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Risk factors and prevalence of periodontitis in community-dwelling elders in Mexico

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Abstract

Aim: The objective of this study was to determine whether an association existed between chronic systemic diseases/conditions, risk factors common in old age, and the extent and severity of chronic periodontal disease.

Materials and Methods: Sociodemographic and lifestyle characteristics were examined by contrasting rural, urban-marginal, and urban social environments in Central Mexico. Data were analysed with Analysis of Variance, χ^2 tests, and multivariable logistic regression.

Results: A total of 473 adults 60 years old and over were interviewed; 315 were also examined and underwent laboratory assays (participation rate, 66%); women, 62%; mean age 73 ± 8 years; 23% edentulous. The distribution of periodontitis by sociodemographic variables showed differences across locales (73% low-urban, 57% middle-urban, 29% rural). The regression model indicated that periodontitis was more frequently associated with low-urban locale, higher systolic blood pressure, higher body mass index, and worse calculus readings, with an interaction whereby being obese and having a high calculus index was associated with a high probability of having periodontitis.

Conclusions: Overall periodontal conditions were fair. While we identified oral, systemic, and social variables that modulated the experience of periodontitis, it would appear that urban, low social class elders appeared to have worse periodontal conditions.

Key words: calculus; cardiovascular disease; diabetes; elderly; hypertension; Mexico; periodontitis; systemic disease.

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Moderate and severe periodontitis are defined variously, using different measurement methods and operational definitions. Despite this inconsistency in definition, the prevalence of severe periodontitis is known to be relatively high in the open population – 11–15% in adult populations in both developed (Albandar et al. 1999) and developing countries (Jiménez Garcia et al. 1995, Gjermo et al. 2002, Dowsett et al. 2001, Ronderos et al. 2001, Borges-Yañez et al. 2004, Taani 2004). Reports from several countries have shown that the prevalence of periodontitis in older adults, defined as at least one site with clinical attachment loss (CAL) > 4 mm, is moderate to high. For example, prevalence was 48–55% in Chinese adults (Corbet et al. 2001); 4–59% in elderly subjects in the US Pacific Northwest (Persson et al. 2004); and 68% in the National Survey of Oral Health in US Employed Adults and Seniors (Albandar 2002b). Higher figures were found in some cases, such as 100% among 50–59 year-olds in Thailand (Baelum et al. 2003) and 91% in elderly subjects (mean age 85 years) in the US Midwest (45% with one or more sites with loss of attachment (LOA) ⩾ 6 mm, and 15% with CAL ⩾ 8 mm) (Levy et al. 2003). In Germany (Mack et al. 2004), the prevalence of periodontal disease (at least one periodontal pocket ⩾ 4 mm) was between 62% and 85% in persons 60–79 years old. Among Mexican Americans in the US, 15% of 60–69 year olds and 9.3% of persons older than 70 years had at least four sites with CAL ⩾ 5 mm and at least one site with pocket depth ⩾ 4 mm (Borrell et al. 2004). When periodontal status is examined according to the Community Periodontal Index of Treatment Needs (CPITN) scores, 70% of persons 60–69 years old in the United Kingdom had CAL > 3.5 mm (Morris et al. 2001). In Finland, 11% had at least one pocket ⩾ 6 mm (CPITN = 4) (Ajwani et al. 2001). In Hong Kong, the percentage of institutionalized dentate subjects with shallow pockets and deep pockets (CPITN score) were 37% and 20% respectively (Lo et al. 2004). In

Jordan, shallow (19%) and deep (11%) pockets were found in the 50–60-year-old age group (Taani 2004). Severe CAL is generally confined to a minority (Locker et al. 2000).

Limited information is available from Latin American and Mexican populations (Jiménez Garcia et al. 1995, Borges-Yañez et al. 2004). In a Brazilian study, 100% of persons 60–69 years old had at least one site $\geqslant 4$ mm, with worse readings associated with lower socioeconomic level, smoking, diabetes, gender, and dental visits (Susin et al. 2004). A report presenting results derived from outpatients at a dental school clinic in Mexico found 83% extent and 3.2 mm severity in persons 60 years and older (Jiménez Garcia et al. 1995). The prevalence of moderate periodontitis (at least one site >4 mm) in all age groups was 43%.

In older populations, the relative contributions to periodontal problems of systemic and local risk factors are unclear. At the local level, risk factors such as calculus (Albandar 1990, Albandar et al. 1996) contribute to the development of periodontal diseases in adults. Subgingival bacteria associated with periodontal/gingival conditions have been found in various countries (Haffajee et al. 2004). Even though systemic/general risk factors for periodontitis are not markedly different across young adult and elderly populations, certain factors affect the severity and distribution of periodontitis and undermine treatment outcomes in older populations. These include lifestyle characteristics, poor attitudes toward dental health, low socioeconomic and educational levels (Dolan et al. 1997, Norderyd & Hugoson 1998, Elter et al. 1999, Paulander et al. 2003), restricted access to dental services, rural residence (Craig et al. 2001, Sbaraglia et al. 2002), presence of systemic diseases (Noack et al. 2000, Buhlin et al. 2003, Persson et al. 2003, Willershausen et al. 2003, Khader et al. 2004, Yoshihara et al. 2004), acute medical conditions such as infectious respiratory diseases (Scannapieco et al. 2003), polypharmacy, poor nutritional status, obesity (Saito et al. 2001, Wood et al. 2003) mental disorders (Teng et al. 2003), and smoking (Bennet & Reade 1982, Genco 1996). More disconcerting for populations at high risk of cardiovascular complications, such as the elderly, is the fact that (Lopez et al. 2004) several studies have reported epidemiological associations between periodontitis and cardiovascular disease (Mattila et al. 1989, DeStefano et al. 1993, Beck et al. 1996, Buhlin et al. 2002, Willershausen et al. 2003). The reason for such associations is unknown; the relationship might be weak (Hujoel 2002), because periodontitis and cardiovascular disease (Armitage 2000) share common risk factors (such as smoking and diabetes) (Beck et al. 1998, Hujoel et al. 2002) that can confound the association (Katz et al. 2002).

