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Epidemiology of periodontal diseases in adults from Latin America

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The epidemiology of periodontal diseases in Latin America was comprehensively reviewed in 2002 (6, 58). Major political, demographic, socio-economic and societal changes have occurred in the last decade in this large and heterogeneous region. The hallmark of periodontal epidemiology in Latin America was the lack of population-based studies with appropriate methodology to assess the distribution and risk factors for periodontal disease.

The aim of this comprehensive review was to update and expand our previous work by providing a broad overview of Latin America and its current socio-demographic status, and by focusing on the epidemiology of periodontal diseases in Latin American adults published in the last 15 years. Another article in this volume will review the literature pertaining to children and adolescents. The literature published in English, Spanish and Portuguese was searched using international and regional databases (MEDLINE, SciELO, BBO and LILACS). Government and health-related sites were also searched for relevant information.

Geography, demographics and economics of Latin American countries

Latin America comprises 20 countries located in South, Central and North America (Mexico) predominantly colonized by Spain and Portugal. The region encompasses ~14% of the world's land (~20,000,000 km^2) and 9% of the world's population (600 million people). The region is demographically diverse, including indigenous inhabitants and European, African, and, more recently, Asian people. Table 1 describes some of the characteristics of 20 recognized countries in the region.

Brazil and Mexico have the largest territories, populations and economies of Latin America. Other large countries include Colombia, Argentina, Venezuela and Peru. Latin America is a very heterogeneous region with great disparity between and within countries. In some countries the gross domestic product per capita is > $US10,000.00 (Argentina, Brazil, Chile, Mexico, Uruguay and Venezuela), whereas in others it is < $US3,000.00 (Haiti, Nicaragua, Honduras and Bolivia). Poverty and indigence has decreased from 40.5% to 31.4% of the population between 1980 and 2010; however, in some countries more than half of the population remains below the poverty line. Great disparity is also observed within countries, as exemplified by economic differences between North and South, urban and rural regions in Brazil and Mexico.

The Latin American population is comprised mostly of young individuals with a median age of 18.9–38.4 years (Table 1). This twofold difference indicates that certain populations are aging faster as a result of decreased nasality and increased longevity. Childhood mortality under the age of five decreased from 153/1000 live births in 1960–34/1000 live births in 2002. In 2010/2011, life expectancy at birth, an important sociodemographic indicator, ranged from 60.8 to 77.6 years.

This discrepancy is also reflected in dental research funding and output. Whilst some countries have systematically improved funding for and publication of epidemiological data, no such data could be found for several other countries. Most of the literature currently available on periodontal epidemiology origi-

Table 1. Demographic and economic information of 20 Latin American countries (2010/2011)

Country	Population (*n*) (148)	Median age of the total population (years) (148)	Life expectancy at birth (years)	Childhood mortality (per 1000 live births) (148)	Gross domestic product ($US) (66)	Gross domestic product per capita ($US) (66)	% Poverty (147)	% Indigence (147)
Argentina	40,518,951	30.4	76.6	19	456,817	10,640	8.6	2.8
Bolivia	10,624,495	21.7	66.9	71	22,887	2,246	54.0	31.2
Brazil	190,755,799	29.1	72.0	36	2,517,927	12,917	24.9	7.0
Chile	17,248,450	32.1	77.3	12	231,302	13,970	11.5	3.6
Colombia	46,043,696	26.8	72.8	23	307,845	6,980	44.3	14.8
Costa Rica	4,562,087	29.4	77.6	11	40,297	8,484	18.9	6.9
Cuba	11,238,200	38.4	77.5	9	Not available	Not available	Not available	Not available
Dominican Republic	10,010,590	25.1	73.7	38	54,912	5,406	41.4	20.9
Ecuador	14,483,499	25.5	75.3	29	65,032	4,352	37.1	14.2
El Salvador	6,183,002	23.2	72.3	39	23,169	3,831	46.4	16.7
Guatemala	14,361,666	18.9	70.3	49	46,383	3,117	54.8	29.1
Haiti	10,085,214	21.4	60.8	123	7,724	739	Not available	Not available
Honduras	8,045,990	21.0	69.4	42	17,000	2,105	67.4	42.8
Mexico	112,336,538	26.6	76.1	29	1,167,124	10,803	36.3	13.3
Nicaragua	5,888,945	22.1	71.5	41	7,050	1,202	61.9	31.9
Panama	3,405,813	27.3	77.2	25	29,799	8,421	25.8	12.6
Paraguay	6,340,641	23.1	75.8	30	22,143	3,421	54.8	30.7
Peru	29,797,694	26.6	70.7	39	167,846	5,614	31.3	9.8
Uruguay	3,368,595	36.7	76.3	15	43,265	14,672	8.6	1.4
Venezuela	29,797,694	26.1	73.6	22	294,271	10,409	27.8	10.7

nates from Brazil and Chile and, as a consequence, these countries are disproportionately represented herein. Dental caries has historically been the main focus in Latin America, as is evident in the Global Oral Health Database from the World Health Organization, which contains caries data for all 20 Latin American countries, but only limited periodontal health information for Brazil and Chile.

Methodological issues in periodontal epidemiology

Periodontal epidemiology has been surrounded by controversies, including disease definitions, examination protocols and units of analysis. These and other methodological issues affect not only how data are collected but also how epidemiological findings are reported and interpreted.

Sequelae of periodontal destruction may be assessed and reported at subject, tooth and site levels. A common approach to describe the periodontal status of a sample or population is to report the average (accompanied with standard deviations, standard errors or confidence intervals) periodontal attachment level/loss, periodontal probing depth and gingival recession. Although averages provide robust estimates in that they are not greatly affected by outliers in epidemiological studies, averages are not easy to interpret. Median values (accompanied with an interquartile range of 25–75%) have been infrequently used and have similar drawbacks for interpretation. Alternatively, the periodontal status may be described by reporting the prevalence and extent of these clinical parameters according to disease severity. In this context, prevalence is defined as the percentage of individuals having at least one site/tooth with a given condition, and extent is defined as the percentage/number of sites/teeth per person having the condition. Severity is provided by the use of thresholds. This approach is not without pitfalls as it also depends on mean/median values and consequently disease distribution.

In spite of the fact that periodontal attachment loss is now the *de facto* hallmark of periodontal destruction (145), most data available for Latin America still relies directly or indirectly on periodontal probing depth estimates. Whereas periodontal attachment loss measures the cumulative periodontal breakdown, periodontal probing depth ignores the periodontal destruction that is accompanied by gingival recession. Studies focusing on the distribution, progression and risk factors for periodontitis should use periodontal attachment loss as the main outcome. Interestingly, studies evaluating the association between periodontal diseases and systemic conditions have also used periodontal probing depth and/or bleeding on probing to better describe the inflammatory burden of the disease (18, 30, 89).

A plethora of periodontitis case definitions have been proposed and used in the literature (9, 52, 88, 112, 124, 145). However, epidemiological studies in Latin America have not consistently used any specific definition. Studies are summarized herein according to data available in the publications, and the results of one survey (132, 134) were re-analyzed according to one case definition proposed by the 5th European workshop of Periodontology: proximal periodontal attachment loss of ≥ 5 mm in $\geq 30\%$ of teeth present.

