Original Article

OBESITY AND DEMOGRAPHICS INFLUENCE ON PERIAPICAL LESIONS, DENTAL CARIES, AND ORAL HEALTH IN ADULTS

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ABSTRACT

According to the World Health Organization (WHO), there are over 2 billion people around the world who are either overweight or obese, growing in numbers and also in the kingdom of Saudi Arabia, which is a major public health issue. With the rising amounts of funds and dental expenditure in the Kingdom of Saudi Arabia, a financial and economic burden on 16.5% of Saudis who happen to spend over 10% of their income on costly procedures of those uninsured such as endodontic root canals or root filled teeth (RFT), which could be associated with the rise of obesity and periapical chronic lesions affecting hard and soft tissues surrounding teeth resulting in bone loss, microorganisms, and toxins released into the pulp visualized by radiographic images. This cross-sectional observational study conducted at a dental school in Jeddah, Saudi Arabia studies the correlation between obesity and RFTs and PLs alongside with other demographics such as gender, age, educational level, and waist circumference. Data was collected from 317 patients visiting the endodontics department clinics and was quantitatively and statistically analyzed using IBM SPSS 24 software package. The study concluded a strong and positive correlation between obesity, waist circumference, age, and male gender with root filled teeth and periapical lesions, and an insignificant correlation with educational levels. The researchers recommended public health policy makers to tax sugary foods, pop drinks, and increased healthcare insurance policy rates on obese individuals.

Key words: Public health, Oral health, Obesity, Demographics, Endodontics, Health policy.

Introduction

With the rise of Catastrophic Dental Expenditure (CDE), equivalent to 10% of an individual's income paid on dental care, 16.5% of the population in the Kingdom of Saudi Arabia were exposed to CDE spent on several dental procedures of them is endodontics and root canal treatments, due to them being uninsured, which is a financial and economic burden on the Saudis [1]. In addition CDE could be correlated to obesity which has a growing prevalence in Saudi Arabia and is also an emerging and serious public health issue worldwide [2].

According to Victoria *et al*. The Kingdom has higher than average obesity prevalence rates which is at over 35% of the national population compared to 13% worldwide [3]. Another study conducted in Saudi Arabia in 2020 by Althumiri *et al*. concluded that the obesity prevalence rates between Saudis in 13 Saudi provinces with a BMI over 30 was almost between 20-25% of the population [4]. According to the World Health Organization, as of 2016, overweight and obese adults are more than underweight. There are over 2 billion people over 18 years that are overweight, of which 25% of them are obese. People's weight is categorized according to the Body Mass Index (BMI) as underweight, normal, overweight, and obese. BMI is calculated by dividing weight by the mass squared [5].

Obesity has been considered a risk factor for several systemic diseases including type 2 diabetes, hyperlipidemia, hypertension, cholelithiasis, arteriosclerosis, and cardiovascular, and cerebrovascular diseases [6]. Saudi Arabia has one of the highest prevalence rates of overweight and obesity. The combination of persisting traditional cultural practices, high weather temperatures during the year, modern cultural changes and economic prosperity leads to unhealthy eating, sedentary lifestyles and weight gain [7]. The prevalence of obesity among adults in Saudi Arabia increased from 22% in 1990-1993 to 36% in 2005 and the overall rate is projected to reach 41% in men and 78% in women by 2022 [8]. Concerning obesity, the association with periodontal inflammation is well established in the literature. The possible connection between chronic oral inflammatory processes of infectious origin and systemic health is becoming one of the most interesting aspects faced by the medical and dental scientific community [9]. Obesity was associated with an increased incidence and prevalence of periodontal disease in adults [10, 11].

A study performed in the Kingdom showed that there was a positive correlation between age and obesity. The study also revealed that males had larger WC compared to female counterparts [12].

