periodontal disease" OR "periodontit* OR "Pyorrhea")

Web of Science

1 TS =("adult" OR "young adult" OR "middle aged" OR "aged, 80 and over" OR "aging OR elderly" OR "ageing" OR "older people")

2 TS =("Residence Characteristics" OR "census block* OR census tract* OR census region* OR "contextual approach* OR contextual characteristic* OR contextual data* OR contextual determinant* OR contextual effect* OR contextual factor* OR contextual analys* OR contextual feature* OR contextual issue* OR contextual variable* OR contextual level*" OR "municipal level*" OR "neighborhood* OR neighbourhood*" OR "state level*" OR "group level*" OR "city level*" OR "area based*" OR "electoral ward*" OR "state variable")

#3 TS =("multilevel analys*" OR "Small-area analys*" OR "Multilevel regression OR Multilevel approach* OR Multilevel Stud* OR Multilevel Analys* OR multilevel model* OR multilevel logistic*" OR "mixed model*" OR "Ecologic Approach*OR Ecologic Stud* OR Ecologic Analys* OR Ecological Approach* OR Ecological Stud* OR Ecological Analys*")

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#2- ('Residence Characteristics':ab,ti OR 'census block*':ab,ti OR 'census tract*':ab,ti OR 'census region*':ab,ti OR 'contextual approach*':ab,ti OR 'contextual characteristic*':ab,ti OR 'contextual data':ab,ti OR 'contextual determinant*':ab,ti OR 'contextual effect*':ab,ti OR 'contextual factor*':ab,ti OR 'contextual analys*':ab,ti OR 'contextual feature*':ab,ti OR 'contextual issue*':ab,ti OR 'contextual variable*':ab,ti OR 'contextual level*':ab,ti OR 'municipal level*':ab,ti OR 'neighborhood*':ab,ti OR 'neighbourhood*':ab,ti OR 'state level*':ab,ti OR 'group level*':ab,ti OR 'city level*':ab,ti OR' area based*':ab,ti OR 'electoral ward*':ab,ti OR 'state variable':ab,ti)

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#4- ('periodontal disease':ab,ti OR 'periodontit*':ab,ti OR 'Pyorrhea':ab,ti)

Figure 2. Search Strategy

Table 4. Main outcomes (pooled odds ratio [OR] and 95% confidence interval [CI]) for studies assessing the association between service level and periodontitis.

Author, year	Country	Age group	Service level	OR	95%CI
			Municipal coverage of primary dental care (OHT/PDC)		
Vettore et al. , 2013[7]	Brazil	35–-44	<25%	1	-
			25-50%	0.40	0.20–0.80*
			>50%	0.90	0.50–1.70
Dalazen et al., 2016[28]	Brazil	65–74	<25%	1	-
			25-50%	0.62	0.44–0.89**
			>50%	0.58	0.37–0.92
Valente et al., 2017[33]	Brazil	35–44 65–74	Enabling (OHT-PDC)	0.99[PR]	0.98–0.99*
Bomfim et al., 2018[35]	Brazil	> 65	<25%	1	
			25-50%	0.80	0.39–1.63
			>50%	0.97	0.49–1.91
			Province level dental services coverage		
Sun et al., 2017[16]	China	35–44	Dentist/population ratio [a]	0.81	0.69–0.95*
		65–74	Dentist/population ratio [a]	0.86	0.78–0.95**

*p < 0.05; **p < 0.01; PR: prevalence ratio; [a] Dentist-to-population is expressed per 10 million individuals.

may be associated with less periodontitis.[7,16,28,33,35] Nevertheless, some limitations of these studies should be addressed. Most were conducted in Brazil, using the same dataset, explaining their consistent findings. In addition, an absence of a gradient in the association was observed. It is unclear whether the effect of primary dental care coverage on periodontitis can be attributed to increased treatment access or preventive care provision. However, the Chinese study showed that greater access to dentists at the provincial level was inconsistent and weakly associated with periodontitis.[16] Indeed, the impact of dental care on dental caries has also been controversial, and broad social factors may play a more important role.[36] However, some contextual effects of preventive dental care on dental caries prevalence have been shown.[37] The impact of dental care on periodontitis at the population level has not been extensively studied. Therefore, future studies in this area are warranted.