Another methodological issue that may impact estimates of disease is the examination protocol used. The full-mouth, six-sites-per-tooth protocol is time consuming, strenuous for examiners, uncomfortable for patients and requires appropriate logistics to be adequately conducted. Several partial-recording protocols have been proposed and used to overcome these drawbacks. However, partial recording protocols inherently introduce bias to disease estimates, and the amount of bias depends on the disease distribution in the target population and the number and location of teeth and sites used by the protocol. Recent studies have confirmed these findings for a Brazilian population (69, 135). Estimates based on partial recording protocols should be adjusted using correction factors specific for the protocol used (4, 135). Interestingly, disease estimates based on averages seem less prone to bias than do prevalence estimates (69, 135) and might be considered an important approach to compare studies that have used different examination protocols. We use this approach to compare periodontal attachment loss progression estimates from different populations.

The Community Periodontal Index, formerly called the Community Periodontal Index of Treatment Needs, was initially proposed by the World Health Organization and has been used by some studies in Latin America. Originally conceived to assess gingival bleeding, calculus and periodontal probing depth in 10 index teeth, some studies have also included periodontal attachment loss in the worst teeth of each available sextant. Estimates of prevalence and extent of periodontal probing depth 4–5 and ≥6 mm have been derived from the Community Periodontal Index of Treatment Needs/Community Periodontal Index. This index and its variations have been widely criti-

cized (8, 11, 12, 68); nevertheless, several oral surveys still use it for periodontal assessment.

Sampling strategies are crucial for the validity of the estimates in epidemiological studies and oral surveys. Convenience samples have been used in studies conducted in Latin America (50, 116, 118, 129), and the representativeness of these samples is unknown. Thus, estimates based on these samples are at high risk of bias and should be interpreted with caution. Studies comprising isolated and/or distinct population groups have also been published and it is unknown how well they represent the periodontal status of those regions and countries.

Oral hygiene and gingivitis

Epidemiological data regarding oral hygiene and gingivitis are scarce in Latin America. Data based on Community Periodontal Index of Treatment Needs/Community Periodontal Index scores are available for some studies; however, owing to the hierarchical nature of the index it is difficult to ascertain precise estimates. Nevertheless, it is clear that gingival bleeding and calculus affect the large majority of individuals in Latin American populations.

Data for the two Brazilian Oral Health National Surveys conducted in 1986 (110) and in 2002–2003 (93) using the Community Periodontal Index of Treatment Needs protocol are presented in Fig. 1. Both surveys clearly demonstrate that the percentage of periodontally healthy subjects (Community Periodontal Index = 0) decreases with increasing age. Although no major changes were observed between 1986 and 2002–2003 in the percentage of healthy individuals within the three age-groups, there was an increase in calculus accumulation: the percentage of 35- to 44-year-old subjects with calculus doubled from 23.6% in 1986 to 46.8% in 2002–2003.

In a southern Brazilian population, the prevalence of supragingival plaque increased with age from 56.9% of sites in 18- to 29-year-old subjects to 72.9% of sites in subjects 60+ years of age (Fig. 2). Similarly, supragingival calculus also increased with age, from 20.9% of sites among 18- to 29-year-old subjects to 43.0% of sites among subjects 60+ years of age (Fig. 3). In contrast, gingival bleeding was somewhat unchanged across age groups, affecting ~30% of sites (Fig. 4). Male subjects had a greater percentage of sites with plaque and calculus, whereas no differences were observed between male and female subjects for gingival bleeding. Lower values for all supragingival parameters were recorded in individuals of high socio–economic status. Whereas smoking exposure was clearly associated with plaque and calculus, an inverse relationship was observed between smoking and gingival bleeding.

Consumption of oral hygiene products

Data on per-capita consumption of dentifrice, toothbrush and mouthwash from 2008 to 2010 for Latin

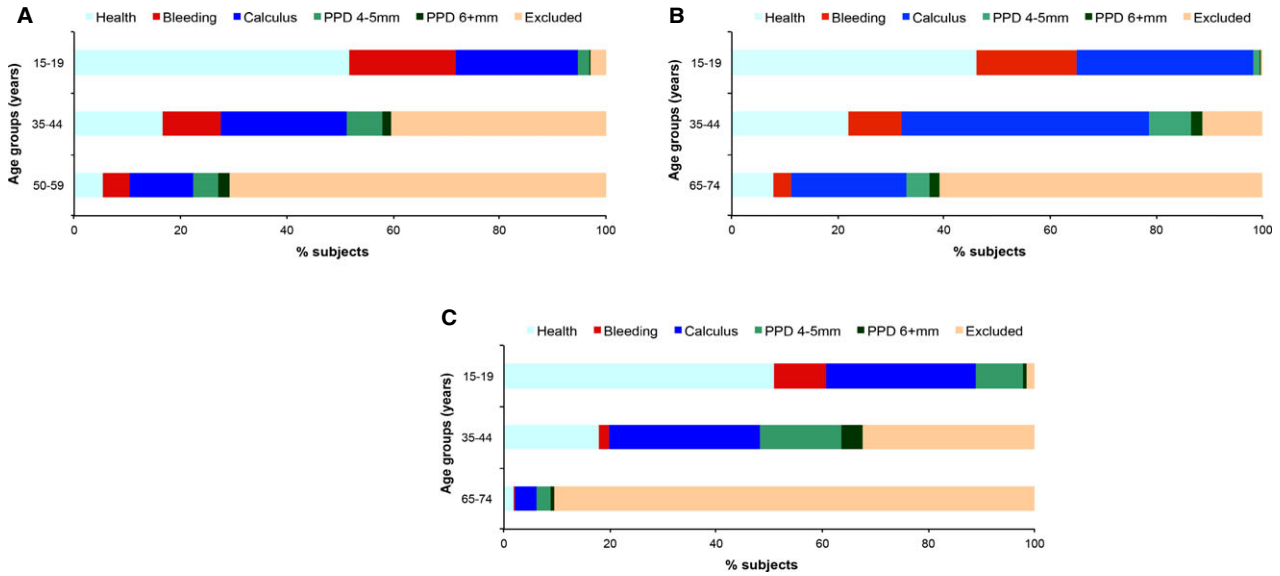

Fig. 1. Community Periodontal Index of Treatment Needs data for the three Brazilian Oral Health National Surveys conducted in 1986 (A), 2002–2003 (B) and 2010 (C). Subjects were excluded due to edentulism. PPD, periodontal probing depth.