Higher BMI values were observed to be positively related to the severity of periodontal attachment loss [13]. Besides,

obese individuals were at greater risk for the progression of periodontal disease despite the divergent results, a plethora of studies were performed relating obesity to dental caries in adults [14]. Numerous studies also relate obesity to dental caries [15-19]. Of note, few studies found a relation between obese subjects and teeth movement during the early phases of orthodontic treatment [20, 21]. Hence, there is a possibility that obesity may also have a link to periapical lesions (PLs) as well.

In a recent study in 2022 performed in Jeddah, Saudi Arabia, researchers found that females had higher dental awareness and knowledge, and better oral health than males; also higher educational levels positively correlated with better oral health outcomes [22].

Kyung Jae *et al*., concluded in an observational study in South Korea that dental decay and caries leading to root-filled teeth (RFT) was directly associated with overweight , obesity, older age groups, and surprisingly specifically women [23]. Schmidt *et al*, also concluded that obesity deteriorates oral health, and is a main risk factor indicating poor periodontal status and increases the incidents of carious lesions [24].

People's educational levels are categorized as being educated with a collegial degree or higher, high school, middle school, elementary school, or no education. A study conducted by Min Hee-Hong and Su-Jin Jung conducted a study to evaluate 191 elderly individuals ages 65 and older oral health status related to their level of education. The study indicates a positive correlation between the level and degree of education and better oral health conditions [25]. A study conducted in Saudi Arabia in 2020, Mosli *et al.* concluded that there was a negative association between the prevalence of obesity and the educational levels, however the group of high income people who are less educated had higher obesity prevalence rates in the Kingdom [26].

PL is an unpleasant outcome of a protective response to the bacteria derived from the infected root canal system, resulting in chronic inflammation [27]. Numerous studies documented the interrelationship between PL and systemic diseases. For example, radiolucent PLs were noted in patients who experienced coronary artery disease and acute myocardial infection [28, 29]. A significant association between PL and type 2 diabetes was well recognized [30-33]. Also, radiolucency patients were likelier to have hepatic disorders [34]. In the literature, relating the presence of PL in obese individuals has so far been subjected to only a single study [15]. Thus, the prime objective of the present study was to investigate the possible association between obesity and the radiographic evidence of PL in dental patients. Researchers in this clinical investigation associate RFT and PL with obesity, waist circumference (WC), and demographics such as age, gender, and educational level. In addition, it concludes by ranking the effects of each of these demographic factors and obesity on both RFT and PL.

Materials and Methods

This cross-sectional study was conducted at Ibn Sina National College of dentistry, Jeddah, Saudi Arabia between July 2019 and February 2020. The study subjects were recruited from dental patients who came consecutively to the dental clinics seeking dental care for the first time at the college hospital. A total of 317 dental patients of both genders who fulfilled the inclusion/ exclusion criteria were the subjects included in this study. The inclusion criteria were patients aged 20 years or older willing to undergo clinical, radiographic examination, and anthropometric measurements. The exclusion criteria included smokers/former smokers, diabetic patients, pregnant women, and patients with less than twenty remaining teeth. The institutional ethics committee approved the study, and signed informed consent was obtained from the participants before their enrollment. The data collection consisted of three parts: intraoral examination, radiographic examination, and body weight and height measurements. Patient data collection was completed on the same day visit for each participant.

A single calibrated dental examiner conducted a full mouth clinical examination. Dental caries was measured using the counts of carious teeth. The teeth were examined visually after being blown dry and probed on each surface. The periodontal examination included probing depth, the presence of plaque, and bleeding on probing. All periodontal parameters were assessed for each tooth at six sites or tooth surfaces: mesiobuccal, midbuccal, distobuccal and three corresponding lingual/palatal sites. In addition, the number of teeth present was recorded.

The number of teeth having identifiable PL, root-filled teeth (RFT) and number of RFT having identifiable PL were evaluated based om a specialized endodontist's examination of digital panoramic and periapical radiographs. A tooth was considered root filled if radio-opaque material was evident in the root canal system. The periapical status was assessed according to pre-established criteria. Each tooth was assessed at 0 for normal: the periodontal ligament space and the surrounding alveolar bone exhibited no alteration at the periapical area -and 1 for periapical lesion (PL): the presence of apical radiolucency or widening of the periodontal ligament space at the apical region to more than twice the normal width [35]. Multi-rooted teeth were evaluated as a single unit. The method of viewing the images was standardized during the radiographic analysis. Third molars (wisdom teeth) were disregarded in clinical and radiographic examinations.