In Mexico, the National Survey of Chronic Diseases (Secretaría de Salud 1995) showed that the most frequent diseases among persons 60 years old and older were hypertension, diabetes mellitus, and cardiovascular conditions. The highest prevalence of diabetes was found in persons 70–79 years old (22.4%) (Olaiz et al. 2003) and also was high in men (20%) and women (25%) 60–69 years old. Twenty-four per cent of the Mexican population had hypertension in 1993 (Secretaría de Salud 1995), rising to 30.7% (Olaiz et al. 2003) in 2000. Furthermore, the Mexican population has a genetic predisposition to metabolic syndrome, diabetes mellitus type 2, and some dyslipidemias (Stern et al. 1991), with a high prevalence of the latter (Gonzalez et al. 1999, Aguilar-Salinas et al. 2001). The high-fat, high-carbohydrate diet, considerable alcohol intake, frequent tobacco consumption, and sedentary lifestyle in an increasingly larger proportion of the Mexican population have been identified as environmental risk factors for some chronic diseases (Munoz et al. 2000). While the availability of epidemiologic information on periodontal conditions is sparse in Mexico, knowledge of systemic/general risk factors contributing to the overall experience of periodontal/gingival conditions is even more limited. The objective of the present study was to determine whether an association existed between some systemic/general risk factors (as defined through biochemical indicators derived from laboratory tests and/or medical history), mouth-level risk factors for periodontitis, and the prevalence of moderate to severe periodontitis in persons 60 years old and older in Central Mexico.

Materials and Methods

The study was performed in accordance with the Helsinki Declaration of Human Studies, and the local Research and Ethics Committee authorized the protocol of this study.

This cross-sectional study included study participants from three different populations (urban areas of middle and low income level, and a rural area) included in the CRONOS Study (Cross-Cultural Research on Nutrition in the Older Adult Study Group), funded by the European Economic Community. The main objective of CRONOS was to describe the nutritional situation of older people in urban and rural communities in developing countries, from transcultural and multicentric perspectives (Van Staveren 1988).

Setting

Middle-urban group

The Centro Urbano *Presidente Miguel Alemán* is a large housing development in a middle-class neighbourhood in Mexico City. The elderly residents are retired civil servants who live in small apartments bought from the federal government during the 1960s. This urban group is classified as middle social class.

Low-urban group

The *Isidro Fabela* neighborhood is on the southern outskirts of Mexico City. This peri-urban community began as an illegal settlement of squatters who migrated to the city over many years. Such rural migrants settled irregularly in an area with no public services or well-defined social organization. Over the years, public services were introduced and the community was annexed to the city in bits and pieces. The residents' characteristics of schooling, employment, and social structure define this group as low urban social class.

Rural group

The *Valley of Solis* is a rural region with several villages, located in the Northwest area of the State of Mexico in the central region of the country, 200 km from Mexico City. Agriculture (corn and wheat) is the main economic activity. Public services are limited; the maximum level of schooling attained and the social structure prevalent in the area define this group as low rural social class.

Sample design

Censuses were performed in the three communities to identify all persons 60 years old and over, and three sample frameworks were designed by systematic random selection. The total numbers of subjects 60 years and older in each community were middle-urban 464, low-urban 332, and rural 469. Sample sizes were 139 (30%), 179 (54%), and 155 (33%), respectively. Only the persons living permanently within the communities were interviewed; all were interviewed in Spanish. All participants were living independently, and no respondent was unable to respond verbally to the interview.

Data collection

The design, purpose, and activities of the study were thoroughly explained in person by staff in the first visit. Informed consent was obtained to collect data using a structured interview, a dental exam, and laboratory assays. Pilot studies were carried out in 20 persons (not included in the final study sample) to assess acceptability and clarity of the questionnaire components and to determine the time it would take to complete the interview with the instrument and the dental exam under field conditions. A previously standardized dentist performed the oral examinations with a flat dental mirror and a dental probe, with the patient sitting on a chair under natural light. Also, examiners were calibrated during to the study, except for the recorders. To reduce systematic and random measurements errors, 10% subjects were recorded twice. No more than five subjects were examined daily by each examiner to avoid fatigue. Several oral health status variables were assessed, but for the present analyses only periodontal disease data will be reported in detail.