The Gini index was inconsistently associated with periodontitis in most studies.[7,15,16,28,32,35] However, relevant limitations should be considered. Firstly, individuals must be exposed to those contextual risk factors for an unknown amount of time to accumulate risk before developing periodontitis. However, urban mobility between areas with different levels of exposure makes it difficult to obtain a precise assessment. Secondly, most of the included studies are cross-sectional, and their temporal relationship cannot be determined. Thirdly, we have few studies with a definitive conclusion, some were multilevel, but others were ecological, prone to the ecological fallacy.[30,32] One possible explanation for these different findings may be related to area size or uncontrolled confounding. It has been assumed that an association is more likely to be found in a large area.[38] Finally, previous studies claim that the association of Gini with dental caries and tooth loss could be explained by psychosocial factors[39] and public policies,[40] but the association between Gini and periodontitis remains unclear.

The level of evidence is weak concerning the methodological quality of the included studies. Moreover, there are only a few studies from a few countries, and this limits our ability to generalize because the evidence they generate lacks external

validity. The lack of clarity about confounding and mediator factors may lead to a spurious association between area-level SES indicators and periodontitis. The strength of the included studies is that most of them had representative samples and minimized selection bias since eleven were cross-sectio nal.[7,10,15,16,24,28,29,31,33–35] All thirteen included studies investigated the impact of contextual factors as the primary exposure to periodontitis. The present review included studies with different measures of CAL and PPD, a source of heterogeneity. These two criteria are being used equally for defining periodontitis. Eight studies used the CPI[7,15,28,29,33–35] and Community Periodontal Index of Treatment Needs (CPITN)[30] indexes, while the other five studies used their own indexes defined methodologically in their respective databases.[10,16,24, 31,32]

This review has limitations and strengths. The presence of cross-sectional studies is a limitation of this review, as it reduces the level of evidence. In addition, observational studies generally have a higher risk of bias and residual confounding, compromising the internal and external validity of results. However, its inclusion of data from representative samples of the general population is a strength.

In conclusion, SES factors and dental care at the area level may influence periodontitis. Nonetheless, current evidence is unclear, and further investigation is required. Longitudinal studies with community-based sampling are warranted, but a solid theoretical framework is necessary to clarify what variables are confounders and mediators both at the area and individual levels. Clinicians and policymakers must be cautious as current evidence is weak about the effects of the contextual provision of access and periodontitis, and an evaluation of population health policies is required.

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References

1. Van Dyke TE, Winkelhoff AJ. Infection and inflammatory mechanisms. J Clin Periodontol. 2013 Apr;40 Suppl 14:S1-7. https://doi.org/10.1111/jcpe.12088
2. Kassebaum NJ, Bernabé E, Dahiya M, Bhandari B, Murray CJ, Marcenes W. Global burden of severe periodontitis in 1990-2010: a systematic review and meta-regression. J Dent Res. 2014 Nov;93(11):1045-53. https://doi.org/10.1177/0022034514552491
3. Knight ET, Murray Thomson W. A public health perspective on personalized periodontics. Periodontol 2000. 2018 Oct;78(1):195-200. https://doi.org/10.1111/prd.12228
4. Demmer RT, Papapanou PN. Epidemiologic patterns of chronic and aggressive periodontitis. Periodontol 2000. 2010 Jun;53(1):28-44. https://doi.org/10.1111/j.1600-0757.2009.00326.x
5. Broadbent JM, Thomson WM, Boyens JV, Poulton R. Dental plaque and oral health during the first 32 years of life. J Am Dent Assoc. 2011 Apr;142(4):415-26. https://doi.org/10.14219/jada.archive.2011.0197
6. Levin L, Margvelashvili V, Bilder L, Kalandadze M, Tsintsadze N, Machtei EE. Periodontal status among adolescents in Georgia. A pathfinder study. PeerJ. 2013 Sep;1:e137. https://doi.org/10.7717/peerj.137
7. Vettore MV, de Marques RA, Peres MA. Social inequalities and periodontal disease: multilevel approach in SB-Brasil 2010 survey. Rev Saúde Pública. 2013;47 Suppl 3:S1-S11. https://doi.org/10.1590/S0034-8910.2013047004422
8. Celeste RK, Oliveira SC, Junges R. Threshold-effect of income on periodontitis and interactions with race/ethnicity and education. Rev Brasil Epidemiol. 2018;22:1-14. https://doi.org/10.1590/1980-549720190001
9. Eke PI, Zhang X, Lu H, Wei L, Thornton-Evans G, Greenlund KJ, et al. Predicting periodontitis at state and local levels in the United States. J Dent Res. 2016 May;95(5):515-22. https://doi.org/10.1177/0022034516629112
10. Bower E, Gulliford M, Steele J, Newton T. Area deprivation and oral health in Scottish adults: a multilevel study. Community Dent Oral Epidemiol. 2007 Apr;35(2):118-29. https://doi.org/10.1111/j.1600-0528.2007.00308.x
11. Zhan Y, Holtfreter B, Meisel P, Hoffmann T, Micheelis W, Dietrich T, et al. Prediction of periodontal disease: modelling and validation in different general German populations. J Clin Periodontol. 2014 Mar;41(3):224-31. https://doi.org/10.1111/jcpe.12208