The Body Mass index (BMI) was calculated by dividing the weight in kilograms by the square of height in meters to assess obesity. The clinician registered the weight and height of each participant in a standardized manner using a medical scale and calculated the BMI. The participants were asked to remove their shoes and heavy garment before taking the

measurements. The BMI values were classified according to the World Health Organization (WHO) guidelines into: underweight, normal weight, overweight and obese [36]. All four categories were included in the study.

Data were collected, tabulated and subjected to statistical analysis using SPSS statistical software for Windows (version 24, SPSS Inc., Chicago, IL). A *P* value of 0.05 or less was considered statistically significant.

Results and Discussion

In total, 317 subjects formed the basis for the current study. The participants were divided into four groups based on their BMI value. After six months of collecting data and patients the researchers found that of the 317 included in the study 123 patients (38.8%) had at least one RFT, and 108 patients (34.1%) had PL.

Qualitative data were described using numbers and percentages. Comparison between different groups regarding categorical variables was tested using Chi-square test. Quantitative data were described using mean and standard deviation for normally distributed data, and the comparison between two independent populations was performed using the independent t-test. Significance test results are quoted as two-tailed probabilities and results were judged at the 5% level. Regression analysis was done to study the effect of body mass index on dental disease.

The relationship between root-filled teeth (RFT) and demographic data, regarding the BMI category found that (83.7%) of positive cases were with root filled teeth were obese cases, where the data shows a significant relationship between the increase in BMI and root-filled teeth.

Regarding the level of education there was a significant increase in the incidence of root-filled teeth in the low- level education group, so there was a significant relationship between the level of education and the root- filled teeth.

The age of the patients showed a significant relation with root-filled teeth; the majority of the positive root-filled teeth group (84.6%) was in age group 25-50 years. Finally, males show significantly higher incidents of RFT compared than females as shown in **Table 2**.

Table 1. Distribution of studied patient groups regarding basic demographic data.

	Number	Percent
Gender		
Male	244	77.0
Female	73	23.0
Age group		
<25 years	82	25.9
25-50	202	63.7
>50	33	10.4
Age Range Mean SD	20.0-60.0 34.8801 10.54608	
Level of Education		
No education	74	23.3
Primary school	75	23.7
Middle school	33	10.4
High school	72	22.7
College	63	19.9
BMI category		
Under weight	62	19.6
Normal weight	70	22.1
Over weight	44	13.9
Obese	141	44.5
BMI Range Mean SD	17.10-58.5 30.81 7.146	
W.C Range Mean SD	52.0-142.0 105.30 14.95	

The relationship between periapical lesion and demographics regarding the BMI category, where approximately (82.4%) of positive periapical lesions belonged to obese patients. This demonstrates a significant relationship between the increase in BMI and periapical lesion.

Regarding the level of education, it was found that there was no significant relation between the incidence of periapical lesions and the level of education group. However, age of patients showed a significant relation with periapical lesion, most of the positive periapical lesion group, which comprises of (89.0%) was in age group of 25-50 years. Finally, speaking about gender males have significantly higher than female incidence rates of periapical lesions, as shown in **Table 3**.

Table 2. Relation between basic demographic data and root-filled teeth incidence.

