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Frequency and Risk Indicators of Periodontal Diseases in a Sample of Adult Egyptian Patients: A Hospital-Based Cross-Sectional Study

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ABSTRACT

This hospital-based cross-sectional study aimed at determining frequency and risk indicators/predictors of periodontitis in a sample of Egyptian adult population and to develop a prediction equation for classifying periodontal diseases. Seven hundred and fifty subjects were consecutively recruited from outpatient Diagnostic Center, Faculty of Dentistry, Cairo University. Validated oral health questionnaire for adults and oral health impact profile-14 (OHIP-14) questionnaire were filled by all patients. Diagnosis was made based on measurements of clinical periodontal parameters including plaque index, bleeding on probing, pocket depth, clinical attachment level and gingival recession. Radiographic examination was performed using digital periapical radiographs. Ordinal logistic regression analysis was used to determine significant predictors of periodontal diseases and discriminant analysis was performed to predict periodontal disease classification. Gingivitis was the most frequent periodontal disease (39.6%) followed by periodontitis stage I (38%), stage II (20.4%), stage III (1.6%) and stage IV (0.4%). The lowest OHIP-14 scores were in patients with periodontitis stages III and IV. Multivariate analysis showed that education ($p < 0.001$), OHIP-14 score ($p = 0.003$), non-smoking ($p = 0.001$) and non-alcohol drinking ($p = 0.021$) were significant negative predictors, while never to clean the teeth ($p < 0.001$) and cleaning the teeth once a month ($p < 0.001$) were significant positive predictors of periodontal disease. Periodontitis stages III and IV were the least frequent on a sample of Egyptian adult patients. Education, frequency of teeth cleaning, smoking, alcohol drinking and OHIP-14 scores were significant predictors of periodontal disease. Through discriminant analysis this study could classify patients into different periodontal diseases with an overall correct prediction of 99.2%.

Keywords: *Cross-sectional; epidemiology; frequency; periodontitis; prevalence; risk factors; smoking*

INTRODUCTION

Periodontal disease has been shown to be one of the most common oral conditions of the human population with a prevalence of 20%–50% of the entire global population, that has widespread in developed as well as developing and underdeveloped countries (Nazir, 2017). Therefore, epidemiologic studies of periodontitis in different populations are useful, not only to determine the prevalence, extent and severity of disease, but also to describe the history of the condition and to identify etiological risk factors of the disease (Raitapuro-Murray *et al.*, 2014).

Further understanding of the prevalence of periodontal disease and advances in scientific research over the last few decades, have allowed many significant risk factors/ indicators for periodontal disease to be identified including tobacco smoking, alcohol, diabetes mellitus, cardiovascular diseases, obesity, osteoporosis and genetic considerations. Since periodontal disease is considered multifactorial, effective disease management requires a clear understanding of all the associated risk factors/indicators (Genco & Borgnakke, 2013; Kumar, 2020; Polak *et al.*, 2020).

Several systematic reviews with meta-analysis as well as meta-regression explored the prevalence of periodontal disease in epidemiologic studies around the world (Kassebaum *et al.*, 2014; Susin *et al.*, 2014; Catunda *et al.*, 2019; Bouziane *et al.*, 2020). The prevalence of aggressive periodontitis differed between geographical locations and different race/ethnicities in addition to being more prevalent among African and Middle East populations compared to Caucasian descents suggesting a genetic tendency and a socio-economic factor for disease susceptibility (Susin *et al.*, 2014). In a systematic review, Catunda *et al.* (2019) reported a wide range of prevalence of periodontitis in young population and suggested that this could indicate differences in population, predisposing factors, or lack of standardisation in diagnosis. Moreover, a recently published systematic review with meta-analysis by Bouziane *et al.* (2020) observed a lack of data regarding the prevalence of aggressive periodontitis in Africa and recommended more epidemiologic studies to be conducted with less heterogeneity, better condition identification and low risk of bias, to accurately address the prevalence of aggressive periodontitis in the African and Arab regions.