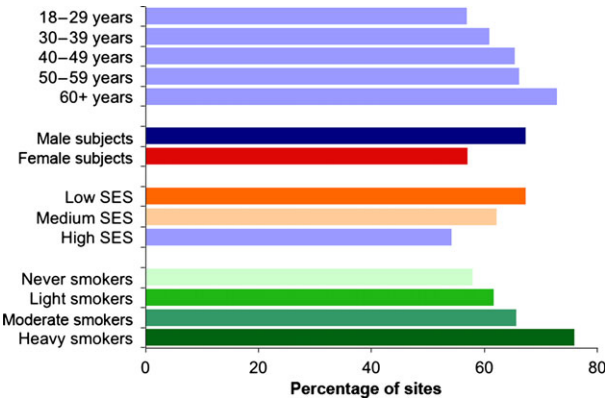

Fig. 2. Percentage of sites per subject with supragingival plaque according to age, gender, socio-economic status (SES) and smoking exposure. Data from the Porto Alegre Study (132, 134).

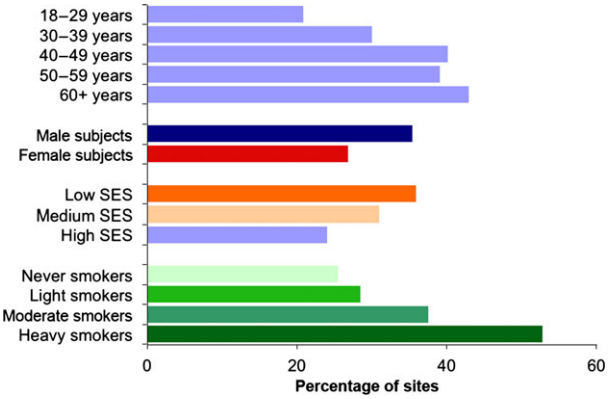

Fig. 3. Percentage of sites per subject with supragingival calculus according to age, gender, socio-economic status (SES) and smoking exposure. Data from the Porto Alegre Study (132, 134).

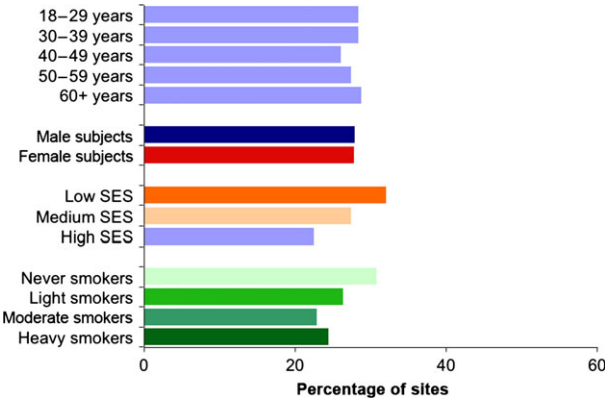

Fig. 4. Percentage of sites per subject with gingival bleeding according to age, gender, socio-economic status (SES) and smoking exposure. Data from the Porto Alegre Study (132, 134).

America are presented in Table 2. A slight increase in the consumption of toothbrushes was observed, whereas consumption of dentifrice and mouthwash was essentially unchanged over this short time-period. Long-term trends for consumption of oral hygiene products were not available. Data for dental floss consumption were only available for Brazil and, on average 18 m of dental floss was consumed per capita per year in 2010. This indicates a three- to four-fold increase in dental floss consumption compared with estimates from 1995 to 1999 (58).

Table 2. Per-capita consumption of different oral hygiene products in Latin America

Product	Year		
	2008	2009	2010
Dentifrice (kg)	0.526	0.523	0.534
Toothbrush (unit)	1.470	1.513	1.622
Mouthwash (L)	0.119	0.120	0.118

Source: Nielsen Retail Index (data kindly provided by Colgate Palmolive).

Current estimates of consumption of oral hygiene products for most South American countries and Mexico are presented in Table 3. Per capita consumption of toothbrushes was highest in Chile and Brazil, and consumption of dentifrice was highest in Venezuela and Brazil. Compared with data from 1999, Brazil, Argentina and Chile doubled their consumption of toothbrushes (58). Mouthwash consumption was low in Latin America, with minimal differences among countries. Only aggregated data were found for Central America, and per capita consumption of toothbrushes and dentifrice in 2010 was 1.192 units and 0.328 kg, respectively. These estimates indicate a lower consumption of oral hygiene products in these countries compared with South American countries and Mexico.

Table 3. Per capita consumption of oral hygiene products in Latin American countries (in 2010)

Country	Oral hygiene product		
	Toothbrush (unit)	Dentifrice (kg)	Mouthwash (L)
Argentina	1.193	0.370	0.122
Brazil	1.925	0.666	0.120
Chile	2.222	0.512	0.115
Colombia	1.730	0.346	0.115
Mexico	1.427	0.441	0.094
Uruguay	1.619	0.409	0.114
Venezuela	1.260	0.722	0.174

Source: Nielsen Retail Index (data kindly provided by Colgate Palmolive).

Among dentate individuals in Porto Alegre, Brazil (132), 10.9% and 86.9% of subjects reported brushing once a day and more than once a day, respectively. Daily use of dental floss and toothpicks was reported, respectively, by 35.0% and 24.1% of subjects. Approximately 87.8% of the population did not use mouthwash. It is important to acknowledge that these estimates were based on data collected in 2001, and since then an increase in dental floss and mouthwash consumption may have occurred.

Contradictory findings on the consumption of oral hygiene products were observed upon comparison of the data from two surveys, conducted 13 years apart in an adult Southern American population (37, 38). Whereas dentifrice consumption in this population was high at both time-points, the percentage of households using more than one tube of dentifrice per month decreased from 81.2% in 1996 to 61.2% in 2009. In contrast, self-reported use of mouthwash increased from 11.4% in 1996 to 24.2% in 2009 (92) and dental floss use increased from 49.6% in 1996 to 62.2% in 2009. Socio-economic factors were significantly associated with the use of oral hygiene products, with subjects of higher socio-economic and educational status having an increased tendency for higher consumption of dentifrice, dental floss and mouthwash. No other population-based studies assessing these outcomes were found.

Occurrence of destructive periodontal disease

Recent cross-sectional studies reporting estimates of periodontal attachment loss and periodontal probing depth in adults from Latin American countries are summarized in Tables 4 and 5. In general, high variability in the estimates of periodontal disease was observed in Latin American adults. As previously discussed, methodological discrepancies among studies (including sampling strategies, sample characteristics, periodontal examination protocols and data analysis) are likely to influence disease estimates. Nevertheless, it is also possible that the differences observed in disease estimates may, to some extent, reflect actual differences in the expression of the disease in different Latin American populations.

In Brazil, three national surveys were conducted using Community Periodontal Index/Community Periodontal Index of Treatment Needs (93, 94, 110), and their main results are shown in Fig. 1. Among the youngest age group (15–19 years), no major changes in the Community Periodontal Index scores were observed between 1986 and 2010, besides a slight increase in the percentage of subjects with calculus. The prevalence of subjects with periodontal probing depth ≥ 4 mm was similar in 1986 and 2002–2003, being ~10% in subjects 35–44 years of age and 6% in subjects 65–74 years of age. In 2010, the prevalence of subjects with periodontal probing depth ≥ 4 mm increased to 19.4% (Table 5). In the 65–74 years old age group, the percentage of subjects excluded due to edentulism increased over time, and this may have hidden the true periodontal condition of this age group. A secondary analysis of the 2002–2003 data showed that periodontal attachment loss and periodontal probing depth ≥ 4 mm on the same tooth were observed in 9.0% of subjects 35–44 years of age (108). This prevalence is considerably lower than that observed in other national/regional surveys in the USA (3, 5) and Europe (126).