BMI category	Root filled teeth			
	Negative		Positive	
	No	%	No	%
Under weight	50	25.8	12	9.8
Normal weight	66	34.0	4	3.3
Over weight	40	20.6	4	3.3
Obese	38	19.6	103	83.7
X^2	128.150			
P	0.0001*			
Level of Ed				

No education	40	20.6	34	27.6
Primary school	47	24.2	28	22.8
Middle school	28	14.4	5	4.1
High school	41	21.1	31	25.2
College	38	19.6	25	20.3
X^2		10.001		
P		0.040*		
Age group				
<25 years	70	36.1	12	9.8
25-50	98	50.5	104	84.6
>50	26	13.4	7	5.7
X^2		38.154		
P		0.001*		
Gender				
Male	139	71.6	105	85.4
Female	55	28.4	18	14.6
X^2		7.990		
P		0.003*		

The relationship between basic demographic data and root-filled teeth incidence rates with the mean BMI in positive cases being 34.09±6.92, while in negative cases it was 29.12±6.67, and there was a significant increase in BMI in positive cases with root-filled teeth.

The age in positive root-filled teeth cases was 38.44±8.19 years, while in negative cases was 33.03±11.15 years. There was a significant increase in age in positive cases more than in negative cases.

The WC in positive cases was 114.36±11.63, while in negative cases was 100.61±14.33; it showed a significant increase in WC in positive root-filled teeth cases more than negative cases.

However, the relationship between basic demographic data and periapical lesion incidence rates with the mean BMI in positive cases being 34.47±6.95, while in negative cases it was 28.50±6.25, apparently there was a significant increase in BMI in positive cases with the periapical lesion.

The age in positive periapical lesion cases was 39.03±7.97 years, while in negative cases was 32.24±11.13 years, showing a significant increase in age in positive cases compared to those in negative cases.

The WC in positive cases was 114.79±11.02, while in negative cases was 99.28±13.98; it showed a significant increase in WC in positive periapical lesion cases compared to negative cases.

Table 4, shows the correlation between both the number of root-filled teeth having periapical lesions and the number of root-filled teeth concerning BMI, age and WC; it was found that there was a significant positive correlation between both number of root-filled teeth having periapical lesion and number of root-filled teeth against the BMI, age and WC. i.e., the increase in BMI, age and WC faced by increasing the number of root-filled teeth having periapical lesion, and the number of root-filled teeth.

Table 3. Relation between basic demographic data and incidence of periapical lesion

	Periapical lesion			
BMI category	**Negative**		**Positive**	
	No	**%**		
Under weight	50	23.9	12	11.1
Normal weight	67	32.1	3	2.8
Over weight	40	19.1	4	3.7
Obese	52	24.9	89	82.4
X^2		0.001*		
P				
Level of Ed				
No education	45	21.5	29	26.9
Primary school	51	24.4	24	22.2
Middle school	28	13.4	5	4.6
High school	42	20.1	30	27.8
College	43	20.6	20	18.5
X^2		8.266		
P		0.082		
Age group				
<25 years	70	33.5	12	11.1
25-50	113	54.1	89	82.4
>50	26	12.4	7	6.5
X^2		25.193		
P		0.001*		
Gender				
Male	151	72.2	93	86.1
Female	58	27.8	15	13.9
X^2		7.719		
P		0.003*		

Table 5, shows the multivariable linear regression of different risk factors on root-filled teeth; from this model, it was found that RFT was affected by different risk factors; the most significant risk factors was increasing in BMI, followed by gender, the WC and finally the age, while the level of education show insignificant effect in this model.

Table 4. Correlation between both the number of root-filled teeth having periapical lesion,Number of root -filled teeth in relation to BMI, age and WC.

		Number of root-filled teeth having periapical lesion	**Number of root- filled teeth**
BMI	Pearson Correlation	.292**	.304**

	P value	.000	.000
Age	Pearson Correlation	.176**	.226**
	P value	.002	.000
WC	Pearson Correlation	.428**	.413**
	P value	.000	.000

Table 5. Multivariable linear regression of different risk factors of root-filled teeth.

