

# Prevalence, and Risk Indicators of Coronal and Root Caries in Mexican Older Adults in Nursing Homes

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**Background:** Several factors are associated with coronal and root caries in older persons. The purpose of this study was to determine the experience, prevalence, and risk indicators (socioeconomic, sociodemographic, and dental variables) of coronal and root caries in older persons residing in nursing homes in Mexico.

**Methods:** A cross-sectional study was carried out in 227 dentate participants with natural teeth. Convenience sample, where all dentate residents were invited to participate. The dependent variables were coronal caries and root caries, which were determined through an oral clinical examination. The independent variables were sociodemographic factors, location, type of center, surfaces free of dental biofilm and calculus, surfaces with recession, retainers in contact with surfaces with recession, xerostomia, smoking, and the previous use of dental services. The binary logistic regression model was used in the analysis.

**Results:** The mean age of the participants in this study was 77.7±8.8 years, and 69.2% were women. Moreover, 71.8% live in long-term care facilities, and 48.0% live in Mexico City. The prevalence of coronal and root caries was found to be 67.8% and 50.7%, respectively. Being male and living in Mexico City were risk indicators for coronal caries, and with a 1% increase in surfaces with no biofilm, the risk decreased by 2%. Being widowed, having government or no social security, denture retainers, and coronal caries were risk indicators for root caries, while the utilization of dental services indicated lower risk.

**Conclusion:** Several variables that differ in nature were found to be risk indicators for coronal and root caries. Coronal caries increases the risk of root caries. Prevention should be aimed at identifying persons at higher risk, and dental care should be improved for persons living in long-term care institutions.

**Keywords:** root caries, dental caries, institutionalization, adult, cross-sectional study, prevalence, risk indicators

## Introduction

Life expectancy and the aging population are increasing worldwide. Aging in Latin American and Caribbean countries is occurring at an accelerated rate.<sup>1</sup> In Mexico, population aging is an important challenge that the country is facing. In a short time, the population of older adults will increase more rapidly in relation to the other age groups. In 1990, the population aged 60 and over represented 6.4% of the total population of Mexico, a proportion that increased to 9.9% in 2010 and 12.0% in 2020, and will reach 21.5% in the year 2050.<sup>2-4</sup> As for access to health services, in Mexico, almost 3 million older adults (20%) are not affiliated with any health service institution.<sup>4</sup> Age is a strong predictor for diverse oral diseases as well as for chronic diseases. Thus, poor oral health, aging, and multimorbidity together represent some of the greatest challenges for health systems because they are highly prevalent in older adults and costly.<sup>5</sup>

Traditionally, much of the long-term care required by older adults is provided at home and is the responsibility of the family.<sup>6</sup> However, due to lower birth rates and the increase in female labor participation among other factors, a decrease

in informal care at home is expected, requiring governments to consider how to manage this future situation.<sup>1</sup> This obliges them to consider the increase in the demand for long-term care that will occur in this growing population.<sup>7</sup> The percentage of the older population that lives in long-term care residences in Mexico is very low (0.2%). According to a census carried out by the Mexican government in 2015, there were 1020 long-term care facilities for older adults, of which only 9% were publicly funded.<sup>8</sup>

In Mexico, older adults who are admitted to public gerontological centers are those who are in a situation of vulnerability according to the Official Mexican Standard PROY-NOM-031-SSA3-2018, Social Assistance. Social assistance services are provided to adults and older adults in situations of risk and vulnerability.<sup>9</sup> Persons who enter these public centers are those in situations of loneliness, abandonment, discrimination, and disability, as well as those who are victims of abuse and who require social assistance services.<sup>9,10</sup> Other conditions include being  $\geq 60$  years of age, not having or having insufficient economic resources, expressed willingness to enter, decreased functional capacity, and not having or having insufficient support networks.<sup>10</sup> There is currently no information on the health conditions of this still small but growing population group. In the near future, the health information of residents in these facilities will be of importance for decision-making in the field of health and social protection policies, which may reduce the state of social exclusion and vulnerability in the older population.

Several studies have suggested that institutionalized elders may have poorer oral health outcomes than home-dwelling elders due to factors such as limited access to dental care, reduced ability to maintain good oral hygiene, and having multiple chronic conditions.<sup>11,12</sup> Residents in long-term care facilities may not have regular dental examinations and treatments, increasing their risk of experiencing undetected oral health problems.<sup>13</sup> It has been found that institutionalized elders with physical limitations or cognitive impairment have more problems performing oral hygiene practices such as tooth brushing and dental flossing, increasing their risk of coronal and root caries, gingivitis, and other health problems.<sup>13,14</sup> They may suffer more and longer chronic conditions affecting their capacity for recovery and the probability of having good oral hygiene; moreover, they might be older, increasing their risk of oral infections and other oral health issues.<sup>15</sup> Home-dwelling elders have more control over their living environment, may be younger, have more access to dental care, and have better oral hygiene practices. They may also have stronger familiar and social support networks than institutionalized elders.<sup>15,16</sup>