This report includes the results from 473 participants, of whom 315 agreed to a dental examination and to give a blood sample for laboratory tests. (In a separate analysis, no significant differences were observed in the sociodemographic characteristics in the group with and without biochemical analysis (data not reported). The participants received written information about the project, provided informed consent, and were examined at home. The participants received written results from the lab tests, and clinical advice was given when appropriate.

A structured interview was conducted in the participant's home. The questionnaire used in the interview assessed demographic and socioeconomic information, family health history, personal medical history, and lifestyle factors such as smoking and physical activity. The structured interview was carried out by a trained interviewer, collecting data on gender, schooling (highest grade attained in formal education), current smoking status (whether the subject stated that s/he smoked every day; number of cigarettes smoked every day), former smoker status (answer to the question: *Have you smoked in the past?*), marital status (single/ married/ widowed/ divorced), and other data. Dietitians performed anthropometric measurements and conducted dietary histories and nutritional assessments (Nelson et al. 1989). Participants' history of myocardial infarction (MI), cerebrovascular disease (CVD), arthritis or arthrosis, osteoporosis, diabetes mellitus (Type 2), and hypertension was established by direct inquiry, by clinical examination, and/or through laboratory assays.

Laboratory tests

At a primary care facility close to their homes, participants had blood specimens taken once after a 12–14 h fast for determination of plasma lipids, lipoproteins, insulin, and glucose concentrations.

Plasma glucose was analysed by the glucose oxidase method (Boeringher Mannheim, Germany). The plasma concentrations of total cholesterol and triglycerides were determined by enzymatic methods (Boehringer). High-density lipoprotein (HDL) cholesterol was measured after precipitation of very low-density lipoproteins and low-density lipoprotein (LDL) by the phosphotungstate method (Boehringer). LDL cholesterol was estimated by the Friedewald formula. The laboratory performing the tests (Instituto Nacional de Ciencias Médicas y de la Nutrición ''Salvador Zubirán,'' Ministry of Health, México) participates in the Lipid Standardization Program of the American College of Pathology.

Definition of variables

Normal glucose tolerance (NGT) was defined as fasting blood glucose <115 mg/dl and no history of diabetes reported on questionnaire. Diabetes was defined as a previous diagnosis of diabetes by World Health Organization (World Health Organization 1985) criteria or a fasting blood glucose value >140 mg/dl with no previous history of diabetes.

Systolic (1st phase) and diastolic (5th phase) blood pressures were measured to the nearest even digit with an electric sphygmomanometer with the subject in the supine position after a 5-min. rest. Hypertension was diagnosed if blood pressure readings were greater than 160/90 mm Hg (Bots et al. 1991).

The anthropometric measurements were performed by a trained nutritionist between 8 and 11 AM. Participants removed their shoes and upper garments and donned an examining gown. Height was measured to the nearest 0.5 cm. Body weight was measured on a balance (calibrated daily) and recorded to the nearest 0.1 kg. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2) and was used as an index of overall adiposity. The cutoff point was 30 or more.

An assortment of dental variables was collected. Periodontitis was measured in terms of the LOA; subjects classified with moderate or severe disease had at least two sites with LOA 4 mm or more (Albandar et al. 1999). Severe periodontitis was considered when at least one site had LOA $\geqslant 6$ mm. Periodontal assessments were performed in the mid-buccal and mesio-buccal sites of all teeth present in contra-lateral quadrants. (Quadrants were randomly selected, or quadrants with more teeth present were selected if substantial loss was apparent.) Attachment levels were measured using a Michigan probe (Hu-Friedy, Chicago, IL, USA). Third molars were not examined. The utilization of dental services in the last 12 months (Yes/No) did not distinguish between various purposes of dental visits but rather identified dichotomic use – non-use of services.

Statistical analyses

Statistical analyses were performed using the NCSS Package® (Kaysville, UT, USA). First, bivariate tests were done to describe the general features of the study populations. One-way analysis of variance was used to establish whether an association existed between (i) systolic blood pressure, glucose, cholesterol, CHDL, LDL, hypertriglycidemia, and missing teeth, and (ii) presence or not of moderate and severe periodontitis. χ^2 tests were used for (i) tobacco consumption; residence in a middle-urban, low-urban, or rural community; gender; dental plaque; and dental calculus, and (ii) presence or not of moderate and severe periodontitis.

For analysis purposes (logistic model), the dependent variable (periodontitis) was dichotomized. The multivariable model (logistic regression) was designed to identify the joint effect of local and systemic/general variables that could have modified the presence of severe or moderate periodontitis. We used the effect likelihood ratio test (LR) to ascertain statistical significance of each variable. Interactions were explored.

Results

Descriptive results

Table 1 shows population characteristics. Men made up between 30% and 46% of the three communities. Mean age was 71 years in the low-urban community and 73 in the middle-urban community and the rural community ($F = 3.2$, $p = 0.04$). Significant differences in the distribution by age and gender were found across the three locales ($p < 0.05$). The marital status distributions were different among the three locales, more widows and single/divorced persons live in the middle urban locale. Differences were observed in level of schooling across the three communities, and in level of schooling for each gender between the rural community and the middle-urban community. The largest proportions of men having university studies (32%) and women having completed high school (30%) were found in the middle-urban community. The rural community had the largest proportions of illiterate men (36.7%) and women (63.1%). The use of dental services was also different across locales: in the rural group we found the lowest utilization (13.4%), while the urban group had the highest (44.1%) (Table 1). The prevalence of moderate or severe periodontitis was 50.7%.

