Epidemiology of apical periodontitis in a representative rural population: Association with diabetes mellitus, arterial hypertension, and smoking - a cross-sectional study

Jeanni Gonçalves Camponogara
Universidade Federal de Santa Maria

Ticiane de Góes Mário Ferreira
Universidade Federal de Santa Maria

Thayná Regina Pelissari
Universidade Federal de Santa Maria

Alessandro Meneghetti Anversa
Universidade Federal de Santa Maria

Carlos Heitor Cunha Moreira
Universidade Federal de Santa Maria

Carlos Alexandre Souza Bier (alexandrebier@gmail.com)
Universidade Federal de Santa Maria

Research Article

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Abstract

Objective To determine whether the systemic diseases diabetes mellitus (DM) and arterial hypertension (AH), and smoking are associated with apical periodontitis (AP) in a representative rural population.

Materials and methods Cross-sectional study using a representative sample of individuals obtained from a population-based epidemiological survey carried out in the rural area of the city of Rosário do Sul, RS, Brazil, from March 2015 to May 2016. Data were collected through structured questionnaires and clinical examination. Binary logistic regression analysis was performed to identify variables independently associated with AP.

Results Of the 584 individuals included in the study, 353 (60.4%) had AP. The presence of AP was independently associated with age (odds ratio [OR] = 1.018, 95% confidence interval [CI]: 1.001-1.035, p = 0.041), active or former smoker (OR = 2.109, 95% CI: 1.256-3.540, p = 0.005) and DM or prediabetes (OR = 1.696, 95% CI: 1.164-2.471, p = 0.006)

Conclusion The study identified significant associations between AP and clinical risk factors. However, it is essential to acknowledge the study's limitations and recommend conducting longitudinal studies to confirm these associations and explore other potential variables involved in the development of AP.

Clinical Relevance The study emphasized the significance of comprehending and managing risk factors in preventing and treating AP.

INTRODUCTION

Apical Periodontitis (AP) is an inflammatory process that arises in the periapical tissues due to microbial infection of the root canal system [1]. It is a host immune response [2], which can manifest acutely or chronically [3] and is identified by periapical radiolucency [4]. Systemic diseases like diabetes mellitus (DM), cardiovascular diseases, and smoking can aggravate AP [5, 6]. Research indicates a rise in the prevalence of AP and nonsurgical conventional endodontic treatment in adults worldwide [7, 8].

DM is a complex systemic disease that impacts the metabolism of carbohydrates, lipids, and proteins, leading to hyperglycemia [9]. This condition is identified by pancreatic beta cells' deficiency in insulin secretion or insulin resistance in the liver and muscle [10, 11]. The worldwide prevalence of DM in 2021 was 537 million adults, corresponding to roughly 1 in 10 adults with the disease [12]. People with DM have a higher prevalence of AP [13], and poorer glycemic control is also associated with a higher prevalence of AP [14, 15].

Arterial hypertension (AH) is a chronic non-communicable disease characterized by elevated blood pressure levels. Several factors can influence it, such as genetics, epigenetics, environment, and social aspects. Pre-hypertension is defined as systolic blood pressure values between 130-139mmHg and diastolic blood pressure between 85-89mmHg, while values equal to or exceeding 140/90mmHg are
classified as systemic arterial hypertension (AH) [16]. In 2019, the global prevalence of AH was 1.39 billion adults [17]. There are limitations and discrepancies in studies investigating the association between AP and AH [18, 19]. However, recent studies have found a significant association between endodontic pathologies and AH [20, 21].

The potential link between smoking and AP has been highlighted. Cigarette smoking compromises both humoral and cellular immunity [22, 23]. Smokers often exhibit limited wound-healing capabilities [24, 25], inadequate blood supply, heightened stimulation of osteoclasts [26], decreased growth factor expression [27], and impaired angiogenic capacity [28, 29]. Smoking can contribute to early necrosis of pulp tissue [30, 31], destruction of periapical bone [30], and degradation of connective tissue [32, 33], thus impairing the healing and repair processes [30, 31]. Although the higher prevalence of AP in smokers may be associated with worse oral hygiene and a greater frequency of sugar consumption [34], the results regarding this association remain conflicting [30, 35–39].