Coronal and root caries represent one of the main oral health problems faced by older adults, resulting in the weakening of the dental structure. Pain, and the loss of teeth, negatively affects masticatory function, aesthetics, general health, nutrition, and quality of life. Several local and general factors are associated with the experience of coronal and root caries in older persons.<sup>17,18</sup> Some general factors associated with coronal caries are advanced age, male sex, living in a rural area, education, current smoking, and the negative self-perception of oral health.<sup>19,20</sup> Local factors including the use of partial dentures, poor oral hygiene, the accumulation of dental biofilm, and levels of lactobacilli and mutans streptococci in saliva have been identified.<sup>19–21</sup> General factors associated with the presence of root caries are sex, age, educational level, social security status, and smoking.<sup>17,22–26</sup>

Untreated root caries especially affects older populations as a result of increased gingival recession. This condition can be the result of periodontitis or the cumulative exposure of root surfaces to normal teeth use; the utilization of removable dental prosthesis; previous dental caries experience; the presence of dental biofilm; or poor oral hygiene.<sup>17,22,24</sup> In general, the risk of coronal and root caries increases due to the use of multiple medications, low salivary flow, cognitive limitations, physical and economic barriers to obtaining dental care, a fear of the dentist, or a self-perception of not needing dental care.<sup>24–27</sup> Moreover, cultural differences can affect the demand of dental services; in some countries, oral health may not be given as much importance as other health concerns.<sup>28</sup> Kiyak suggested that age, gender, the perception of dental treatment, culture, the cost of dental services, and opinions of the dentist guide the dental health behavior of elders when seeking dental care.<sup>29</sup> Reports of the dental conditions of people in long-term care residences have shown that the prevalence of dental caries is higher than in non-institutionalized elders.<sup>12,30</sup> The prevalence of coronal caries in institutionalized older people varies from 46% in Italy<sup>31</sup> and 51% in Canada<sup>27</sup> to 68% in Australia<sup>32</sup> and 90.4% in China.<sup>33</sup> In elders living independently in Mexico City was 90.8%, in persons with social security was 99.7%, in older persons attending a public dental service was 78%.<sup>34</sup> In Colombia, a study found a prevalence of root caries and non-treated moderate–extensive caries lesions of 46% and 54.4%, respectively.<sup>35</sup> The

prevalence of root caries observed in people living in long-term care facilities is 95.3% in Mexico,<sup>36</sup> 46.4% in India,<sup>37</sup> 30% in Hong Kong,<sup>17</sup> 44% in Canada,<sup>27</sup> 51% in Italy,<sup>31</sup> and 77% in Australia.<sup>32</sup>

There is scarce information about the coronal and root caries experience of institutionalized older adults in Mexico, especially with respect to the most vulnerable individuals living in public facilities. Linking the risk factors for root caries to expected caries risk can help identify individuals who may be at higher risk for developing root caries and thus develop a preventive plan. The purpose of this study is to determine the experience, prevalence, and risk indicators (socioeconomic, sociodemographic, and dental variables) of coronal and root caries in older persons residing in nursing homes in Mexico. The information obtained is of importance to decision-makers in the field of health and social protection policies since it is necessary to have information that allows for a reduction in the conditions of vulnerability and social exclusion of the older population.

## Materials and Methods

### Design Population and Sample of Study

This was a cross-sectional study. The study population was residents 60 years old and over from 4 public long-term care centers along with attendees of a public day care center in 4 cities in central Mexico; this was the reference population from which people were selected to participate in a clinical trial (ClinicalTrials.gov NCT0443241). Some of the methodology used in this study has been previously published elsewhere.<sup>38</sup> All facilities are administered by a public welfare institution that works at the federal and state levels and serves adults over 60 years old subject to social assistance or who are in a situation of vulnerability or disadvantage according to the Official Mexican Standard PROY-NOM-031-SSA3-2018, Social Assistance. They provide social assistance services to adults and older adults in situations of risk and vulnerability.<sup>9</sup> The gerontological centers—2 in Mexico City, 1 in Cuernavaca City, and 1 in Oaxaca City—provide comprehensive residential care (24-hour rooms; food, recreational, social, and cultural activities; and medical, psychological, and social work attention) 365 days a year. Day care centers provide day care (food; recreational, social and cultural activities; medical–primary health care; and referral to areas of psychological and social work care). The participants from the day care center were residents of Toluca City. These public long-term care facilities account for 50% of the public facilities in these states. In Morelos and Oaxaca, these are the only public facilities. In Mexico City, there are 28 long-term care facilities, of which 6 are public, and of those, 2 are administered by the public welfare institution. Finally, in the city of Toluca, there are 15 public day care centers, of which we worked in one.<sup>10</sup>

We used the following parameters<sup>36</sup> to determine sample size: level of confidence  $(1-\alpha) = 95\%$ , precision  $(d) = 2\%$ , proportion to estimate = 95.3, and 5% estimated losses, with a final sample of 228 subjects. A convenience sampling method was used, in which participation was voluntary. A total of 435 older adults were registered at the centers, and 52 presented severe cognitive impairment or a disease that prevented clinical examination or interview as identified by a report provided by the authorities of each center. All residents and attendees with no cognitive disorders were invited to participate (383 persons), of whom 4 did not accept and 152 did not fulfill the selection criteria. Thus, 227 signed the informed consent form and were included in the study.