While demographic information is included for the whole sample (473),

Table 1. Distribution of socio-demographic characteristics by locale of residence

	Locale						Total		χ^2	p
	Middle-urban		Low-urban		Rural		N	%		
	N	%	N	%	N	%				
Gender										
Male	54	30.2	52	37.4	71	45.8	177	37.4	8.6	0.013
Female	125	69.8	87	62.6	84	54.2	296	62.6		
Total	179	100.0	139	100.0	155	100.0	473	100.0		
Marital status										
Married	56	31.8	84	61.8	111	72.5	251	54.0	67.1	<0.001
Widowed	83	47.2	44	32.4	36	23.5	163	35.1		
Single/divorced	37	21.0	8	5.9	6	3.9	51	11.0		
Total	176	100.0	136	100.0	153	100.0	465	100.0		
Schooling										
Illiterate	6	3.4	56	40.6	80	52.3	142	30.2	281.1	<0.001
Elementary incomplete	29	16.2	47	34.1	69	45.1	145	30.9		
Elementary complete	30	16.8	29	21.0	4	2.6	63	13.4		
Middle and higher	114	63.7	6	4.3	0	.0	120	25.5		
Total	179	100.0	138	100.0	153	100.0	470	100.0		
Smoking										
No	144	81.8	123	89.1	140	90.9	407	87.0	6.7	0.03
Yes	32	18.2	15	10.9	14	9.1	61	13.0		
Total	176	100.0	138	100.0	154	100.0	468	100.0		
Past smoking										
No	96	54.5	82	59.4	90	59.2	268	57.5	3.1	0.52
Yes, cigarette	80	45.5	56	40.6	61	40.1	197	42.3		
Yes	0	.0	0	.0	1	.7	1	0.2		
Total	176	100.0	138	100.0	152	100.0	466	100.0		
Age										
60–79	141	78.8	119	85.6	110	71.0	370	78.2	9.2	0.01
80+	38	21.2	20	14.4	45	29.0	103	21.8		
Total	179	100.0	139	100.0	155	100.0	473	100.0		
Diabetes										
No	114	77.6	61	62.9	72	80.9	247	74.2	11.9	0.02
Yes	28	19.0	33	34.0	17	19.1	78	23.4		
Undetermined	5	3.4	3	3.1	0	.0	8	2.4		
Total	147	100.0	97	100.0	89	100.0	333	100.0		
Use of dental services in the last 12 months										
No	62	55.9	63	67.7	123	86.6	248	71.7	30.01	<0.001
Yes	49	44.1	30	32.3	19	13.4	98	28.3		
Total	111	100	93	100	142	100	346	100		
Moderate or severe periodontitis										
No	52	43	27	26.7	101	70.6	180	49.3	48.5	<0.001
Yes	69	57	74	73.3	42	29.4	185	50.7		
Total	121	100	101	100	143	100	365	100		

the periodontal examination considered only 365 (77%) persons 60 years old and over with at least one tooth present; for the logistic regression analysis, 170 persons who had complete records were included.

We compared sociodemographic variables, BMI, and periodontitis between subjects included and not included in the logistic regression analysis. No statistically significant differences were found for mean age, gender, schooling, marital status, BMI, smoking, or distribution of periodontitis; only differences in the distribution by locale were found ($p = 0.012$). No differences were found for blood pressure, cholesterol, glucose, LDL, and HDL between edentulous and non-edentulous. Overall, 22.8% of participants were edentulous and were excluded from further analyses in the present report.

Of note are the facts that only 10% of the 365 participants were current smokers; no differences were found by locale.

The highest proportion with previous diagnosis of diabetes or a fasting blood glucose value > 140 mg/dl was observed in the low-urban community (35.2%) and the lowest in the rural community (17.9%) ($\chi^2 = 6.1$, $p = 0.045$).

Mean glucose levels were higher in the low-urban group (119.1 mg/dl), followed by the rural group (92.9 mg/dl) and the middle-urban group (80.2 mg/dl) ($F = 10.2$, $p < 0.001$). Mean cholesterol value was 213.8 mg/dl, with the highest value in the middle-urban group (225 mg/dl) and the lowest in the rural group (200.5 mg/dl) (F = 8.1, $p < 0.001$). HDL mean values were similar in the rural and the middle-urban group (48 mg/dl), and lower in the low-urban group (42.9 mg/dl) ($F = 5.1$, $p = 0.007$). LDL mean values were higher in the middle-urban group (157.1), followed by the low-urban group (144.3) and the rural group (130.4) ($F = 10.3$, $p < 0.001$). The group showing the highest mean BMI score was the low-urban (27.3), and the lowest was the rural group (23.2) ($F = 23.7$, $p < 0.001$). Hypertension higher than 160/90 mm Hg was more prevalent in the low-urban community (46%), followed by the middle-urban community (31%) and the rural community (27.9%) ($\chi^2 = 9.7$, $p = 0.008$). The highest systolic blood pressure values were observed in the middle-urban community (138.3 mm Hg) and the lowest in the rural community (120.3 mm Hg), while diastolic blood pressure was similar among the three communities (81.7 mm Hg) ($F = 2.6$, $p = 0.09$).