To date, conclusive evidence on the association between AP and DM, AH, and smoking has not been found in the literature. Furthermore, it is worth noting that these pathologies and the habit of smoking are prevalent among rural populations [40–44]. However, studies must investigate the relationship between these conditions and AP in rural populations. Thus, this study aims to evaluate if systemic diseases such as DM and AH, as well as smoking, are associated with AP in a representative rural population.

**MATERIALS AND METHODS**

A cross-sectional observational study included a sample of individuals obtained from a population-based epidemiological survey conducted in the rural area of the city of Rosário do Sul from March 2015 to May 2016 [45]. Rosário do Sul is situated in the western region of Rio Grande do Sul, Brazil, with a total population of 40,000 people, of which 4,776 live in rural areas [46].

A representative sample of the rural population was selected for the epidemiological survey using the multistage probabilistic sampling method, which considered the number of individuals and households registered in each census sector according to the Brazilian Institute of Geography and Statistics (IBGE) territorial mapping. The sample size was estimated with the following parameters: rural population of individuals aged ≥ 15 years (4,000 inhabitants), precision level of 4%, design effect of 1.3, and confidence interval of 95%. Following these parameters and adjusting for finite populations, the sample was estimated at 580 individuals. An additional 87 subjects (15%) were added to compensate for non-respondents. From the 36 Rural Census Enumeration Areas (AECR) in the rural area of Rosário do Sul, 17 AECRs were randomly selected using Research Randomizer. A total of 1087 individuals were selected. Of these, 399 did not participate in the study due to refusal, the impossibility of attending the examination unit, unspecified reasons, absence after several contact attempts, or incomplete evaluation. All participants provided written informed consent before the study. The present study was conducted following the ethical principles of the Declaration of Helsinki and approved by the Research Ethics Committee of the Federal University of Santa Maria (UFSM), RS, Brazil (CAAE: 37862414.5.0000.5346).
Moreover, the study followed the reporting guidelines outlined in the "Strengthening the Reporting of Observational Studies in Epidemiology" (STROBE) statement [47].

The inclusion criteria for the present study were individuals aged 18 years or older with at least one periapical radiograph of a tooth and provided complete clinical and sociodemographic data.

**CLINICAL AND SOCIODEMOGRAPHIC CHARACTERISTICS**

Trained dentists applied structured questionnaires comprising medical, behavioral, and sociodemographic data through individual, face-to-face. A comprehensive description of the interviews and evaluations can be found in the epidemiological survey [45].

During the clinical examination, the participants' systolic (SBP) and diastolic (DBP) blood pressure were measured using a G-TECH automatic sphygmomanometer, model MA 100. The measurements were taken on the left arm while sitting down, with their legs uncrossed and feet flat on the floor, and their arm resting at heart level on a table [45]. SBP was defined as a reading of ≥ 135mmHg, while high DBP*) was defined as a reading of ≥ 80mmHg, as per previously established criteria [16].

The evaluation of glycemic levels was carried out by measuring glycated hemoglobin (HbA1c) from blood samples collected during the clinical examination [45]. DM was defined as HbA1c levels ≥ 6.5%, and prediabetes was defined as levels ranging from 5.7–6.4% [48].

The individuals' smoking habits were identified through a questionnaire, categorizing them as current, former, and never-smokers.