The inclusion criteria were: 1) men and women, 2) 60 years old and over, 3) residing in any of the 4 long-term care facilities or participants at the day care center, 4) voluntarily participate and sign the informed consent form. Exclusion criteria were: 1) persons with any disease or health condition preventing them from answering the interview questions or performing the clinical examination, 2) severe cognitive impairment (serious behavioral problems, mobility and communication problems) identified by the report provided by the authorities of each center ( $n=52$ ), 3) being edentulous ( $n=99$ ) and 4) severe hearing loss ( $n=53$ ).

Participants who signed the informed consent form were interviewed and clinically examined by two calibrated dental surgeons; they were assisted by two trained dental students who registered the information. The examiners were trained by one dental professional with clinical and epidemiological experience in evaluating coronal and root caries as well as the functionality of dentures and the presence of biofilm and dental calculus who had performed standardized clinical evaluations in previous studies. The inter-examiner kappa scores for dental biofilm and calculus; root caries; and coronal

caries were 88%, 78%, and 90%, respectively. Participants were examined at each center in a portable dental chair under artificial light. The clinical examination was performed with a dental mirror and PCP 11.5 periodontal probe (Hu-Friedy).

## Variables

### Dependent Variables

The dependent variables were untreated coronal and root caries, although coronal caries was considered as an independent variable for root caries. Coronal caries experience was assessed with the Decayed, Missing, and Filled Teeth Index (DMFT Index) measuring all teeth affected by dental caries according to the criteria of the World Health Organization.<sup>39</sup> Only decayed teeth were included in the estimation of the prevalence of caries.

Root caries was defined as root surfaces with caries experience according to the classification of root caries using the International Caries Classification and Management System (ICCMSTM).<sup>40</sup> The ICCMS criteria for root caries are based on the presence of cavitation. Sound: root surface does not exhibit any unusual discoloration, a surface defect at the cemento-enamel junction (CEJ) or on the root surface; initial lesion: clearly demarcated area on the root surface or at the CEJ (light/dark brown, black), no cavitation or loss of anatomical contour < 0.5 mm; moderate–extensive lesion: clearly demarcated area on the root surface or at the CEJ (light/dark brown, black) and cavitation (loss of anatomical contour), < 0.5 mm–2 mm (moderate), > 2 mm (extensive). Moderate and extensive categories were considered root surface caries. Four surfaces of each tooth were examined.

### Independent Variables

Local factors: Dental biofilm and calculus were evaluated estimating the percentage of surfaces with no biofilm and the percentage of surfaces with no calculus. Two surfaces per tooth (lingual and buccal) were evaluated and surfaces free of dental biofilm or calculus were identified according to the Green and Vermillion criteria.<sup>41</sup> The number of removable partial denture retainers in contact with surfaces with gingival recession and the number of surfaces with gingival recession were recorded. The information was obtained via clinical dental examination.

General factors: location of gerontological center (city where the center was located): Mexico City, other cities (Oaxaca, Cuernavaca, Toluca); type of gerontological center: long-term care, day care center; sex: male, female; age: years; civil status: single, divorced/married/widowed; schooling: illiterate, incomplete primary, complete primary/secondary, high school/college; social security (right of people to receive medical services in public or private health institutions as a consequence of a job benefit for being a pensioner or retiree, for registering or acquiring health insurance, or for being a family member designated as a beneficiary): social security, government insurance, no social security;<sup>42</sup> current smoking: answer to the question: Do you smoke? (no, yes); self-reported xerostomia: answers to the questions: Do you often feel your mouth is dry? Do you have difficulty swallowing food due to dry mouth? (no, yes); and use of dental services in the previous 12 months: answer to the question: Have you received dental care in the last 12 months? (no, yes). The information was obtained via interview.

## Statistical Analysis

The distribution by sex, civil status, schooling, social security, xerostomia, smoking, use of dental services, and type and location of the gerontological center according to the presence of coronal and root caries was described as counts with percentages and compared using chi-square tests. Age, percentage of surfaces with no biofilm, percentage of surfaces with no calculus, number of denture retainers in contact with root surfaces with gingival recession, and number of surfaces with recession showed no normal distribution (Shapiro–Wilk test) and were described with median and interquartile range (IQR) and compared according to the prevalence of coronal and root caries with non-parametric tests (Mann–Whitney *U*-test).