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	-.775	.192		-4.028	0.0001*
Age	.008	.002	.173	3.576	0.004*
Gender	-.165	.053	-.143	-3.129	0.002*
WC	.007	.002	.216	3.291	0.001*
Level of Ed	-.018	.015	-.056	-1.219	0.224
BMI category	.134	.026	.328	5.223	0.0001*

a. Dependent Variable: Root-filled teeth

Table 6, shows the multivariable linear regression of different risk factors on periapical lesions; from this model, it was found that the periapical lesion was affected by different risk factors; the most significant risk factors were increasing in BMI, followed by gender, the WC and finally the age, while the level of education shows insignificant effect in this model.

The present study aimed to explore the probable association between obesity and root-filled teeth, and the presence of PL based on radiographic examination in dentate individuals visiting dental school clinics. The study also compared the participants categorized according to their BMI regarding different dental and demographic variables, such as age, gender, and educational levels.

Table 6. Multivariable linear regression of different risk factors of Periapical lesion.

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	-.595	.200		-2.967	.003*
Age	.005	.002	.120	2.307	.022*
Gender	-.158	.055	-.140	-2.873	.004*
WC	.006	.002	.195	2.772	.006*
Level of education	-.014	.016	-.044	-.901	.368
BMI	.112	.027	.283	4.197	.0001*

a. Dependent Variable: Periapical lesion

The present results revealed a strong correlation between obesity and the presence of PL in the investigated sample with the same correlation of obesity to root-filled teeth. There is scarce information addressing the association between obesity and PL in which the number of PL was examined as a component of the dental index [15]. This study's results found that contribution of obesity to the number of PL teeth was not neglectable.

In the present study, most of RFT were identified with PL in all four groups. Although, we did not have insight into the quality of the endodontic filling in RFT, poorly performed root canal treatments were highly associated with the radiographic appearance of PL among the Saudi population [37-39]. This situation may have occurred because most of the endodontic treatment is performed by general dentists in Saudi Arabia [40, 41]. The limited number of specialized endodontists in the Kingdom of Saudi Arabia as well and the low inclination of general dentists to refer patients could be why the endodontic treatment falls below the general standards of care in Saudi Arabia [40]. However, it should be considered that the identified RFT with PL in the present study may have been in a healing phase since we had no data on the time when RFT received treatment.

Individuals with obesity appeared to have poor oral health behavior. Studies showed that individuals with increased BMI had slightly worse dental health represented by multiple missing teeth, increased number of decayed teeth and severity of the periodontal disease [10]. In another study, obese patients were least likely to use inter-dental brushes/flossing regularly and had more missing teeth [42]. Also, those with higher BMI were positively related to bleeding on probing [43]. Poor oral care habits displayed by lower daily frequency of tooth brushing, usage of fewer secondary oral products and irregular dental visits were identified in obese individuals [19, 44]. Periapical radiographs and cone beam computed tomography (CBCT) are more accurate for detecting radiolucent PLs [45]. No significant difference was found in the detection of periapical radiolucency when comparing orthopantomogram (OPG) and periapical radiographs [46, 47]. In this study, the use of digital panoramic radiographs was feasible due to the availability of the digital panoramic machine in the college hospital. Besides, OPG allows all teeth to be examined on a single image, resulting in a relatively low radiation dose. To eliminate the effect of smoking and diabetes on the frequency of PL, current/former smokers and diabetic patients were excluded from the present study. It was reported that radiolucent PL was significantly associated with diabetes and smoking [31, 38], given the increasing

prevalence of both conditions among the Saudi population [48, 49].

BMI was used as indicator of obesity in the current study. However, BMI is not the gold standard for diagnosing obesity; different conclusions have been drawn regarding the superiority of using BMI or other obesity indices to predict obesity [50]. Hence, the use of BMI to assess obesity is still controversial and different results may be obtained with other obesity parameters.

This study's main is being cross-sectional, making it impossible to determine the direction of causal relations. Also, this study sample was taken from one institution in one city; thus, the findings are preliminary and cannot be generalized to the whole nation of Saudi Arabia. Moreover, several potentially important variables were not incorporated in the present analysis; biochemical measurements of inflammatory mediators were not assessed, and the effect of socio-demographic factors was not examined. Finally, results may have been influenced by the unequal numbers in BMI categories.