Substantially higher estimates of periodontitis among adults were also found in Porto Alegre, Brazil (132, 134). The overall prevalence for periodontal attachment loss of ≥ 5 mm and ≥ 7 mm was, respectively, 62.6% (standard error = 1.8) and 37.3% (standard error = 1.5) among subjects ≥ 18 years of age with at least six teeth present. These individuals had, on average, 23.6% (standard error = 1.0) and 9.2% (standard error = 0.6) of teeth affected by periodontal attachment loss of ≥ 5 mm and ≥ 7 mm, respectively. Severe periodontal attachment loss was frequently observed in all age groups; however it affected a small proportion of the teeth among young subjects (Fig. 5). The prevalence of periodontitis, defined as individuals with periodontal attachment loss of ≥ 5 mm affecting ≥ 30% of teeth, was 31.4% (standard error = 1.8) and it increased sharply with age (Fig. 6). Periodontitis was more prevalent among male subjects, persons with a low socio-economic status and heavy smokers. Among subjects ≥ 18 years of age with at least six teeth present, periodontal probing depth ≥ 5 mm and gingival recession ≥ 3 mm affected 59.9% and 55.8% of subjects and 14.0% and 16.9% of teeth (133, 138), respectively, indicating that most of the periodontal attachment loss was accompanied by gingival recession instead of deepening of the periodontal pockets. Somewhat similar findings were observed in a convenience sample of adults attending a public Dental School in Rio de Janeiro (129).

The First Chilean National Dental Examination Survey conducted in 2007 observed a high prevalence of severe periodontal attachment loss (55). Periodontal attachment loss of ≥ 5 mm affected 58.3% (standard

Table 4. Summary of the methodology of cross-sectional studies of periodontal disease in urban and isolated areas of Latin American countries

Source	Country	Year of survey	Sample	Age (years)	*n*	Protocol	Definition criteria of periodontitis
Urban areas							
Pinto 1988 (data from Brazilian Ministry of Health) (110)	Brazil	1986	Representative National	35–44 65–74	3344 2256	Community Periodontal Index	Not determined
Brazilian Ministry of Health 2004 (93)	Brazil	2002–2003	Representative National	35–44 65–74	13,431 5349	Community Periodontal Index	Not determined
Brazilian Ministry of Health 2010 (94)	Brazil	2010	Representative National	35–44 65–74	9441 7116	Community Periodontal Index	Not determined
Peres et al. 2007 (data from Brazilian Ministry of Health 2004) (108)	Brazil	2002–2003	Representative National	35–44	11,342	Community Periodontal Index	Periodontal probing depth ≥ 4 mm in one or more sites and periodontal attachment loss ≥ 4 mm in one or more sites
Susin et al. 2004, 2011 (132)	Brazil	2001	Representative Regional	30+ 20–29	974 328	Full-mouth Six sites	Moderate: periodontal attachment loss ≥ 5 mm in 15–50% of teeth Severe: periodontal attachment loss ≥ 5 mm in ≥ 50% of teeth Proximal periodontal attachment loss ≥ 3 mm in two or more teeth
Silva-Boghossian et al. 2009 (129)	Brazil	2005–2007	Convenience	21–70	491	Full-mouth Six sites	Moderate: periodontal attachment loss ≥ 5 mm in > 10% of sites Severe: periodontal attachment loss ≥ 7 mm in one or more sites

Table 4. (*Continued*)

Source	Country	Year of survey	Sample	Age (years)	*n*	Protocol	Definition criteria of periodontitis
Gamonal et al. 2010 (55)	Chile	2007	Representative National	35–44 65–74	1092 469	Full-mouth Six sites	Periodontal attachment loss ≥ 3, ≥ 4, ≥ 5 and ≥ 6 mm in one or more sites
Lopez et al. 2001 (81)	Chile	1999	Representative Students	12–21 18–21	9162 735	Partial Six sites	Periodontal attachment loss ≥ 3 mm in one or more teeth
Collins et al. 2005 (36)	Dominican Republic	Not determined	Representative High school	12–21 18–21	2007 Not determined	Partial Six sites	Periodontal attachment loss ≥ 3 mm in one or more sites
Romanelli et al. 2007 (116)	Argentina	1999–2000	Convenience	18–84	3694	Community periodontal index	Not determined
Isolated areas							
Dowsett et al. 2001 (50)	Guatemala	1999	Finite subpopulation (n = 2500)	18–75	125	Full-mouth Six sites	Not determined
Ronderos et al. 2001 (118)	Colombia	1993	Finite subpopulation (n = 1827)	20+	224	Ramfjord teeth	Periodontal attachment loss 4–6 mm and ≥ 7 mm at the most severely affected site Mean periodontal attachment loss as a dependent variable for the multivariable model
Corraini et al. 2008 (40)	Brazil	2005–2006	Finite subpopulation (n = 458)	12+	214	Full-mouth Six sites	Periodontal attachment loss ≥ 5 mm and ≥ 7 mm in one or more sites

Table 5. Summary of findings of cross-sectional studies of periodontal disease in urban and isolated areas of Latin American countries

Source	Descriptive findings	Risk estimates from multivariable models
Urban areas		
Brazilian Ministry of Health 1986 (110)	35- to 44-year-old subjects: ~16% without periodontal alterations (Community Periodontal Index = 0) and ~9% with periodontal probing depth ≥ 4 mm (Community Periodontal Index ≥ 3) 65- to 74-year-old subjects: ~5.5% without periodontal alterations (Community Periodontal Index = 0) and ~6% with periodontal probing depth ≥ 4 mm (Community Periodontal Index ≥ 3)	Not determined
Brazilian Ministry of Health 2004 (93)	35- to 44-year-old subjects: 21.9% without periodontal alterations (Community Periodontal Index = 0) and 9.9% with periodontal probing depth ≥ 4 mm (Community Periodontal Index ≥ 3) 65- to 74-year-old subjects: 7.9% without periodontal alterations (Community Periodontal Index = 0) and 6.3% with periodontal probing depth ≥ 4 mm (Community Periodontal Index ≥ 3)	Not determined
Brazilian Ministry of Health 2011 (94)	35- to 44-year-old subjects: 17.8% without periodontal alterations (Community Periodontal Index = 0) and 19.4% with periodontal probing depth ≥ 4 mm (Community Periodontal Index ≥ 3) 65- to 74-year-old subjects: 1.8% without periodontal alterations (Community Periodontal Index = 0) and 3.3% with periodontal probing depth ≥ 4 mm (Community Periodontal Index ≥ 3)	Not determined
Peres et al. 2007 (data from Brazilian Ministry 2004) (108)	9.0% of subjects with co-occurrence of periodontal probing depth and periodontal attachment loss ≥ 4 mm in one or more sites	Dark skin color: odds ratio = 1.6 (1.2–2.1) Male gender: odds ratio = 1.5 (1.2–1.7) Age 40–44 years: odds ratio = 1.4 (1.2–1.6) Education ≤ 4 years: odds ratio = 1.5 (1.2–2.1) Low income: odds ratio = 1.7 (1.3–2.1)
Susin et al. 2004, 2011 (132)	49.7% of subjects had periodontal attachment loss ≥ 5 mm at ≥ 30% of teeth Subjects 30+ years of age: 28.4% with moderate periodontitis and 30.4% with severe periodontitis 43.5% of 20- to 24-year-old subjects and 72% of 25- to 29-year-old subjects with chronic periodontitis	Older age (50+ years): odds ratio = 25.4 (19.0–33.7) Male gender: odds ratio = 1.6 (1.1–2.5) Low socio-economic status: odds ratio = 1.8 (1.3–2.6) Heavy smoking: odds ratio = 8.2 (5.5–12.2) Irregular dental visits: odds ratio = 2.1 (1.1–4.0) Older age (25–29 years): odds ratio = 7.2 (3.7–14.0) Low socio-economic status: odds ratio = 1.9 (1.4–2.7) Heavy smoking: odds ratio = 1.7 (1.1–2.7) Calculus: odds ratio = 2.0 (1.2–3.2)