12. Albandar JM. Global risk factors and risk indicators for periodontal diseases. Periodontol 2000. 2002;29(1):177-206. https://doi.org/10.1034/j.1600-0757.2002.290109.x
13. Genco RJ, Borgnakke WS. Risk factors for periodontal disease. Periodontol 2000. 2013 Jun;62(1):59-94. https://doi.org/10.1111/j.1600-0757.2012.00457.x
14. Oppermann RV, Haas AN, Rösing CK, Susin C. Epidemiology of periodontal diseases in adults from Latin America. Periodontol 2000. 2015 Feb;67(1):13-33. https://doi.org/10.1111/prd.12061
15. Celeste RK, Fritzell J, Nadanovsky P. The relationship between levels of income inequality and dental caries and periodontal diseases. Cad Saude Publica. 2011 Jun;27(6):1111-20. https://doi.org/10.1590/S0102-311X2011000600008
16. Sun X, Bernabé E, Liu X, Gallagher JE, Zheng S. Do contextual factors have a role in periodontal disease? J Clin Periodontol. 2017 Jan;44(1):13-21. https://doi.org/10.1111/jcpe.12630
17. Vazquez FL, Cortellazzi KL, Bulgareli JV, Brizon VSC, Zanin, L, Guerra LM, et al. Individual and contextual variables related to periodontal disease: multilevel analysis in underprivileged adolescents in Brazil. J Dent Health Oral Disord Ther. 2018;9(3):229-37. https://doi.org/10.15406/jdodt.2018.09.00383
18. Macintyre S, Maciver S, Sooman A. Area, class and health: should we be focusing on places or people? J Soc Policy. 1993;22(2):213-34. https://doi.org/10.1017/S0047279400019310
19. Diez-Roux AV. Neighborhoods and health: where are we and where do we go from here? Rev Epidemiol Sante Publique, 2007 Fev;55(1):13-21. https://doi.org/10.1016/j.respe.2006.12.003
20. Macintyre S, Ellaway A. Neighbourhood and health. In: Grham H, editor. Understanding health inequalities. Berkshire: McGraw-Hill Education; 2009. p. 84-100.
21. Wen M, Browning CR, Cagney KA. Poverty, affluence, and income inequality: neighborhood economic structure and its implications for health. Soc Sci Med. 2003 Sep;57(5):843-60. https://doi.org/10.1016/S0277-9536(02)00457-4
22. Cohen DA, Mason K, Bedimo A, Scribner R, Basolo V, Farley TA. Neighborhood physical conditions and health. Am J Public Health. 2003 Mar;93(3):467-71. https://doi.org/10.2105/AJPH.93.3.467
23. Ross CE. Walking, exercising, and smoking: does neighborhood matter? Soc Sci Med. 2000 Jul;51(2):265-74. https://doi.org/10.1016/S0277-9536(99)00451-7
24. Borrell LN, Burt BA, Warren RC, Neighbors HW. The role of individual and neighborhood social factors on periodontitis: the third National Health and Nutrition Examination Survey. J Periodontol. 2006 Mar;77(3):444-53. https://doi.org/10.1902/jop.2006.050158
25. Weden MM, Bird CE, Escarce JJ, Lurie N. Neighborhood archetypes for population health research: is there no place like home? Health Place. 2011 Jan;17(1):289-99. https://doi.org/10.1016/j.healthplace.2010.11.002
26. Akinkugbe AA, Slade GD, Divaris K, Poole C. Systematic review and meta-analysis of the association between exposure to environmental tobacco smoke and periodontitis endpoints among non-smokers. Nicotine Tob Res. 2016 Nov;18(11):2047-56. https://doi.org/10.1093/ntr/ntw105
27. Kennedy BP, Kawachi I, Glass R, Prothrow-Stith D. Income distribution, socioeconomic status, and self rated health in the United States: multilevel analysis. BMJ. 1998 Oct;317(7163):917-21. https://doi.org/10.1136/bmj.317.7163.917