Differences in coronal caries distribution by root caries status were estimated with a chi-square test. The significance level was established at 0.05. Univariate and multivariate logistic regression models were fitted; the dependent variables were the presence of coronal caries (participants with decayed teeth > 0) and the presence of root caries (participants with decayed surfaces > 0). The independent variables included were variables with clinical and sociodemographic significance, and sex and age were confounding variables. Theoretically significant variables were included. Moreover,

variables with a p value of <0.25 in the bivariate analysis were included in the model to adequately control the effect of confounding factors.<sup>43,44</sup> All analyses were performed using Stata software version 16 (StataCorp LP, College Station, TX, USA).

## Ethical Issues

This investigation was approved by the Research and Ethics Committee of the Faculty of Dentistry, National Autonomous University of Mexico (CIE/0810/03/2017) (ClinicalTrials.gov NCT0443241).

## Results

The mean age of the dentate participants was 77.7 ±8.8 years, 69.2% were women, 71.8% were living in long-term care facilities, and approximately half of the participants resided in Mexico City. Most of the participants (44.4%) were divorced or single and 34.7% were widowed. A total of 13.7% participants were illiterate, and one-third (34.5%) had completed primary or secondary school. Around half of the participants had social security as they were retired workers or were insured by their children, one-quarter were insured by the government social security system, and one-fifth (19.8%) had no social security. One-third of the participants reported xerostomia, and 67.4% had used dental services in the previous 12 months (Table 1).

**Table 1** Distribution of the Study Variables According to the Prevalence of Coronal Caries (Percentages and Mean and Standard Deviation)

	<b>Without Caries (n=73) 32.2%</b>	<b>With Caries (n=154) 67.8%</b>	<b>P value</b>	<b>Total (n=227)</b>
Sex (n=227) Female (n=157) Male (n=70)	38.9% 17.2%	61.2% 82.9%	0.001	69.2% 30.8%
Civil status (n=225) Single–divorced (n=100) Married (n=47) Widowed (n=78)	26.0% 38.3% 35.9%	74.0% 61.7% 64.1%	0.21	44.4% 20.9% 34.7%
Schooling (n=226) Illiterate (n=31) Incomplete primary (n=65) Complete primary–secondary (n=78) High school–college (n=52)	22.6% 30.8% 38.5% 30.8%	77.4% 69.2% 61.5% 69.2%	0.42	13.7% 28.8% 34.5% 23.0%
Social security (n=222) Social security (n=120) Government insurance (n=58) No social security (n=44)	32.5% 36.2% 27.3%	67.5% 63.8% 72.7%	0.63	54.1% 26.1% 19.8%
Xerostomia (n=225) No (n=150) Yes (n=75)	32.0% 32.0%	68.0% 68.0%	1.00	66.7% 33.3%
Smoking (n=225) No (n=214) Yes (n=11)	31.8% 36.4%	68.2% 63.6%	0.75	95.1% 4.9%
Use of dental services in previous 12 months (n=222) No (n=74) Yes (n=153)	37.7% 29.4%	62.3% 70.6%	0.22	31.1% 68.9%

(Continued)

**Table 1** (Continued).

	<b>Without Caries (n=73) 32.2%</b>	<b>With Caries (n=154) 67.8%</b>	<b>P value</b>	<b>Total (n=227)</b>
Location of center (n=227) Mexico City (n=109) Other cities (n=118)	20.2% 43.2%	79.8% 56.8%	0.0001	48.0% 52.0%
Type of center (n=227) Long-term care (n=163) Day care center (n=64)	26.4% 46.9%	73.6% 53.1%	0.003	71.8% 28.2%
	<b>Mean <math>\pm</math>SD (median; IQR)</b>	<b>Mean <math>\pm</math>SD (median; IQR)</b>		<b>Mean <math>\pm</math>SD (median; IQR)</b>
Age in years (n=225)	76.2 $\pm$ 8.6	78.5 $\pm$ 8.7	0.04	77.7 $\pm$ 8.8
Mean percentage of surfaces with no biofilm	64.8 $\pm$ 32.2% (73.9; 41.6) %	52.6 $\pm$ 33.6% (60.0; 63.1) %	0.009	56.5 $\pm$ 33.6% (64.3; 60.0) %
Mean percentage of surfaces with no calculus	79.3 $\pm$ 22.4% (86.1; 29.5) %	79.9 $\pm$ 19.4% (83.3; 22.6) %	0.64	79.7 $\pm$ 20.4% (85.0; 23.6) %

The prevalence of coronal caries was 67.8% (95% CI: 61.5%-73.6%), and was higher among men, among older persons, in participants from Mexico City, and in persons living in long-term care facilities ( $p < 0.05$ ). Overall, the median percentage of surfaces with no biofilm was 64.3% and was lower in persons with coronal caries ( $p = 0.009$ ) (Table 1).