Table 5. (*Continued*)

Source	Descriptive findings	Risk estimates from multivariable models
Silva-Boghossian et al. 2009 (129)	~60% of subjects with moderate periodontitis ~60% of subjects with severe periodontitis	Bleeding on probing > 30%: odds ratio = 22.5 (8.1–62.9) Smoking: odds ratio = 8.9 (2.0–39.8) Four or more missing teeth: odds ratio = 2.5 (1.4–4.5) Bleeding on probing > 30%: odds ratio = 24.9 (9.7–64.1) Smoking: odds ratio = 7.7 (2.4–24.5)
Gamonal et al. 2010 (55)	38.6% of 35- to 44-year-old subjects with periodontal attachment loss of ≥ 6 mm at one site 69.3% of 65- to 74-year-old subjects with periodontal attachment loss of ≥ 6 mm at one site	Older age (65–74 years): odds ratio = 3.7 (2.7–4.9) Male gender: odds ratio = 1.8 (1.4–2.3) Education ≤ 12 years: odds ratio = 1.3 (1.1–1.7) Smoking: odds ratio = 1.3 (1.1–1.7)
Lopez et al. 2001 (81)	8.2% of 18- to 21-year-old subjects with periodontal attachment loss of ≥ 3 mm in one or more teeth	Older age (compared with 12- to 14-year-old subjects): odds ratio = 2.9 (1.8–4.9) Male gender: odds ratio = 0.7 (0.6–0.9) Brushing frequency < 1/day: odds ratio = 2.0 (1.25–3.25) Never seen a dentist: odds ratio = 2.1 (1.5–2.9) Governmental school support: odds ratio = 1.4 (1.1–1.9)
Collins et al. 2005 (36)	4.8% of 18- to 21-year-old subjects with periodontal attachment loss of ≥ 3 mm in one or more teeth	Older age (compared with 12- to 14-year-old subjects): odds ratio = 1.6 (1.1–2.2)
Romanelli et al. 2007 (116)	14.3% of subjects with periodontal probing depth > 5.5 mm	Not determined
Isolated areas		
Dowsett et al. 2001 (50)	96% of subjects with periodontal attachment loss of ≥ 5 mm at one or more sites	Not determined
Ronderos et al. 2001 (118)	40.6% of subjects with periodontal attachment loss of 4–6 mm and 7.1% of subjects with periodontal attachment loss of ≥ 7 mm	Linear regression coefficients for a 10-year increase in age (0.49), mean bleeding on probing (0.23) and calculus (0.20) R^2 = 0.54
Corraini et al. 2008 (40)	Periodontal attachment loss of ≥ 5 mm increased from 37.1% in 20- to 29-year-old subjects to 100% in subjects 50+ years of age Periodontal attachment loss of ≥ 7 mm increased from 8.1% in 20- to 29-year-old subjects to 83.3% in subjects 50+ years of age	Older age (30+ years): odds ratio = 11.4 (2.7–47.4) Smoking: odds ratio = 2.4 (1.0–6.0) ≥ 75% sites with plaque: odds ratio = 2.8 (1.1–7.1) ≥ 50% sites with calculus: odds ratio = 10.6 (2.5–44.8) Smoking: odds ratio = 8.2 (3.4–20.0)

Odds ratio values are given with 95% confidence intervals in parentheses.

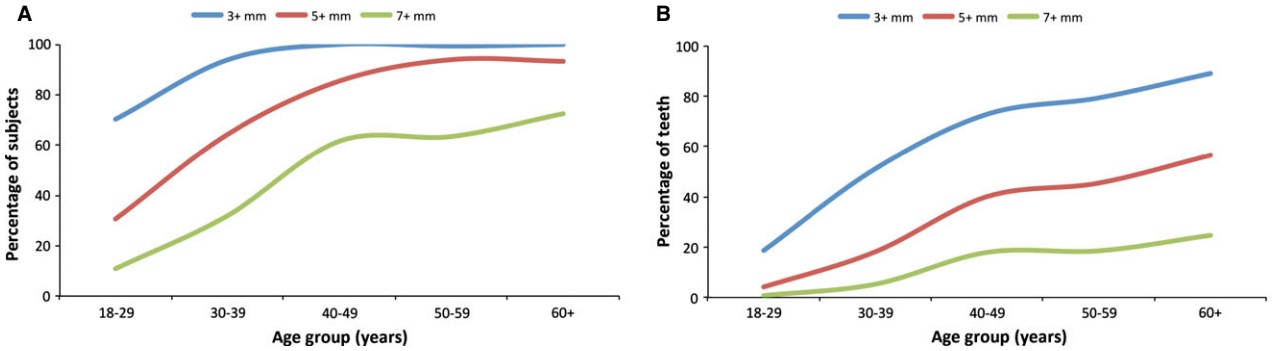

Fig. 5. Prevalence (percentage of subjects) (A) and extent (percentage of teeth/subject) (B) of different thresholds of periodontal attachment loss according to age group. Data from the Porto Alegre Study (132, 134).