As it has been reported Saudis are amongst the highest consumers of carbonated drinks worldwide, and ranked at the fourth highest level globally. With that fact taken into consideration alongside the findings of this study it shows the importance of approaching obesity as a national public health issue. It calls for effective prevention strategies and policies to reduce its prevalence in different age groups and halt its growth rate in the future. These suggested policies could include taxation on sugary sweets, drinks, and increased healthcare insurance policy rates for obese individuals.

Conclusion

Within the recognized limitations of the present study, the findings demonstrated a strong correlation between obesity as determined by BMI and the occurrence of PL, and RFT evaluated by panoramic radiographs.

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References

1. AlBaty A, AlGhasham H, Al Wusaybie M, El Tantawi M. Dental expenditure and catastrophic dental expenditure in Eastern Saudi Arabia: pattern and associated factors. J Clin Exp Dent. 2019;11(7):e601.
2. Hossain P, Kawar B, El Nahas M. Obesity and diabetes in the developing world--a growing challenge. N Engl J Med. 2007;356(3):213-5.
3. Salem V, AlHusseini N, Abdul Razack HI, Naoum A, Sims OT, Alqahtani SA. Prevalence, risk factors, and interventions for obesity in Saudi Arabia: A systematic review. Obes Rev. 2022:e13448.
4. Althumiri NA, Basyouni MH, AlMousa N, AlJuwaysim MF, Almubark RA, BinDhim NF, et al. Obesity in Saudi Arabia in 2020: Prevalence, Distribution, and Its Current Association with Various Health Conditions. Healthcare (Basel, Switzerland). 2021;9(3).
5. Organization WH. Overweight and obesity. 2020.
6. Khanna S, Mali AM. Evaluation of tumor necrosis factor-alpha (TNF-alpha) levels in plasma and their correlation with periodontal status in obese and non-obese subjects. J Indian Soc Periodontol. 2010;14(4):217-21.
7. DeNicola E, Aburizaiza OS, Siddique A, Khwaja H, Carpenter DO. Obesity and public health in the Kingdom of Saudi Arabia. Rev Environ Health. 2015;30(3):191-205.
8. Al-Quwaidhi AJ, Pearce MS, Critchley JA, Sobngwi E, O'Flaherty M. Trends and future projections of the prevalence of adult obesity in Saudi Arabia, 1992-2022. East Mediterr Health J. 2014;20(10):589-95.
9. Segura-Egea JJ, Martin-Gonzalez J, Castellanos-Cosano L. Endodontic medicine: connections between apical periodontitis and systemic diseases. Int Endod J. 2015;48(10):933-51.
10. Pischon N, Heng N, Bernimoulin JP, Kleber BM, Willich SN, Pischon T. Obesity, inflammation, and periodontal disease. J Dent Res. 2007;86(5):400-9.
11. Morita I, Okamoto Y, Yoshii S, Nakagaki H, Mizuno K, Sheiham A, et al. Five-year incidence of periodontal disease is related to body mass index. J Dent Res. 2011;90(2):199-202.
12. Al-Ghamdi S, Shubair MM, Aldiab A, Al-Zahrani JM, Aldossari KK, Househ M, et al. Prevalence of overweight and obesity based on the body mass index; a cross-sectional study in Alkharj, Saudi Arabia. Lipids Health Dis. 2018;17(1):1-8.
13. Genco RJ, Grossi SG, Ho A, Nishimura F, Murayama Y. A proposed model linking inflammation to obesity, diabetes, and periodontal infections. J Periodontol. 2005;76(11 Suppl):2075-84.
14. Gaio EJ, Haas AN, Rosing CK, Oppermann RV, Albandar JM, Susin C. Effect of obesity on periodontal attachment loss progression: a 5-year population-based prospective study. J Clin Periodontol. 2016;43(7):557-65.
15. Prpic J, Kuis D, Pezelj-Ribaric S. Obesity and oral health--is there an association? Coll Antropol. 2012;36(3):755-9.
16. Mathus-Vliegen EM, Nikkel D, Brand HS. Oral aspects of obesity. Int Dent J. 2007;57(4):249-56.