The prevalence of root caries was 50.7% (95% CI: 44.1%-57.2%). Persons with root caries were older, and prevalence was higher among those with government insurance and no social security, those who smoked, in participants from Mexico City, those living in long-term care facilities, and in persons with coronal caries ( $p < 0.05$ ). The median percentage of surfaces with no biofilm was lower in persons with root caries, and the median number of retainers in contact with root surfaces as well as the median number of surfaces with recession was higher in persons with root caries ( $p < 0.05$ ) (Table 2).

The multivariate model for coronal caries showed that the risk of coronal caries was higher among men (OR=2.3; 95% CI: 1.1–5.0) and in persons from centers in Mexico City (OR=3.0; 95% CI: 1.3–6.8). Moreover, for every 1% increase in surfaces with no biofilm, the risk of coronal caries decreased by 2%, and for every 1% increase in surfaces with no calculus, a 2% increase in coronal caries was estimated (Table 3).

The risk of root caries was higher among widowed participants (OR=2.8; 95% CI: 1.2–6.9), in persons with government insurance (OR=1.1; 95% CI: 1.1–5.4) or with no social security (OR=4.9; 95% CI: 1.8–13.9), and in persons with coronal caries (OR=3.4; 95% CI: 1.6–7.3). Participants who had used dental services in the previous 12 months had a 55% lower risk of having root caries. Moreover, for each retainer in contact with surfaces with gingival recession, there was a 50% increase in the probability of having root caries (Table 4).

## Discussion

The purpose of this study was to determine the experience, prevalence, and risk indicators (socioeconomic, sociodemographic, and dental variables) of coronal and root caries in older persons residing in four public long-term care centers as well as persons attending a public day care center in central Mexico. Overall, we found a higher prevalence of coronal caries than root caries, and both were more prevalent in the institutionalized persons than in those attending the day care center, suggesting that the risk of untreated coronal and root caries is an important health issue in older persons and is higher in residents in long-term care centers. These results can only be generalized to the population 60 years old and over in long-term care public facilities in central Mexico, which account for 100% of the facilities in Oaxaca and Cuernavaca, 33% of those in Mexico City, and 6.7% of the public day care centers in Toluca City. Public facilities represent only 9% of all the long-term care residences in Mexico.<sup>45</sup> This is the first study carried out in public gerontological centers serving low-income elders in several cities in central Mexico; this model allowed us to

**Table 2** Distribution of the Study Variables According to the Prevalence of Root Caries (Percentages and Mean and Standard Deviation)

	<b>Without Root Caries 49.3% (n=112)</b>	<b>With Root Caries 50.7% (n=115)</b>	<b>P value</b>	<b>Total (n=227)</b>
Sex (n=227)			0.060	
Female	53.5%	46.5%		69.2%
Male	40.0%	60.0%		30.8%
Civil status (n=225)			0.220	
Single–divorced	50.0%	50.0%		44.4%
Married	59.6%	40.4%		20.9%
Widowed	43.6%	56.4%		34.7%
Schooling (n=226)			0.090	
Illiterate	35.5%	64.5%		13.7%
Incomplete primary	46.2%	53.8%		28.8%
Complete primary–secondary	60.3%	39.7%		34.5%
High school–college	46.2%	53.8%		23.0%
Social security (n=222)			<0.001	
Social security	60.8%	39.2%		54.1%
Government insurance	44.8%	55.2%		26.1%
No social security	25.0%	75.0%		19.8%
Xerostomia (n=225)			1.000	
No	49.3%	50.7%		66.7%
Yes	49.3%	50.7%		33.3%
Smoking (n=225)			0.030	
No	50.9%	49.1%		95.1%
Yes	18.2%	81.8%		4.9%
Use of dental services in previous 12 months (n=222)			0.470	
No	46.4%	53.6%		31.1%
Yes	51.6%	48.4%		68.9%
Location of center (n=227)			<0.001	
Mexico City	35.8%	64.2%		48.0%
Other cities	61.9%	38.1%		52.0%
Type of center (n=227)			<0.001	
Long-term care	41.1%	58.9%		71.8%
Day care center	70.3%	29.7%		28.2%
Coronal caries (n=227)			<0.001	
No	69.9%	30.1%		32.2%
Yes	39.6%	60.4%		67.8%
	<b>Mean ±SD (median; IQR)</b>	<b>Mean ±SD (median; IQR)</b>		<b>Mean ±SD (median; IQR)</b>
Age in years	75.7±8.8	79.7±8.3	0.0003	77.7 ±8.8
Percentage of surfaces with no biofilm	63.2±32.0% (70.7; 42.2) %	50.0 ±34.0% (56.9; 64.6) %	0.004	56.5 ±33.6% (64.3; 60.0) %
Percentage of surfaces with no calculus	82.3±19.1% (86.2; 20.4) %	77.1±21.2% (83.3; 29.0) %	0.050	79.7 ±20.4% (85.0; 23.6) %

(Continued)