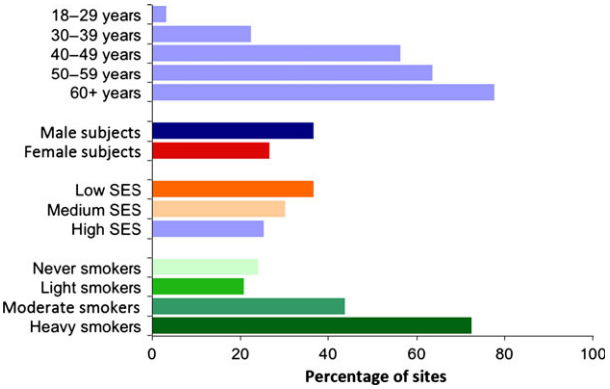

Fig. 6. Prevalence of periodontitis (≥ 30 per cent of teeth with periodontal attachment loss of ≥ 5 mm) according to age, gender, socio-economic status (SES) and smoking exposure. Data from the Porto Alegre Study (132, 134).

deviation = 49.3) of 35- to 44-year-old subjects and 81.4% (standard deviation = 38.9) of 65- to 74-year-old subjects. Mean periodontal attachment loss was substantially higher among the older age group; however, no differences were observed for mean periodontal probing depth. Lopez et al. evaluated a large sample of adolescents and young adults in Santiago, Chile, including 735 individuals 18–21 years of age (81). The prevalence of periodontal attachment loss of ≥ 3 mm among these individuals was 8.2% and, on average, 3.4 teeth were affected. The prevalence was higher among male subjects, whereas extent was higher among female subjects.

A large sample of patients seeking dental care in private practices, hospitals and community health centers in 23 different regions in Argentina was examined using the Community Periodontal Index (116). Overall, the prevalence of periodontal probing depth 3.5–5.5 mm and ≥ 5.5 mm was 26.4% and 14.3%, respectively. Periodontal probing depth of ≥ 5.5 mm was mostly localized to one or two quadrants (67.2% of subjects). Only 3.2% of the participants presented with periodontal health (Community Periodontal Index = 0). The prevalence of deep probing depths showed a steady increase with age.

A representative sample of adolescents and young adults in San Domingo, Dominican Republic, was periodontally examined using a partial recording protocol which included six sites of all incisors and first and second molars (36). The prevalence of periodontal attachment loss of ≥ 3 mm was 4.8% among 18- to 21-year-old subjects and the prevalence was higher in female subjects than in male subjects.

Recent studies have evaluated the periodontal status of isolated populations in Latin America. One study examined Mayan Indians from Guatemala and showed that virtually all subjects had periodontal attachment loss of ≥ 4 mm (50). In southwestern Colombia, 40.6% of Indians living in the Amazon rain forest showed periodontal attachment loss of 4–6 mm, with estimates increasing from 23.1% to 66.7% in subjects 20–29 and ≥ 50 years of age, respectively (118). In Brazil, Corraini et al. (40) studied an isolated population living in the Atlantic Forest in the southeastern part of the country and demonstrated that periodontal attachment loss of ≥ 5 mm and ≥ 7 mm was highly prevalent among subjects ≥ 30 years of age.

Overall, studies on the prevalence of destructive periodontal disease in urban and isolated areas of Latin America indicate a high prevalence and low extent of moderate to severe periodontal attachment loss. Within the limitations of the available data, it seems that periodontal attachment loss is more prevalent in Latin America than in the USA (3, 5) and Europe (23, 71). Comparisons with other regions are difficult owing to lack of data and high heterogeneity of findings; nevertheless, Latin America seems to have less periodontal disease compared with other developing countries in Asia (39) and Africa (13).

Progression of periodontal attachment loss

Longitudinal studies evaluating the incidence and progression of periodontitis are scarce in the literature and this is particularly true for Latin America. The few available studies have used convenience samples or samples with specific characteristics, limiting the external validity of the findings.

To the best of our knowledge, the 5-year follow-up of the original Porto Alegre Oral Health Survey, Brazil, is the only population-based prospective study that has been conducted in Latin America (62). In short, 697 of 1465 dentate subjects obtained from the sample drawn to represent the metropolitan area of Porto Alegre were periodontally examined using a full-mouth six-sites-per-tooth protocol after 5 years. Overall, 56.0% and 36.2% of the subjects had periodontal attachment loss progression of ≥ 3 mm in two or more and four or more teeth, respectively. The mean annual periodontal attachment loss progression varied according to the protocol used to calculate the individual mean – 0.31 mm/year and 0.10 mm/year using the worst proximal site or all four proximal sites of each tooth, respectively. Whereas periodontal attachment loss progression was very frequent, it affected a reduced number of teeth and sites. The percentage of subjects with periodontal attachment loss progression and mean annual periodontal attachment loss progression increased in older age groups, in male subjects and in subjects of low socio-economic status (Fig. 7). Compared with samples from other populations (Table 6), the progression of periodontal disease observed in this population was intermediate to that observed in populations with limited dental care and to well-maintained populations from the USA, Europe, Asia and Oceania (10, 57, 67, 75, 84, 125, 128, 143, 149).

Other longitudinal studies with convenience and smaller samples were also conducted in Brazil (43, 99, 102, 103). However, these studies are not the focus of the present review because their samples comprised adolescents and diabetics. No other longitudinal studies could be identified in Latin America.

Risk factors for chronic periodontitis

A variety of environmental, behavioral, sociodemographic and biologic variables have been evaluated as possible risk factors for periodontitis. Most of the studies in the literature have used cross-sectional and case–control designs, whereas few longitudinal and interventional studies have been conducted to determine risk factors for chronic periodontitis. Current evidence regarding risk factors/indicators in Latin America is summarized in Table 5.

Demographics and socio-economic factors have clearly been associated with periodontal disease in Latin America (Table 5). Whereas these relationships are unclear in the literature, with supporting (19, 21, 127) and contradictory (70) evidence, studies conducted in Latin America seem to be uniquely positioned to help elucidate this conundrum. Higher prevalence and periodontal attachment loss progression have been demonstrated in male subjects than in female subjects (55, 62, 129, 132). Paradoxically,

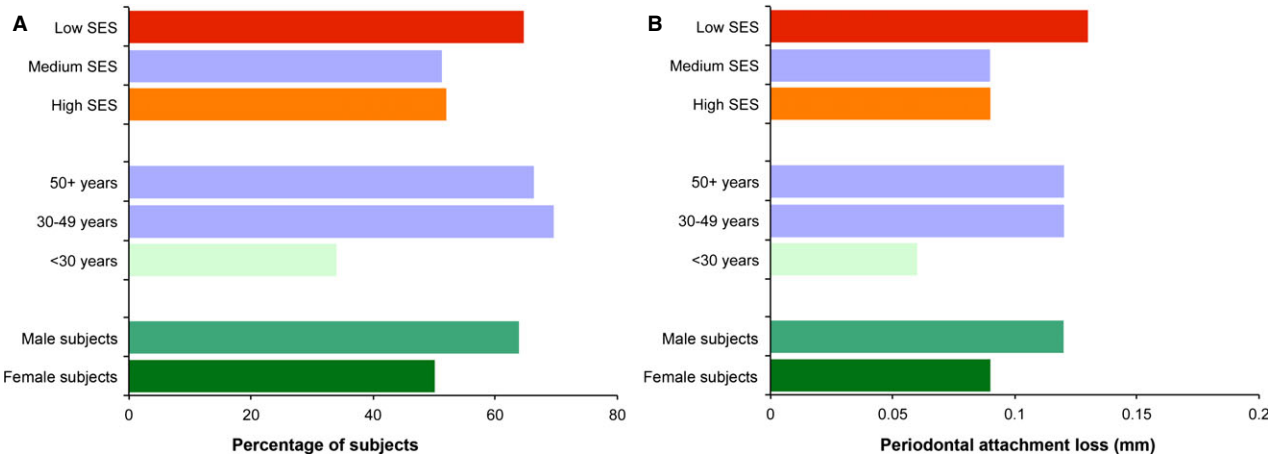

Fig. 7. Percentage of subjects with periodontal attachment loss progression of ≥ 3 mm in two or more teeth (A) and mean annual periodontal attachment loss progression (B) according to socio-economic status (SES), age and gender. Data from the longitudinal component of the Porto Alegre Study (62).