Current research demands reporting the prevalence of periodontitis in different populations, this might open more epidemiologic studies for public health intervention of periodontitis at local levels to improve the health of the adult population. Thus, population-based data is crucial to understand the distribution and determinants of diseases and their application to preventive initiatives (Eke *et al.*, 2020). Residents of developing countries were found to be more prone to periodontal diseases compared to those of developed countries due to lack of awareness and proper oral hygiene measures, a relatively expensive dental care system and lower socio-economic status (Bouziane *et al.*, 2020). To the best of the author's knowledge, there is insufficient data in the current periodontal literature concerning periodontal disease prevalence in the Arab African population. Hence, there is a need for epidemiological studies representing the adult population from this region to enable proper development of guidelines and appropriate public health programs (Elamin *et al.*, 2010; Al-Harthi *et al.*, 2013).

Quality of life assessment is currently considered as an important component for evaluating healthcare results in public health programmes. The oral health impact profile-14 (OHIP-14) was developed as a shorter version of the OHIP-49 that comprises 14 items exploring seven dimensions of impact. This instrument has been one of the most widely used oral health related quality of life (OHRQoL) indicators internationally with content validity for

different populations (Buset *et al.*, 2016). In a systematic review, Ferreira *et al.* (2017) stated that the negative impact of periodontal disease on OHRQoL has been investigated less than other oral problems, such as dental caries and tooth loss. The authors suggested that a better understanding of the perception of individuals regarding the impact of periodontal disease could help ensure treatment planning that fits the needs of the periodontitis patient.

Based on the above-mentioned data, this hospital-based cross-sectional study was conducted to determine the frequency and risk indicators/predictors of periodontal diseases in adult Egyptian outpatients attending the diagnostic centre at Faculty of Dentistry, Cairo University as well as to develop a prediction equation for classifying periodontal diseases among Egyptian population.

MATERIALS AND METHODS

Ethical Review

This is a hospital-based cross-sectional study. The study protocol was registered in ClinicalTrials.gov (ID: NCT03779763) and approved by the Research Ethics Committee, Faculty of Dentistry, Cairo University (December 2018) (Ref. No.: 181215) and performed according to the Declaration of Helsinki (Palacios, 2013). The detailed steps were clearly described to all patients who agreed to participate in this work and signed a written informed consent.

Study Design and Participants

The present cross-sectional study included 750 patients in a sample of adult Egyptian patients seeking dental treatment at Faculty of Dentistry, Cairo University. Patients were recruited in a consecutive manner from the Diagnostic Center at the Faculty of Dentistry, Cairo University, in which each consecutive eligible patient who presented to the outpatient clinic was approached for enrolment. This study was conducted from June 2019 till December 2019 and screening of patients was continued where every subject meeting the inclusion criteria was selected until the target sample was achieved. Sample size calculation was performed using prevalence of aggressive periodontitis as the primary outcome, based on a previous study reporting a prevalence of 2% (Alshammari, 2017). Using a 95% confidence level, acceptable margin of error 1% and 0.05 significance level, the estimated sample size was 750 subjects. Sample size calculation was performed using Epi Info™ 7.2.2.2 programme (Centres for Disease Control and Prevention US). Identifying and recruiting potential patients was achieved through patients' database. Inclusion criteria included adult patients above 18 years old and patients with dental complaints seeking treatment at the outpatient clinic. Exclusion criteria were those with mouth opening problems or undergoing intermaxillary fixation where oral examination was not possible, patients diagnosed with psychiatric problems or suffering from drugs intoxication.