**Table 2** (Continued).

	<b>Without Root Caries 49.3% (n=112)</b>	<b>With Root Caries 50.7% (n=115)</b>	<b>P value</b>	<b>Total (n=227)</b>
Retainers in contact with surfaces with gingival recession	0.40 ±1.3% (0.0; 0.0) %	0.74±1.3% (0.0; 1.0) %	0.010	0.57±1.3% (0.0; 1.0) %
Surfaces with recession	12.8±12.5% (11.0; 14.5) %	20.9±17.6% (17.0; 19.0) %	<0.001	16.9±15.8% (14.0; 18.0) %

**Table 3** Crude and Adjusted Logistic Regression Models for the Association Between Coronal Caries and Sociodemographic and Clinical Variables (n = 225)

Variables	Crude Model			Adjusted Model		
	OR	95% CI	P value	OR	95% CI	P value
Age	1.03	0.99–1.06	0.08	1.00	0.96–1.00	0.90
Sex						
Female (reference)	1			1		0.04
Male	3.10	1.50–6.20	0.002	2.30	1.10–5.00	
Civil status						
Single–divorced.	1			1		0.65
Married	0.56	0.27–1.20	0.13	1.30	0.48–3.30	0.85
Widowed	0.63	0.33–1.10	0.16	1.10	0.49–2.40	
Utilization of services						
No (reference)	1			1		
Yes	1.40	0.79–2.60	0.22	1.30	0.66–2.50	0.46
Location of center						
Other cities (reference)	1			1		0.01
Mexico City	3.00	1.70–5.40	<0.001	3.00	1.30–6.80	
Type of center						
Long-term center (reference)	1			1		
Day care center	0.41	0.22–0.74	0.003	0.98	0.39–2.50	0.97
Percentage of surfaces with no plaque	0.99	0.98–0.99	0.01	0.98	0.97–0.99	0.02
Percentage of surfaces with no calculus	1.0	0.98–1.00	0.84	1.02	1.001–1.04	0.03

**Abbreviations:** CI, confidence interval; OR, odds ratio.

evaluate factors such as the geographical location of the center and compare results by the type of center. Although this study provided insight into the factors associated with the prevalence of coronal and root caries, its cross-sectional design did not allow us to establish causal relationships; thus, we were able to identify risk indicators for coronal and root caries but were not able to identify risk factors.

In this epidemiological study, there was some consideration regarding the validity of certain measurements previously identified as risk factors for root caries that did not exhibit an association in this study. The self-reports of xerostomia (two questions) could have resulted in underestimations of the condition; thus far, the Xerostomia Inventory has not been validated in Mexico.<sup>46</sup> In this study, the number of persons who smoked was very low, and no association with root caries could be established. No estimation of periodontal conditions was performed, which has also been identified as a risk indicator. It would be beneficial to include residents with cognitive impairment in further studies as they are at higher risk of dental problems.



**Table 4** Crude and Adjusted Logistic Regression Models for the Association Between Root Caries and Sociodemographic and Clinical Variables (n = 219)

Variables	Crude Model			Adjusted Model		
	OR	95% CI	P value	OR	95% CI	P value
Age	1.06	1.02–1.08	0.001	1.02	0.98–1.10	0.400
Sex						
Female (reference)	1			1		
Male	1.7	0.90–3.00	0.060	0.74	0.34–1.60	0.440
Civil status						
Single–divorced	1			1		
Married	0.68	0.37–1.40	0.280	2.40	0.81–7.20	0.110
Widowed	1.30	0.71–2.30	0.390	2.80	1.20–6.90	0.020
Utilization of services						
No (reference)	1			1		0.048
Yes	0.81	0.45–1.40	0.450	0.45	0.20–0.99	
Location of center						
Other cities (reference)	1			1		
Mexico City	2.90	1.70–5.00	<0.001	1.20	0.48–3.20	0.650
Type of center						
Long-term center (reference)	1			1		
Day care center	0.29	0.15–0.55	<0.001	0.52	0.18–1.50	0.250
Social security						
Social security (reference)	1			1		
Government insurance	1.90	1.00–3.60	0.040	1.10	1.10–5.40	0.030
No social security	4.60	2.10–10.10	0.000	4.90	1.80–13.90	0.002
Schooling						
Illiterate (reference)	1			1		
Incomplete primary	0.64	0.26–1.60	0.32	0.57	0.18–1.70	0.320
Complete primary–secondary	0.36	0.15–0.86	0.02	0.34	0.11–1.00	0.060
High school–college	0.64	0.25–1.60	0.34	0.85	0.27–2.80	0.800
Smoking						
No (reference)	1			1		
Yes	4.70	0.90–22.10	0.05	3.30	0.55–20.20	0.190
Retainers in contact with surfaces with gingival recession	1.20	0.99–1.60	0.060	1.50	1.10–1.90	0.004
Surfaces with recession	1.04	1.02–1.06	<0.001	1.02	0.99–1.05	0.070
Coronal caries						
No (reference)	1			1		
Yes	3.50	1.90–6.40	<0.001	3.40	1.60–7.30	0.001
Percentage of surfaces with no plaque	0.99	0.98–0.99	0.004	0.99	0.98–1.00	0.560
Percentage of surfaces with no calculus	0.99	0.97–1.0	0.060	0.99	0.98–1.10	0.610