17. Kantovitz KR, Pascon FM, Rontani RM, Gaviao MB. Obesity and dental caries--A systematic review. Oral Health Prev Dent. 2006;4(2):137-44.
18. Kim YS, Kim JH. Body mass index and oral health status in Korean adults: the Fifth Korea National Health and Nutrition Examination Survey. Int J Dent Hyg. 2017;15(3):172-8.
19. Ostberg AL, Bengtsson C, Lissner L, Hakeberg M. Oral health and obesity indicators. BMC Oral Health. 2012;12:50.
20. Saloom HF, Papageorgiou SN, Carpenter GH, Cobourne MT. Impact of Obesity on Orthodontic Tooth Movement in Adolescents: A Prospective Clinical Cohort Study. J Dent Res. 2017;96(5):547-54.
21. Consolaro A. Obesity and orthodontic treatment: is there any direct relationship? Dental Press J Orthod. 2017;22(3):21-5.
22. Rajeh MT. Gender Differences in Oral Health Knowledge and Practices Among Adults in Jeddah, Saudi Arabia. Clin Cosmet Investig Dent. 2022;14:235.
23. Kim K, Han K, Yang S. Association between overweight, obesity and incidence of advanced dental caries in South Korean adults: A 10-year nationwide population-based observational study. Plos One. 2020;15(2):e0229572.
24. Schmidt J, Vogel M, Poulain T, Kiess W, Hirsch C, Ziebolz D, et al. Association of Oral Health Conditions in Adolescents with Social Factors and Obesity. Int J Environ Res Public Health. 2022;19(5):2905.
25. Min HH, Jung SJ. The Relationship between Oral Health Education Experience, Oral Health Knowledge Level, Oral Health Education Request Level, and the Geriatric Oral Health Assessment Index (GOHAI) of Some Elderly. J Converg Inf Technol. 2022;12(1):109-18.
26. Mosli HH, Kutbi HA, Alhasan AH, Mosli RH. Understanding the interrelationship between education, income, and obesity among adults in Saudi Arabia. Obesity Facts. 2020;13(1):77-85.
27. Sasaki H, Hirai K, Martins CM, Furusho H, Battaglino R, Hashimoto K. Interrelationship Between Periapical Lesion and Systemic Metabolic Disorders. Curr Pharm Des. 2016;22(15):2204-15.
28. Costa TH, de Figueiredo Neto JA, de Oliveira AE, Lopes e Maia Mde F, de Almeida AL. Association between chronic apical periodontitis and coronary artery disease. J Endod. 2014;40(2):164-7.
29. Willershausen I, Weyer V, Peter M, Weichert C, Kasaj A, Munzel T, et al. Association between chronic periodontal and apical inflammation and acute myocardial infarction. Odontol. 2014;102(2):297-302.
30. Segura-Egea JJ, Martin-Gonzalez J, Cabanillas-Balsera D, Fouad AF, Velasco-Ortega E, Lopez-Lopez J. Association between diabetes and the prevalence of radiolucent periapical lesions in root-filled teeth: systematic review and meta-analysis. Clin Oral Investig. 2016;20(6):1133-41.
31. Al-Zahrani MS, Abozor BM, Zawawi KH. The relationship between periapical lesions and the serum levels of glycosylated hemoglobin and C-reactive protein in type 2 diabetic patients. Saudi Med J. 2017;38(1):36-40.
32. Segura-Egea JJ, Castellanos-Cosano L, Machuca G, Lopez-Lopez J, Martin-Gonzalez J, Velasco-Ortega E, et al. Diabetes mellitus, periapical inflammation and endodontic treatment outcome. Med Oral Patol Oral Cir Bucal. 2012;17(2):e356-61.
33. Segura-Egea JJ, Jimenez-Pinzon A, Rios-Santos JV, Velasco-Ortega E, Cisneros-Cabello R, Poyato-Ferrera M. High prevalence of apical periodontitis amongst type 2 diabetic patients. Int Endod J. 2005;38(8):564-9.
34. Gronkjaer LL, Holmstrup P, Schou S, Schwartz K, Kongstad J, Jepsen P, et al. Presence and consequence of tooth periapical radiolucency in patients with cirrhosis. Hepat Med. 2016;8:97-103.
35. De Moor RJ, Hommez GM, De Boever JG, Delme KI, Martens GE. Periapical health related to the quality of root canal treatment in a Belgian population. Int Endod J. 2000;33(2):113-20.
36. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults: executive summary. Expert Panel on the Identification, Evaluation, and Treatment of Overweight in Adults. Am J Clin Nutr. 1998;68(4):899-917.
37. Alfouzan K, Baskaradoss JK, Geevarghese A, Alzahrani M, Alhezaimi K. Radiographic Diagnosis of Periapical Status and Quality of Root Canal Fillings in a Saudi Arabian Subpopulation. Oral Health Prev Dent. 2016;14(3):241-8.
38. Al-Nazhan SA, Alsaeed SA, Al-Attas HA, Dohaithem AJ, Al-Serhan MS, Al-Maflehi NS. Prevalence of apical periodontitis and quality of root canal treatment in an adult Saudi population. Saudi Med J. 2017;38(4):413-21.
39. Alrahabi M, Younes HB. A cross-sectional study of the quality of root canal treatment in Al-Madinah Al-Munawwarah. Saudi Endod J. 2016;6(1):31.
40. Al-Fouzan KS. A survey of root canal treatment of molar teeth by general dental practitioners in private practice in Saudi Arabia. Saudi Dent J. 2010;22(3):113-7.
41. Iqbal A, Akbar I, Qureshi B, Sghaireen MG, AL-Omiri MK. A survey of standard protocols for endodontic treatment in north of KSA. ISRN Dent. 2014;2014.
42. Prpić J, Kuiš D, Glažar I, Pezelj Ribarić S. Association of obesity with periodontitis, tooth loss and oral hygiene in non-smoking adults. Cent Eur J Public Health. 2013;21(4):196-201.
43. Kongstad J, Hvidtfeldt UA, Grønbæk M, Stoltze K, Holmstrup P. The relationship between body mass index and periodontitis in the Copenhagen City Heart Study. J Periodontol. 2009;80(8):1246-53.
44. Park JB, Nam GE, Han K, Ko Y, Park YG. Obesity in relation to oral health behaviors: An analysis of the