The distribution of periodontitis by sociodemographic variables showed that differences were significant across locales (73% periodontitis in the low-urban group, 57% in the middle-urban group, and 29% in the rural group ($\chi^2 = 48.5$, $p < 0.001$)).

In general, we did not observe differences in terms of periodontitis across the various levels of utilization of dental services in the prior 12 months. For example, of those that had not used dental services, 49.4% had moderate or severe periodontitis, compared to 55.4% who had used dental services ($\chi^2 = 0.97$, $p = 0.324$). Differences across locales were not significant.

Regarding the mean values for biochemical markers, BMI, age, number of teeth, plaque, and calculus across the presence or absence of moderate and severe periodontitis, we found that mean age (73.2 years) and lower number of teeth (14.6), and higher values for systolic blood pressure (132.8 mm Hg), plaque (1.2), and calculus (1.4) were significantly higher in the severe or moderate periodontitis group than in the no periodontitis group (Table 2). The distribution of periodontitis showed marginally significant differences ($\chi^2 = 2.8$, $p = 0.09$) in the diabetic group (61.5%) *versus* the non-diabetic group (49.5%). Current smoking was not associated with periodontitis ($\chi^2 = 2.2$, $p = 0.13$).

Multivariate model results

Our multiple logistic regression model used moderate and severe periodontal disease as the outcome variable (Table 3). The following variables were significant: locale (likelihood ratio (LR) $p = 0.0031$), systolic blood pressure (LR $p = 0.017$), and calculus (LR $p = 0.0625$). An interaction between BMI and calculus was detected (LR $p = 0.05$). To explore the interaction, both variables were dichotomized: the cutoff point for BMI was $\geqslant 30$ and the model used the mean value for calculus. In this way, four groups were formed: high BMI and high calculus; high BMI and low calculus; low BMI and high calculus; and low BMI and low calculus. The probability estimated by the model to have periodontitis was 0.68, 0.34, 0.60 and 0.43, respectively, suggesting that being obese and having a high calculus index was associated with a high probability of having periodontitis.

Table 2. Mean values for laboratory assay markers, body mass index, age, number of teeth, dental plaque, and dental calculus across presence of periodontitis

	No periodontitis			Moderate or severe periodontitis			Total			*t*	*p*
	N	Mean	SD	*N*	Mean	SD	*N*	Mean	SD		
Age	180	71.5	8.26	185	73.20	8.3	365	72.35	8.30	3.9	0.048
BMI	152	25.6	4.84	169	25.73	4.9	321	25.67	4.87	0.06	0.814
Teeth	180	18.5	8.27	185	14.62	7.6	365	16.55	8.16	22.2	< 0.001
Systolic BP (mm Hg)	144	126.8	21.06	137	132.88	24.2	281	129.78	22.81	5.0	0.026
Diastolic BP (mm Hg)	142	81.4	19.12	134	82.07	18.2	276	81.71	18.63	0.09	0.758
Glucose (mg/dL)	117	93.1	45.46	126	102.86	48.4	243	98.17	47.15	2.6	0.108
Cholesterol (mg/dL)	117	214.6	40.42	126	213.04	42.5	243	213.79	41.43	0.09	0.769
Triglycerides (mg/dL)	117	155.5	96.02	126	166.18	125.7	243	161.04	112.29	.55	0.460
HDL (mg/dL)	117	48.1	12.49	126	46.15	12.7	243	47.1	12.61	1.5	0.227
LDL (mg/dL)	115	144.9	40.16	124	144.54	40.1	239	144.76	40.04	0.01	0.930
Dental calculus	168	.83	0.65	171	1.21	0.91	339	1.02	.814	19.6	< 0.001
Dental plaque	168	1.0	0.61	171	1.38	0.86	339	1.20	0.77	20.1	< .001

BMI, body mass index; BP, blood pressure; HDL, high-density lipoprotein; LDL, low-dendity lipoprotein.

Table 3. Logistic regression model for periodontitis (dependent variable: moderate or severe periodontal disease, two or more sites with LOA ⩾4 mm)

Term	Estimate	Standard error	Probability > χ^2	OR	CI lower 95%	CI upper 95%
Intercept	− 4.3149	2.4095	0.0733			
Referent rural locale						
Urban middle locale	0.6416	0.4988	0.1983	1.8994	0.7164	5.1176
Urban low locale	1.8142	0.5683	0.0014	6.1361	19.4853	2.0746
Age	0.0479	0.0275	0.0813	1.0490	0.9948	1.1086
Referent male						
Gender (female)	− 0.7733	0.4215	0.0665	1.1367	1.0000	1.3058
Systolic blood pressure	0.0204	0.0088	0.0199	1.0206	1.0036	1.0389
BMI	− 0.0698	0.0442	0.1142	0.9325	0.8524	1.0170
Referent no diabetes M						
Diabetes	0.0764	0.4553	0.8668	1.0794	0.4390	2.6473
Number of teeth present	0.0447	0.0249	0.0725	1.0457	0.9965	1.0991
Calculus	0.2319	0.2507	0.3548	1.2610	0.7779	2.0964
(BMI)*(calculus)	0.1281	0.0675	0.0576	1.1367	1.0000	1.3058
Referent non-smoker						
Current smoker	0.5806	0.6537	0.3744	1.7872	0.4974	6.6898
Referent no dental visit last 12 months						
Dental visit last 12 months	− 0.2221	0.4204	0.5974	0.8009	0.3490	1.8296

Pseudo-$R^2 = 0.2097$; $\chi^2 = 48.17$; $p < 0.0001$.
LOA, loss of attachment.