**Abbreviations:** CI, confidence interval; OR, odds ratio.

The higher prevalence of coronal and root caries in the institutionalized participants and the higher risk of coronal caries among the participants from Mexico City found in this study could be the result of a course of life experiences that may have contributed to the conditions of vulnerability that caused these individuals to enter a long-term care facility. In

Mexico, many older adults migrated from rural areas or smaller cities when they were young. In general, they had a very low educational level, and throughout their lives they lost their prior lifestyles, diet, and social and family support, especially in low-income populations.<sup>47,48</sup> These events are what distinguish the institutionalized elders in public facilities in Mexico and characterize those people with poor oral health conditions.<sup>49</sup> It has been noted that experiencing these types of events at different stages of life have a negative cumulative result on health.<sup>50</sup> Moreover, negative oral health conditions in older adults have been linked to socioeconomic conditions throughout life.<sup>49,51</sup> Poor oral health in institutionalized elders is also conditioned by other factors such as functional dependence, reduced mobility, multimorbidity, and cognitive impairment.<sup>13–15</sup> Other factors include limited access to dental care, reduced ability to maintain good oral hygiene, multiple chronic conditions, and depression, which affect the capacity of recovery or the probability of having good oral hygiene; moreover, such individuals might be older, increasing the risk of oral infections and other health issues.<sup>15</sup> It is important to consider that oral health practices (tooth brushing) in institutionalized elders can sometimes be omitted or performed less frequently, increasing the risk of oral problems. A report on the oral health conditions of persons residing in nursing homes in the US found that only 16% of residents received oral care, which mainly consisted of tooth brushing. Moreover, it was identified that the nursing staff was not adequately prepared to provide oral health care.<sup>13</sup> However, some interventions have been shown to be effective; a randomized trial carried out in 2019 concluded that regular tooth brushing every 2 weeks by a dental nurse can improve oral health and could reduce the incidence of caries.<sup>52</sup> A factor associated with the higher prevalence of coronal and root caries found in persons residing in Mexico City is migration to Mexico City, which can be regarded as a “turning point” that modifies the course of people’s lives through exposure to other environments, contexts, living conditions, and culture.<sup>47,53</sup>

As found in this study, those participants who used dental services and those with social security had a lower risk of root caries compared with persons with no social security or government insurance. Persons with no social security are unlikely to use dental services or will use private services in the case of emergency. Those insured by the government (Seguro Popular) have access to the restoration of root and coronal caries, but there is a possibility that they will not use these services due to accessibility or transportation restrictions or for personal reasons.<sup>54,55</sup> A study carried out in the US also found that persons with no health insurance had a higher prevalence of caries.<sup>56</sup>

Overall, the use of dental services in Mexico is not very frequent. Even when there are public dental services available, almost all the dental health care is provided by private practitioners, and a smaller percentage is provided by public services or social security services.<sup>57</sup> The dental services provided by public services are basic procedures and do not comprise complex oral rehabilitations; the private sector performs these procedures.<sup>58</sup> Low-income populations and many older persons are at risk of poor health conditions because of a lack of access to dental health care (economic, geographic, social security factors) as well as a very low knowledge of the impact of dental health on general health and on the quality of life; culture; and the perception of dental treatment.<sup>29</sup> In this study, the utilization of dental services decreased the probability of having root caries; this negative association was also found in a study from the US (“infrequent dental visits”).<sup>55</sup>

Other reasons could be that older persons may not consider oral health as a health issue, may have a good perception of their oral health despite their oral health problems, or may not grant importance to oral health.<sup>28,59</sup> Mexico is a medium-income country; its cultural and economic conditions do not favor prevention and dental care. Several authors have pointed out that oral health and general health seem to be associated in sick populations. If there is no apparent disease, oral health and general health can be considered as separate constructs. If a population does not consider oral health to be an important health issue, defining oral health policies will be a low priority.<sup>60,61</sup>

In Mexico, the priorities reflected by dental health policies are to decrease the prevalence of coronal caries, periodontal disease, and oral cancer,<sup>62</sup> but the results from this study show relatively high caries prevalence rates. The National Specific Action Program for the Prevention, Detection, and Control of Oral Diseases 2024 presents public policy for dental health to guarantee universal access to quality integral health services. This policy promotes attention for older adults under a community health approach, promoting the participation of the community in the operation of programs.<sup>58</sup> However, the Specific Action Program in Attention to Aging 2020–2024 does not consider dental health prevention or treatment among its target actions.<sup>63</sup> Nevertheless, the Health Care Model for Well-Being published in 2022 includes oral

health promotion and oral health education activities oriented to older adults 60 years old and over as well as prevention education and attention for dental diseases at the community level.<sup>64</sup>