**RADIOGRAPHIC EXAMINATION AND EVALUATION**

A periapical survey was conducted by four trained examiners using the paralleling technique with a ProDental X-ray device, set at 60 KvP and 10 mA and digital sensor RVG # 15100, Kodak (Carestream Dental, GA, USA) with periapical positioner RINN XCP-DS (Dentsplay), following the manufacturer's specifications. Images were captured using the Kodak Dental System Imaging program and processed using software installed on an Acer Aspire 1410 notebook. No radiographic examination of the third molars was performed. The radiographic analysis was performed in a dark room with a 20-inch AOC monitor, 1600x900 60 hertz resolution, by an examiner previously trained and calibrated through 20 periapical radiographs chosen randomly from the same database. The inter-examiner Kappa (k) coefficient was 0.8, and the intra-examiner Kappa (k) coefficient was 0.7.

The apical regions of the radiographs were evaluated and classified using “The Periapical Index” (PAI) on a 5-point scale: 1, normal periapical structures; 2, small changes in the bone structure; 3, changes in bone structure with some mineral loss; 4, periodontitis with the well-defined radiolucent area; 5, severe periodontitis with exacerbated features [49]. The remaining roots were also classified using the PAI index. Teeth with no visible apical structure or with radiographic images without adequate clarity for evaluation were excluded. In multirooted teeth, the root with the highest score was considered for the classification.
of the PAI index. The individuals were dichotomized based on the dental element with the highest score by the PAI index classification. The absence of a periapical lesion was considered if the PAI score was 1 or 2, while the presence of a periapical lesion was considered if the PAI score was 3, 4, or 5 [49].

**STATISTICAL ANALYSIS**

The outcome of this study was to determine whether DM, AH, and smoking are associated with a higher prevalence of AP.

Quantitative variables were reported as means and standard deviation, and categorical variables as absolute and relative frequency. AP was dichotomized (presence and absence) for analysis [49]. The chi-square test was used to compare categorical variables, and the independent t-test was employed for continuous variables.

Binary logistic regression was performed with the variables that exhibited a $p$-value $< 0.05$ in the univariate analysis to determine the variables independently associated with AP and estimate prevalence ratios.

The significance level was 5%. All statistical analyzes were performed using SPSS software, version 21, Chicago, IL, USA.

**RESULTS**

In the epidemiological survey, 688 individuals were included, of which 584 were eligible for the present study. The following were excluded: 68 edentulous individuals, 23 minors, seven who did not have a radiographic examination, three without clinical evaluation, and three whose radiographs were invalid due to poor visualization of the tooth apex or inadequate clarity (Fig. 1).

The clinical characteristics of the participants and their association with the presence of AP are presented in Table 1. Of the 584 individuals studied, 353 (60.4%) had AP, and 231 (39.6%) did not. The group of individuals with AP exhibited a greater prevalence of males ($p = 0.044$), older age ($p < 0.001$), non-white ethnicity ($p = 0.045$), smoking status (current or former) ($p < 0.001$), high systolic blood pressure ($p = 0.026$), diabetes or prediabetes ($p < 0.001$), and lower number of teeth ($p = 0.042$) when compared to the group without AP (Table 1).
The multivariate binary logistic regression analysis showed that the presence of AP was independently associated with age (odds ratio [OR] = 1.018, 95% confidence interval [CI]: 1.001-1.035, \( p = 0.041 \)), active or former smoker (OR = 2.109, 95% CI: 1.256-3.540, \( p = 0.005 \)) and DM or prediabetes (OR = 1.696, 95% CI: 1.164-2.471, \( p = 0.006 \)) (Table 2).

### DISCUSSION

The present study investigated the association between AP and DM, AH, and smoking in a representative sample of a rural population in southern Brazil. The results of this epidemiological study highlight essential associations between AP and demographic, behavioral, and systemic characteristics, such as advanced age, active or former smoking, and the presence of DM or prediabetes. These findings are...
consistent with previous studies in the scientific literature [8, 13, 35–37] and emphasize the importance of identifying risk factors that contribute to the development of AP to prevent and treat this condition.