Discussion

Periodontal conditions

Periodontal measurements

Of the elders examined, 28% experienced moderate periodontitis (at least two sites with LOA ⩾4 mm). Comparing this prevalence with previously published reports is difficult due to the diversity of disease definitions, classification categories, and cutoff points that appear in the literature (Kingman & Albandar 2002). In the absence of surveys in Mexican elders using the definition we used, we will contrast our findings with international studies that used LOA to estimate periodontitis prevalence. In Germany, the prevalence of periodontal disease (presence of at least one periodontal pocket ⩾4 mm) in 60–69-year-old persons was 85% in men and 71% in women (Mack et al. 2004), which was higher than the prevalence we observed. A study in Thailand detected 100% of 50–59 year olds having at least one site with LOA⩾4 mm (Baelum et al. 2003), while a study in Brazil found that 100% of adults aged 60–69 years old presented with LOA⩾4 mm (Susin et al. 2004). Allowing for some lassitude in terms of methods being somewhat different, Argentinian (34%, moderate and 39%, severe periodontitis) and Brazilian data (49%, moderate and 18%, severe periodontitis) offer similar prevalence levels to our results (Gjermo et al. 2002).

Studies in American populations also showed a higher prevalence of LOA than our study. For example, Albandar (2002b) found higher prevalence in the National Survey of Oral Health in US Employed Adults and Seniors, 1985–1986, with 51.7% of seniors having attachment loss ⩾6 mm. Levy et al. (2003) found that 91% of the subjects (mean age 85 years) had at least one site with LOA⩾4 mm, and 45% had one or more sites with LOA⩾6 mm. In a study of Mexican-Americans aged 50 years and older, the prevalence of periodontitis was 9.4%, defining periodontitis as at least four sites with LOA⩾5 and at least one site with pocket depth ⩾4 mm (Borrell et al. 2004). Comparing the prevalence with previously published reports is difficult due to the diversity of disease definitions, classification categories, and cutoff points that appear in the literature, (Kingman & Albandar 2002), in the comparison above described the same cut-off point is used (LOA⩾4). However, there are differences in the number of sites and teeth examined among studies and age groups. Borrell & Papapanou (2005) addressed that there is a need to standardize the ''case'' definition of periodontitis, so more valid comparisons among different populations and analysis of risk factors can be done.

Calculus

Plaque and calculus are established risk factors for periodontitis (Abdellatif & Burt 1987, Page et al. 2002), and we found them to be associated with periodontal disease. The low urban group had the highest prevalence of periodontal disease and also showed more plaque and calculus than the other two groups. However, no difference in plaque and calculus accumulation was found between the middle-urban and rural groups. Furthermore, an interaction was detected with BMI (see below).

Systemic/general health conditions

Cardiovascular conditions

Several cardiovascular risk factors were present in a large proportion of the elders. About a quarter of them presented high levels of triglycerides and cholesterol, and close to one-fifth were obese. Our findings are similar to those of the National Health Survey in Mexico (Velázquez et al. 2002), where 21.8% of elders (70–79 years old) were obese. A large Mexican survey found that adults in 417 cities had a poor lipid profile (HDL cholesterol was low in about a third of the population) and a high prevalence of insulin resistance (Aguilar-Salinas et al. 2001). In recent years, there has been an increase in the prevalence of cardiovascular risk factors and diabetes in the Mexican population overall (Lara-Rodriguez et al. 1996; Velázquez et al. 2002). The reasons for this deterioration are complex and relate to environmental factors, such as lifestyle (predominantly poor patterns of physical activity and diet), as well as genetic factors (Escobedo-de la Pena & Santos-Burgoa 1995, Flores-Martinez et al. 2004).

Blood pressure

High blood pressure was highly prevalent in the population studied – 61.2% were hypertensive. This prevalence was higher than the values obtained in the National Chronic Disease Survey (1993) (Tapia-Conyer 1993) and the National Health Survey in Mexico (2000), where 51.9% of the 70–79 year olds had hypertension (Olaiz et al. 2003). An additional problem in the Mexican population is that only 20% of patients had their hypertension situation adequately managed (Velázquez et al. 2002). We found a positive association between systolic blood pressure and periodontal disease, but not with diastolic blood pressure, as did a study in Italian patients (Angeli et al. 2003). Left ventricular hypertrophy, which is a frequent finding in hypertensive patients (Cuspidi et al. 2005), was an independent predictor of periodontal disease. But when this variable was incorporated in the model, systolic blood pressure was no longer significant (Angeli et al. 2003).