The overall prevalence of coronal caries was lower in this study than in previous reports on elders living independently in Mexico City<sup>34</sup> and was similar to reports on institutionalized persons in Australia (68%).<sup>32</sup> In this study, since prevalence was estimated only with respect to non-treated dental caries, it can be considered high. While in a previous study carried out in Mexico, prevalence was estimated when the DMFT score was >0. Likewise, the prevalence of root caries in institutionalized elders was lower in this study compared with that reported by another study in Mexico<sup>36</sup> where the estimation of prevalence included decayed and filled surfaces and the population examined was relatively small. Compared with institutionalized elders in Colombia, the results from this study show slightly higher estimations for both conditions.<sup>35</sup> The high prevalence of untreated coronal and root caries found in this study indicates the need for immediate care. High rates of edentulism have also been reported as well as non-functional removable prosthesis, conditions which impact the quality of life.<sup>65</sup>

One of the risk indicators identified for coronal caries in this population was being male. This factor was also reported by studies in Brazil and Belgium.<sup>20,66</sup> It has been reported that women use more dental services than men and that even when caries experience is higher among women, untreated lesions are higher among men.<sup>67</sup> In this study, we found that more surfaces free of dental biofilm were an indicator of a lower risk of coronal caries, assuming that the percentage of surfaces with no biofilm are a proxy for oral hygiene; this is consistent with reports from other countries about oral hygiene and the risk of caries.<sup>21,68</sup>

Among the risk indicators identified for root caries in this study was being widowed. Widows are perhaps more likely to live alone, have a low income, and face accessibility barriers, a lack of transportation, poor oral hygiene practices, or a low utilization of dental services.<sup>54,55</sup> A study carried out in Chile identified a higher Root Caries Index in widowed participants compared with single and married participants.<sup>69</sup> We identified well-known local risk indicators for root caries: coronal caries and retainers in contact with surfaces with gingival recession. Tan observed similar results when evaluating proximity to dentures.<sup>24</sup> There is a high usage rate of removable prostheses among the older Mexican population. A study in persons  $\geq 70$  years old in Mexico City found that 68% of removable prostheses were not functional.<sup>65</sup> Persons wearing removable partial dentures should be considered at increased risk, and special attention should be paid to preventive activities aimed at the proper cleaning and care of removable dental prosthesis. The presence of coronal caries was found to increase the risk of experiencing root caries. Several studies have reported the association of coronal decayed and filled surfaces with the development of root caries.<sup>17,70</sup> Beck and Drake found that people experiencing coronal and root caries had more gingival recession, and another study found that hyposalivation increased risk in older adults.<sup>71</sup> In this study, no association was found with smoking, but there was a low number of participants who smoked (n=11). It is worth considering what Kassebaum et al identified as the three peaks of burden in untreated caries. Among them is reaching 70 years of age, when several factors related to aging, general health, and tooth retention increase the risk of caries problems.<sup>72</sup>

Among the strengths of this study, it can be mentioned that clinical examinations were carried out, which, unlike self-reports, some clinical oral health variables could be underestimated. In addition, various variables of different nature were studied to explain the presence of coronal and root caries. This study has limitations, which must be taken into account to interpret the results. For example, its cross-sectional design, in which the problem of temporal ambiguity is presented, since we can only discuss about associations and not a causal effect. Another limitation observed is related to the type of public gerontological center, which may not be representative of the entire population of that age in the communities where the home nursing centers are located. This was a convenience sample, however, all residents fulfilling selection criteria were invited to participate. This type of sampling could introduce a selection bias, since the participants who accepted to participate could be persons more interested in their oral health conditions or those with worse health conditions expecting a diagnosis or to be treated, even when no treatment was offered. Another limitation could be that no information about access to dental services was obtained in this study, reducing the possibility of explaining the differences in the utilization of dental services. On the other hand, there might be an underestimation of coronal and root caries since no radiographs were taken.

## Conclusion

Several variables that differ in nature were found to be risk indicators for coronal and root caries. Coronal caries increases the risk of root caries. Further research on the factors associated with oral morbidity in persons living in institutions is required to identify treatment needs; the complexity of dental and systemic conditions; and the impact of oral health conditions on the quality of life. Oral health promotion should emphasize oral hygiene, regular dental check-ups, proper denture care, and healthy lifestyles in older adults. Prevention should be aimed at identifying persons at higher risk, and dental care should be improved for persons living in long-term care institutions, with special emphasis on prevention and treatment of coronal and root caries.

## Institutional Review Board Statement

This study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Research and Ethics Committee of the Faculty of Dentistry, National Autonomous University of Mexico (CIE/0810/03/2017).

## Data Sharing Statement

Any data related (only individual deidentified participant data) to this study can be provided upon reasonable request to the corresponding author. Email: aborges@unam.mx.

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## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

## Informed Consent Statement

Informed consent was obtained from all subjects involved in this study.

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## Disclosure

The authors report no conflicts of interest in this work.

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