In our study, age was identified as an independent risk factor for the development of AP, with a 1.8% increase in risk for each year of growth in age. This finding was already expected, as aging can result in changes in the immune system and a decrease in the repair capacity of periapical tissues [50], in addition to increasing the incidence of carious lesions and restorations [51]. Risk factors such as a more significant cumulative effect associated with smoking and a higher incidence of DM may be more prevalent in individuals of advanced age, thus associating these variables with the development of AP.

The presence of active smoking or a history of smoking was identified as a significant risk factor for the development of AP, consistent with previous studies [35–37]. Active or former smokers in this study showed a 2.1 times greater risk of developing AP than nonsmokers. Tobacco has well-established adverse effects on oral health, compromising the immune response [22, 23], reducing tissue vascularity [26], and impairing wound healing [24, 25], all of which make smokers more vulnerable to periapical infections such as AP.

The presence of systemic conditions, such as DM or prediabetes, was also found to be associated with the development of AP. Individuals with these conditions had a 1.7 times greater risk of having AP compared to those without these conditions. These findings are consistent with previous research, which has shown a link between DM and the occurrence of AP [13]. Scientific studies have extensively investigated the relationship between DM and oral health. Evidence indicates that uncontrolled glycemic control can affect the host's immune response, compromise tissue healing and vascularization, and increase susceptibility to bacterial infections, including periapical conditions [14, 15, 52, 53].

The findings of this study have important implications for clinical practice, emphasizing the need to prevent risk factors associated with pulp necrosis and subsequent AP, including smoking and DM or prediabetes. Moreover, appropriate endodontic treatment is crucial in managing pulpal necrosis to avoid the onset of AP. However, it is essential to acknowledge some limitations of this study, such as its cross-sectional design, which precludes establishing causal relationships between risk factors and the incidence of AP. Furthermore, the study sample was derived from an epidemiological survey limited to a rural area, which may restrict the generalizability of the results to other populations or clinical settings. The study did not account for other potential confounding factors, such as medication use or family history, which could impact the observed outcomes.

CONCLUSION

The present study underscores the significance of preventing and managing AP in individuals with risk indicators, including advanced age, active or former smoking, and DM or prediabetes. Oral health promotion initiatives can be implemented to reduce the prevalence and severity of BP, such as adopting healthy lifestyle habits, maintaining oral hygiene, education to stop smoking, and adequate glycemic control in diabetic patients. Moreover, increasing awareness among healthcare professionals and
patients about the link between these risk factors and AP is crucial to encourage a comprehensive and preventive clinical approach. Nonetheless, the study's limitations must be acknowledged. It is recommended to conduct longitudinal studies and randomized clinical trials to confirm such associations and investigate other possible variables involved in the etiology of AP.

Declarations

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Author contributions All authors contributed to the study conception and design. Material preparation and data collection were performed by Ticiane de Góes Mário Ferreira, Carlos Heitor Cunha Moreira, Thayná Regina Pelissari, Jeanni Gonçalves Camponogara and Carlos Alexandre Souza Bier. Jeanni Gonçalves Camponogara and Alessandro Meneghetti Anversa performed the statistical analyses. The first draft of the manuscript was written by Jeanni Gonçalves Camponogara and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data availability The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethical approval The Research Ethics Committee of the Federal University of Santa Maria (UFSM), RS, Brazil (CAAE: 37862414.5.0000.5346) approved this study. And they were conducted following the Declaration of Helsinki of 1975, as revised in 2013.

Informed consent Informed consent was obtained from all participants in the study.

Conflict of interest The authors declare that they have no conflict of interest.

References


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Figures
Selected individuals  
\( n = 1087 \)

Non-participants  
\( n = 399 \)

Participants  
\( n = 688 \)

Excluded individuals (\( n = 104 \))
- Edentulous (\( n = 68 \))
- Minor (\( n = 23 \))
- Missing radiographic (\( n = 7 \))
- Without clinical evaluation (\( n = 3 \))
- Invalid radiographs (\( n = 3 \))

Included Individuals  
\( n = 584 \)

Figure 1

Flowchart of individuals included in the study.