Korea National Health and Nutrition Examination Survey 2008-2010. Exp Ther Med. 2016;12(5):3093-100.
45. Estrela C, Bueno MR, Leles CR, Azevedo B, Azevedo JR. Accuracy of cone beam computed tomography and panoramic and periapical radiography for detection of apical periodontitis. J Endod. 2008;34(3):273-9.
46. Ahlqwist M, Halling A, Hollender L. Rotational panoramic radiography in epidemiological studies of dental health. Comparison between panoramic radiographs and intraoral full mouth surveys. Swed Dent J. 1986;10(1-2):73-84.
47. Molander B, Ahlqwist M, Gröndahl HG. Panoramic and restrictive intraoral radiography in comprehensive oral radiographic diagnosis. Eur J Oral Sci. 1995;103(4):191-8.
48. Meo SA. Prevalence and future prediction of type 2 diabetes mellitus in the Kingdom of Saudi Arabia: A systematic review of published studies. J Pak Med Assoc. 2016;66(6):722-5.
49. Bassiony MM. Smoking in Saudi Arabia. Saudi Med J. 2009;30(7):876-81.
50. Ko KP, Oh DK, Min H, Kim CS, Park JK, Kim Y, et al. Prospective study of optimal obesity index cutoffs for predicting development of multiple metabolic risk factors: the Korean genome and epidemiology study. J Epidemiol. 2012:JE20110164.