Table 6. Periodontal attachment loss progression in different populations, according to periodontal recording protocol

Protocol/Study	Country	Mean progression (mm/year)
Two sites per tooth (mesiobuccal and midbuccal)		
Loe et al. 1986 (75)	Sri Lanka	0.20
van der Velden et al. 2006 (149)	Indonesia	0.11
Haas et al. 2012* (62)	Brazil	0.08
Schatzle et al. 2003 (125)	Norway	0.05
Four sites per tooth		
Baelum et al. 1997 (10)	China	0.17
Machtei et al. 1999 (84)	USA	0.12
Haas et al. 2012 (62)	Brazil	0.10
Ismail et al. 1990 (67)	USA	0.04

*For comparison, estimates were based only on mesiobuccal and buccal sites.

female subjects have higher tooth-loss rates compared with male subjects, irrespective of having higher dental-care utilization (137). Age has been associated with periodontal attachment loss, with older individuals having a higher likelihood of having severe periodontitis. Interestingly, periodontal attachment loss progression seems to plateau in older individuals, indicating that compromised teeth are being extracted (62). Associations between socio-economic indicators and periodontal destruction have also been clearly demonstrated in these populations, with individuals of lower socio-economic position, income and education having a higher likelihood of having periodontitis (15, 28, 87, 132, 134). The study of associations between periodontal disease and race/ethnicity/skin color is very complex in Latin America as a result of the mixing of different races in the overall population and historical disparities. Studies from Brazil have observed a higher likelihood of periodontitis in non-White people than in White people after adjusting for other confounding factors (108, 132), indicating that these populations are at a disadvantage and should be targeted for health promotion.

Smoking is the most important preventable risk factor for several diseases and conditions, including periodontitis (2). Studies in Latin America (Table 5) confirm the deleterious effect of smoking on periodontal health, including a dose–response relationship with lifetime exposure to smoking (40, 55, 129, 132, 134, 136). No population-based longitudinal studies assessing the impact of smoking on periodontal status could be found in the literature. A large proportion of the burden of periodontitis has been attributed to cigarette smoking in populations in developed countries (49, 144). Using data derived from the Porto Alegre study, it was estimated that cessation of smoking could potentially prevent more than 90,000 cases of periodontitis in that urban population (136). A recent clinical study performed at a smoking-cessation clinic in São Paulo, Brazil, demonstrated that patients with periodontitis who stopped smoking benefited more from nonsurgical periodontal therapy than did those who failed to stop smoking (119). This study also highlights the challenges faced by smoking-cessation programs as only 17 of 93 individuals stopped smoking after 1 year. Additionally, two systematic reviews, published by Brazilian groups, indicated the benefits of smoking cessation for periodontal health (31, 53).

Diabetes mellitus is also a well-recognized risk factor for periodontitis (33). In spite of the importance of this risk factor, very few studies have directly investigated the effect of diabetes on periodontal health in Latin America. Susin et al. (132, 134) observed univariable associations between self-reported diabetes and periodontal attachment loss. However, these associations were not significant in multivariable models, probably because of the lack of proper diagnosis of the condition. Similar limitations were observed in other studies (40, 43). Glycemic control was negatively associated with periodontal attachment loss severity and tooth loss in two convenience samples of diabetic patients from a University Hospital in Colombia (22) and a periodontal clinic in São Paulo (123). Novaes et al. (97, 98) followed up one group of patients with type I diabetes and another group with type II diabetes and found that, compared with nondiabetic patients, diabetic patients had higher progression of periodontal attachment loss. Costa et al. (43) observed increased odds of 3.7 for periodontitis progression in diabetic patients compared with non-diabetic patients in a private practice in Belo Horizonte, Brazil, participating in a periodontal maintenance program. It has also been demonstrated that diabetes mellitus may impair the response to periodontal therapy (60) and that the impairment may be dependent on the glycemic

control (35), but no studies were found in samples from Latin American patients with diabetes.

The obesity pandemic that has affected developed nations in the last decades has spread to developing countries, including those in Latin America. Two recent meta-analyses found that obese subjects had a higher chance of having destructive periodontal disease (29, 139). Using data from the Porto Alegre Study, Dalla-Vecchia et al. (48) were one of the first to investigate this association. Whereas no association was observed between obesity and periodontitis among male subjects, obese female subjects were twice as likely to have the disease compared with normal-weight women. Longitudinal data analysis of this sample confirms these initial findings. Confirmatory results were also observed in convenience samples from other Brazilian samples (32, 107). Interestingly, obesity did not adversely affect the clinical and cytokine profile outcomes for nonsurgical periodontal treatment (157).

Although it is clear from biological and clinical standpoints that bacteria are necessary for the initiation and progression of periodontitis (63, 131), the epidemiological relationship between biofilm and destructive periodontal disease is complex as a result of its proximity to the outcome (proximal factor) and relationship to socio-demographic and environmental factors. Nevertheless, biofilm (measured by clinical indices) and calculus (used as a surrogate for long-term exposure to biofilm) have been associated with periodontal attachment loss in Latin America (Table 5). Calculus was strongly associated with periodontal attachment loss and gingival recession in the Porto Alegre study (132–134), and plaque was associated with periodontal attachment loss in another two studies with samples from Brazil (40, 129).

Other risk factors/indicators, including psychosocial factors (27, 64, 151), metabolic syndrome (20, 78), osteoporosis/osteopenia (106), arthritis (90, 109), use of cyclosporine (155) and alcohol consumption (72), have also been investigated in Latin American studies, with mixed results obtained.

Periodontal disease, oral health and quality of life

Quality of life is an emerging field in the dental literature, and few studies in Latin America have studied the impact of periodontal disease on quality of life. Several oral health-related quality-of-life instruments have been developed, including the popular Oral Health Impact Profile, which has been validated for Portuguese and Spanish languages.

Lopez & Baelum (80) observed a negative impact of periodontal attachment loss and necrotizing gingivitis on oral health-related quality of life in Chilean adolescents and young adults. Interestingly, this negative effect was greater for individuals of lower socio-economic position. These findings were not corroborated in a study with a small sample of Brazilian adolescents (17). Studies using convenience samples of Brazilian adults (7, 16) showed an association between periodontal disease and Oral Health Impact Profile scores that indicated a negative impact on quality of life. Functional limitation seems to explain the negative impact of periodontal disease on quality of life in these samples (7, 80). Also, a study performed in patients undergoing orthodontic treatment in Brazil (156) demonstrated that gingival enlargement affects oral health-related quality of life. Using data from a national oral survey in Brazil, Cascaes et al. (25) observed that individuals with periodontitis were 40% (prevalence ratio = 1.4, 95% confidence interval: 1.2–1.5) more likely to rate their oral health as poor, even after adjusting for other covariates.