Some epidemiological studies have shown a relationship between periodontal disease or tooth loss and high blood pressure (Taguchi et al. 2004). Data from the Framingham Heart Study showed that the relationship of blood pressure and risk of coronary heart disease changes with age. In younger subjects, diastolic blood pressure is a stronger predictor of coronary heart disease; however, in older people, diastolic and systolic pressure, and pulse were comparable risk factors of coronary heart disease (Franklin et al. 2001). It appears possible that the relationships of diastolic and systolic blood pressure and periodontitis change with age.

The reason for the association between hypertension and periodontitis it is not clear. It may be that development of microcirculation dysfunction derived from hypertension affects periodontal tissues, perhaps coupled with arteriolar and capillarity rarefaction that can induce ischemia (Chapple et al. 2000, Serne et al. 2001). In hypertensive patients, changes in the vessel layers had been detected as a thickening of the intimae and elastic layer, and a decrease in the lumen of vessels irrigating the periodontal membrane (Castelli et al. 1978). With the homeostasis of the periodontal tissues altered, the inflammatory conditions present in periodontitis could increase damage to periodontal tissues. Alternatively, the association of high blood pressure with periodontal disease may be related to side effects of drugs used to treat high blood pressure, since the β-adrenoceptor antagonists tend to produce xerostomia (Nederfors 1996). The OH:SALSA aging study detected a 20% reduction in salivary output associated with drugs used for high blood pressure (Dodds et al. 2000). While xerostomia can affect oral mucosa, a relationship between xerostomia and periodontal disease has not been unequivocally established (Janket et al. 2003).

Finally, data from the NHANES III showed that C-reactive protein (CRP) and blood pressure were positively related (King et al. 2004). The complex scenario depicting the relationship between periodontal disease and CVD risk factors is compounded by the likelihood of it being bidirectional, with a large array of immunological, inflammatory, and genetic factors intervening (Slade et al. 2003; Pussinen et al. 2004).

Diabetes

The prevalence of diabetes in 60–79 year olds was about 22% in the National Health Survey 2000, close to the 25% found in the present study. The association between LOA and diabetes mellitus was marginally significant in the bivariate analysis and not significant in the multivariate model. The relationship between diabetes and periodontitis has been found in population-based surveys (Skrepcinski & Niendorff 2000, Tsai et al. 2002) but might be less consistent in elderly persons, perhaps due to accumulated/differential tooth loss and presence of co-morbidities (Zielinski et al. 2002, Persson et al. 2003), or it might be altogether absent (Tomita et al. 2002, Persson et al. 2003). Establishing the relationship between these two chronic conditions is of particular importance considering the high prevalence of diabetes in Mexico. Questions about sharing common genetic markers, effect of periodontal treatment on glycemic control, impact of lack of good glucose control on periodontitis, and the web of interactions between these aspects and psychosocial variables in the elderly require further research.

Body mass index

The association of BMI and periodontal disease is equivocal (Al Zahrani et al. 2003, Wood et al. 2003, Torrungruang et al. 2005). NHANES III data showed an association between BMI in young subjects (18–34 year olds) and periodontal disease; however, no association was detected in the older age groups (Al Zahrani et al. 2003). A cross-sectional study in Japanese subjects showed that in the highest categories of BMI, obesity was a significant risk factor for periodontitis after adjusting for several known periodontitis risk factors (Saito et al. 2001). A case control study of periodontitis and risk markers for atherosclerosis found an association with BMI, which was higher among cases with severe periodontal disease (Buhlin et al. 2003).

This is the first study, to our knowledge, to find an interaction between BMI and calculus. The logistic regression model showed that the group with high BMI (BMI $\geqslant 30$) and abundant calculus had a high probability of having moderate or severe periodontitis. Longitudinal studies had showed that good oral hygiene is a highly specific predictor of periodontal stability (Lang et al. 1990). The relatively weak interaction between BMI and calculus suggests that more studies are necessary to investigate in greater detail the complex relationships between periodontal features, and local and systemic risk factors for periodontitis in the elderly. We could speculate that the presence of calculus may be a marker for use of dental services (possible surrogates for poorly defined concepts such as access to dental services, or dental IQ), accepting that the relationship could be modified by other factors.

Smoking

The proportions of current smokers and never smokers found in the present study are consistent with data from the National Health Survey 2000 in Mexico. In the present study, 10.2% were current smokers and 58.4% never smoked, corresponding to the National Survey proportions of 11.5% and 59.8%. At the bivariate analysis level we found an association between periodontitis and cigarettes smoked, resembling observations derived from studies in adults living in developed and developing countries that support a dose–response relationship (Do et al. 2003, Nishida et al. 2005). In the moderate SES group, 13.0% of elders smoked, leading to an association between tobacco use and moderate or severe periodontitis in which 86.7% of smokers were affected. In the two low socioeconomic level locales (rural or urban), overall tobacco use and mean cigarette consumption were lower to begin with – we speculate that the two features contributed to the observed lack of association in the regression model. While we acknowledge that self-reported smoking may have validity problems, other studies have not been able to detect an association between periodontal disease and tobacco in the elderly (Persson et al. 2004, Thomson et al. 2004). In fact, a study in Sri Lanka showed that the effect of oral hygiene was more important than tobacco use as an indicator of risk of periodontitis (Amarasena et al. 2002), and another study in the USA suggested that smoking was a weak predictor of periodontitis in the elderly (Persson et al. 2005). The proportion of current smokers and the cut-off point for periodontitis (LOA$\geqslant$4) in the latter study and ours are very similar.