28. Dalazen CE, De Carli AD, Bomfim RA, Dos Santos ML. Contextual and individual factors influencing periodontal treatment needs by elderly Brazilians: a multilevel analysis. PLoS One. 2016 Jun;11(6):e0156231. https://doi.org/10.1371/journal.pone.0156231
29. Chalub LL, Martins CC, Ferreira RC, Vargas AM. Functional dentition in Brazilian adults: an investigation of social determinants of health (SDH) using a multilevel approach. PLoS One. 2016 Feb;11(2):e0148859. https://doi.org/10.1371/journal.pone.0148859
30. Hobdell MH, Oliveira ER, Bautista R, Myburgh NG, Lalloo R, Narendran S, et al. Oral diseases and socio-economic status (SES). Br Dent J. 2003 Jan;194(2):91-6. https://doi.org/10.1038/sj.bdj.4809882
31. Borrell LN, Beck JD, Heiss G. Socioeconomic disadvantage and periodontal disease: the dental atherosclerosis risk in communities study. Am J Public Health. 2006 Feb;96(2):332-9. https://doi.org/10.2105/AJPH.2004.055277
32. Sabbah W, Sheiham A, Bernabé E. Income inequality and periodontal diseases in rich countries: an ecological cross-sectional study. Int Dent J. 2010 Oct;60(5):370-4. https://doi.org/10.1922/IDJ_2480Sabbah05
33. Valente MI, Vettore MV. Contextual and individual determinants of periodontal disease: multilevel analysis based on Andersen's model. Community Dent Oral Epidemiol. 2018 Apr;46(2):161-8. https://doi.org/10.1111/cdoe.12349
34. Lorenzo-Erro SM, Massa F, Álvarez-Vaz R, Schuch HS, Correa MB, Peres MA. The role of contextual and individual factors on periodontal disease in Uruguayan adults. Braz Oral Res. 2018 Jul;32(62):e62. https://doi.org/10.1590/1807-3107bor-2018.vol32.0062
35. Bomfim RA, Frias AC, Pannuti CM, Zilbovicius C, Pereira AC. Socio-economic factors associated with periodontal conditions among Brazilian elderly people: multilevel analysis of the SBSP-15 study. PLoS One. 2018 Nov;13(11):e0206730. https://doi.org/10.1371/journal.pone.0206730
36. Nadanovsky P, Sheiham A. Relative contribution of dental services to the changes in caries levels of 12-year-old children in 18 industrialized countries in the 1970s and early 1980s. Community Dent Oral Epidemiol. 1995 Dec;23(6):331-9. https://doi.org/10.1111/j.1600-0528.1995.tb00258.x

37. Celeste RK, Nadanovsky P, De Leon A. Association between preventive care provided in public dental services and caries prevalence. Rev. Saúde. Pública. 2007;41(5):830-38. Httpa://doi.org/10.1590/S0034-89102007000500018
38. Wilkinson RG, Pickett KE. Income inequality and population health: a review and explanation of the evidence. Soc Sci Med. 2006 Apr;62(7):1768-84. https://doi.org/10.1016/j.socscimed.2005.08.036
39. Celeste RK, Nadanovsky P, Leon AP, Fritzell J. The individual and contextual pathways between oral health and income inequality in Brazilian adolescents and adults. Soc Sci Med. 2009 Nov;69(10):1468-75. https://doi.org/10.1016/j.socscimed.2009.08.005
40. Celeste RK, Nadanovsky P. How much of the income inequality effect can be explained by public policy? Evidence from oral health in Brazil. Health Policy. 2010;97(2-3):250-58. https://doi.org/10.1016/j.healthpol.2010.05.015