The relationship between oral health-related quality of life and periodontal treatment has also been investigated. Costa et al. (42) demonstrated that patients compliant with periodontal maintenance had lower Oral Impact in Daily Performance scores than did patients who missed recall appointments, and this negative impact was related to functional performance, speaking and smiling. The effect of periodontal therapy on the quality of life of pregnant women was assessed in a large clinical trial (154). Women who received nonsurgical periodontal treatment were six times less likely to have a worsening on Oral Health Impact Profile scores compared with women who received only limited dental treatment. Therefore, it was suggested that periodontal treatment might limit the decrease in oral health-related quality of life during pregnancy (95).

Periodontal diseases as a risk factor for systemic conditions

Periodontitis has been associated with several systemic conditions, including adverse pregnancy outcomes, cardiovascular diseases, respiratory diseases, diabetes and renal malfunctioning. The biological plausibility of these associations relies mainly on the low-grade systemic inflammatory burden that has been associated with periodontitis (24, 51, 76). Most

Table 7. Latin American studies investigating the association of periodontal disease with systemic conditions

Condition	Association	Case–control and cross-sectional studies	Interventional studies
Low birth weight/preterm birth	+	Romero et al. (117)	
	+	Marin et al. (86)	
	–	Lunardelli & Peres (83)	
	+	Cruz et al. (44)	
	+	Moliterno et al. (91)	
	–	Castaldi et al. (26)	
	–	Bassani et al. (14)	
	–	Vettore et al. (150)	
	+	Cruz et al. (46)	
	+	Guimaraes et al. (61)	
	+		Lopez et al. (79)
	+		Lopez et al. (77)
	–		Oliveira et al. (104)
	–		Weidlich et al. (154)
Coronary heart disease	+	Lopez et al. (82)	
	+	Lim et al. (73)	
	+	Accarini & de Godoy (1)	
	+	Rech et al. (113)	
	+	Vidal et al. (2011) (153)	
	+	Rivas-Tumanyan et al. (114)	
	+	Flores et al. (54)	
Diabetes	+		Rodrigues et al. (115)
	+		O'Connell et al. (100)
	–		da Cruz et al. (2008) (47)
	–		Santos et al. (122)
	+		Correa et al. (41)

of the studies conducted in Latin America have focused on adverse pregnancy outcomes, cardiovascular diseases and glycemic control, with mixed findings obtained (Table 7).

Periodontal disease and adverse pregnancy outcomes

Early clinical evidence regarding the effect of periodontal therapy on the incidence of preterm birth/low birth weight came from two Chilean randomized clinical trials. The first study demonstrated, in 351 pregnant women with periodontitis, that periodontal treatment before 28 gestational weeks reduced the incidence of preterm birth/low birth weight from 10.11% to 1.63% (79). The second study evaluated the effect of gingivitis treatment in 834 women and demonstrated a reduction from 6.71% to 2.14% in the incidence of preterm birth/low birth weight (77). However, recent clinical trials have not corroborated the findings of these initial studies, as indicated by recent meta-analyses (30, 111).

A series of recent cross-sectional and case–control studies have also been conducted in Latin America, providing conflicting evidence regarding the association between periodontal disease and preterm birth/low birth weight (14, 26, 44, 46, 61, 83, 86, 91, 117, 150). Moreover, two randomized clinical trials recently conducted in Brazil have investigated the

effect of nonsurgical treatment on preterm birth/low birth weight (101, 154). These studies compared nonsurgical periodontal treatment with no treatment (101) or supragingival scaling (154) and both included women with widespread periodontal inflammation, but limited periodontal destruction. No significant differences between experimental groups were observed. Clinical studies with different study designs were also conducted in Brazil, with mixed results obtained (45, 56, 59, 121).

Periodontal disease and cardiovascular disease

The link between periodontitis and cardiovascular disease is controversial in the literature and a recent statement of the American Heart Association has been widely publicized (74). Meta-analyses of observational studies support an association between periodontal disease and cardiovascular disease (18, 65, 96). Epidemiological studies conducted in Latin America have, in general, supported this association; however, the results displayed high variability (1, 54, 73, 82, 104, 113, 114, 153). Periodontal treatment has been shown to reduce short-term levels of systemic markers of inflammation (105). Short-term studies with limited sample sizes showed a reduction in systemic markers associated with cardiovascular disease, including C-reactive protein and interleukin-6 (41, 85, 152). No long-term studies assessing this relationship or the effect of periodontal therapy on cardiovascular outcomes were found in Latin American countries. At this time, a randomized controlled clinical trial is being conducted to assess the potential impact of periodontal therapy in cardiovascular risk markers (120).

Periodontal disease and diabetes mellitus

A bidirectional relationship between periodontal disease and diabetes has been proposed (140). Periodontitis may impair glycemic control in patients with diabetes (34, 141, 146), and periodontal treatment may improve glycemic control in patients with diabetes, as demonstrated by recent meta-analyses (130, 142). Interventional studies conducted in Brazil achieved controversial findings, with some studies observing significant reductions in the levels of glycosylated hemoglobin (41, 100, 115), whereas others did not find significant changes after periodontal therapy (47, 122). These conflicting findings may be explained, at least in part, by different therapeutic strategies, small sample size and patient characteristics.

Concluding remarks

Latin America has seen important cultural, social and political transformation, as well as economic progress, in the last two decades and yet it is a very heterogeneous region. Millions have risen above the poverty line in most countries; however, in some countries, more than half of the population is still below the poverty line. Within-country differences are as profound as between-country disparities and should not be overlooked. In this context, any serious strategy to reduce the burden of disease should be based on minimizing social inequalities and strengthening health-promotion initiatives.

A high prevalence of periodontal destruction was observed in most studies, with high variability on the estimates. Periodontitis was not homogenously distributed in Latin American populations, and sex/gender, race/ethnicity/skin color, education/schooling, socio-economic classification/status/position and income were associated with the occurrence of periodontitis. Studies using inadequate sampling strategies, inadequate examination protocols and poor data analysis provide biased estimates and should be avoided.

Whereas Latin American populations clearly share with other regions the most important risk factors for periodontal disease, namely biofilm, smoking and diabetes, it is also evident that Latin America may have specific expression of the disease and exposure to risk factors. Population diversity, heterogeneous adoption of western culture, and inherent economic and social inequality provide unique circumstances for the study of social, demographic and economic factors and their interactions with traditional biological and environmental risk factors.

The amount of epidemiological data on periodontal diseases has increased since our last review in 2002; however, most of the studies are concentrated in a few countries. The scope of the literature available has also broadened to include oral health-related quality of life and systemic interactions, but studies used mostly cross-sectional designs and small convenience samples. To advance epidemiological knowledge in Latin America, large population-based cross-sectional and longitudinal studies using appropriate methodology should be the future focus of the research agenda of researchers and public health planners.

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