Locale of residence

Important differences among the urban and rural elderly were observed for both periodontal disease and cardiovascular risk factors. The elderly from the rural community had lower prevalence of periodontal disease than the middle-urban and low-urban groups. This finding was the opposite of findings from North America, Africa, and Scandinavia, where rural inhabitants had a higher prevalence of periodontal disease (Dolan et al. 1997, Paulander et al. 2004, Varenne et al. 2004). Furthermore, elderly community-dwelling Israelis living in rural areas had a higher mean attachment loss than those living in urban areas (Adut et al. 2004).

In the present study, the rural elderly had not only better periodontal health than their urban counterparts but also a lower prevalence of cardiovascular risk factors. While it is possible that lifestyle and diet drive these results (de Chavez et al. 1993), such differences also may be related to overall health status.

It is important to point out that very probably there are differences in the type of diet and physical activity among the three localities, since these characteristics are inherent to the geographical and socio-cultural environment of each locale. For example, the elderly living in the rural setting have more physical activity and probably a higher fibre intake than the elderly living in urban localities.

Some studies have highlighted the intimate association between periodontal disease and cardiovascular diseases, stroke, and other systemic problems (Beck et al. 1996, Geerts et al. 2004, Paquette 2004). These factors are different between the rural and the urban areas in the present study, with urban elderly experiencing higher levels of fasting glucose, prevalence of diabetes, and BMI than the rural elderly. In addition, mean cholesterol values were higher than the recommended values in the urban groups, and the rural group had both a better lipid profile and a lower systolic blood pressure. The commonly assumed facts of sparser health services and lower life expectancy in the rural area suggest that we could be witnessing a ''healthier survivor bias,'' but it may be that the health difference between the urban and rural areas depends on other factors – for example, psychological aspects. A study of deprivation, social class, and quality of life in British elderly showed that living in a rural area was associated with lower risk of poor morale (Breeze et al. 2005). At the present stage of our research, we are able only to speculate about other dimensions of health-related factors that could be contributing to the phenomena observed.

Socioeconomic status variables

Inequalities in health status associated with socioeconomic variables have been documented for decades in the North America, Europe, and Latin America (Feinstein 1993, Almeida-Filho et al. 2003, Comaru & Westphal 2004, Kunst et al. 2005). Higher periodontal disease prevalence has been reported in low income groups as well (Rozier & Beck 1991, Dolan et al. 1997). However, this relationship is not universal: while an analysis of social factors and periodontal diseases in the NHANES III showed that high-income Blacks had a higher prevalence of periodontitis than low-income Blacks, this type of relationship was not detected among Mexican-Americans. Conversely, lower educational attainment was associated with higher prevalence of periodontal disease in Mexican-Americans (Borrell et al. 2004). We found that the low-income urban group also had a lower level of education and showed the highest periodontal damage, compared with the middle-income urban group. Psychological aspects may play a role in these differences – Genco et al. (1999) found that variables associated with psychological stress, particularly those related with economic constraints, had a negative impact on periodontal health (Gjermo et al. 2002), perhaps as a consequence of changes in inflammatory responses (Kiecolt-Glaser et al. 2003).

After adjusting for selected systemic and local risk factors, the effect of locale of residence remained significant. Both rural elderly and low-income urban elderly were poor, but their health status differences were considerable. It appears that being poor in a rural area and being poor in an urban area have a different impact on cardiovascular and periodontal risk.

Conclusions

The results of the present study have good external validity considering its probabilistic sample design and the high participation rate of the elderly persons in the selected locales. Population-based studies such as this one have the advantage of reducing selection bias that is common in samples taken from hospitals or dental clinics. Conclusions from the present study, however, cannot be directly extrapolated to the entire elderly Mexican population.

In general, we found that periodontal conditions among elderly persons living in middle-urban, low-urban, and rural locales had substantial room for improvement. The poor elderly living in urban environments could have the worst of both worlds, however, through being affected by lower educational attainment and income, and the poorer diet and lifestyle of urban Mexico. The distribution of the elderly segment of the population in Mexico and its future projections (Consejo Nacional de Población 1999) indicate that the proportion of older adults will increase from 4.8% in 2000 to 6.2% in 2010 and to 13.2% by 2030. Such growth rates are similar to the trends forecasted for developed and developing countries, emphasizing the need to accurately establish the profile of oral health problems that will challenge the well-being and health care needs for this segment of the population.

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Clinical Relevance

Scientific rationale: The relationship between periodontal health and systemic/general health has been insufficiently characterized, in particular in developing countries.

Principal findings: After controlling for age, sex, general health, and calculus, urban residence remained a risk marker for periodontitis. As rural communities increasingly replicate the urban lifestyle, and more people become urban dwellers, periodontal deterioration and its relationship with general health may become more apparent.

Practical implications: It is important to improve oral health care using individualized and group-level interventions based on sound evidence, with dental professionals being knowledgeable about coexistence of periodontal and systemic conditions.