Interview and Data Collection

Oral Health Questionnaire for Adults

A WHO structured oral health questionnaire for adults was selected (World Health Organization, 2013) and was completed for each patient by the examiner (OKG). All questions were explained and translated into Arabic language using a validated Arabic version of the WHO questionnaire which accurately reflected the content and the intent of the original version as it contained the same meaning. This translation also demonstrated adequate psychometric properties in terms of validity and reliability (Khoshnevisan *et al.*, 2016). The first section included questions regarding patients' demographic data including the patients' gender, age, and the nature of the location of living; either an urban or rural place in addition to information about the level of education of patients. The second part

included questions regarding the medical and dental history. While the third part included questions regarding the oral health behaviour and oral hygiene habits. And finally, the fourth part was questions related to the smoking habits and alcohol consumption.

OHIP-14

The secondary outcome in this observational cross-sectional study was the oral health related-quality of life (OHR-QoL), which was evaluated using OHIP-14 questionnaire (Slade, 1997). All questions were explained and translated into Arabic language using a validated Arabic version of the OHIP-14 questionnaire (Al Habashneh *et al.*, 2012). The OHIP-14 defines seven dimensions of impact: functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability and handicap. Each dimension was assessed in two questions and the response for each item was recorded on a five-point scale (0 = never, 1 = hardly ever, 2 = occasionally, 3 = fairly often and 4 = very often).

Clinical Periodontal and Radiographic Parameters

Based on the clinical and radiographic assessment, diagnosis and case identification of periodontal diseases was performed according to the new classification of periodontal disease (Tonetti *et al.*, 2018) and the recruited participants were either diagnosed as gingivitis or periodontitis and the stages and grades of periodontitis were also specified. Full mouth clinical examinations were performed for all recruited patients by a trained examiner (OKG). Calibration exercises for probing measurements were done in five patients before the study with a good intra-examiner agreement of a 0.82κ value. The periodontal parameters recorded for all participants included; plaque index (PI) (Silness & Löe, 1964), dichotomous bleeding on probing (BoP) expressed as percentage (Trombelli *et al.*, 2018), pocket depth (PD), clinical attachment level (CAL) and gingival recession depth (RD). PD was measured from the free-gingival margin to the base of the pocket with a light force applied, CAL was measured from the cemento-enamel junction (CEJ) to the base of the pocket and RD was measured from the CEJ to the most apical extension of the gingival margin (Ramfjord, 1967). Measurements were recorded at six sites for all teeth mesio-buccal, mesio-lingual, mid-buccal, disto-buccal, disto-lingual, and mid-lingual using William's graduated periodontal probe (Martin™ graduated periodontal probe No. 43-357-00, KLS Martin Group, Germany) and were rounded to the highest whole millimeter.

Alveolar bone level and grading of periodontitis were determined by taking digital periapical radiographs for the most affected area. The radiographic images were transferred to a personal computer for analysis. Linear measurements of bone loss were determined by a radiologist (FD) to calculate the percentage of bone loss by dividing the depth of the defect by the root length (Papapanou *et al.*, 2018). Using Digora software® (Digora for Windows 2.8™, SOREDEX Inc., Tuusula, Finland), linear measurements were made on digital periapical radiographs using a digital phosphor storage plate (PSP) sensor size 2 (Eagle Eye™ PSP Imaging Plate, US). The first linear measurement was measured from the CEJ to the base of the intra-bony defect to detect the defect depth, while the second linear measurement was measured from the CEJ to the tip of the root to detect the root length.

Statistical Analysis

Qualitative data were presented as frequencies and percentages. Quantitative data were presented as mean±standard deviation (SD). Ordinal logistic regression analysis was used to determine significant predictors of periodontal diseases. Model fit was tested using Chi-square test and Pseudo R^2 tests and the model was fit to describe the relations between the dependent

and independent variables. The regression coefficient (b), standard error (SE) and 95% confidence interval were calculated. Discriminant analysis was performed to determine discriminant functions for predicting periodontal disease classification based upon data of age, PD, CAL, RD, BoP and PI. The significance level was set at $p \leq 0.05$. Statistical analysis was performed with IBM SPSS Statistics (IBM SPSS Statistics for Windows Version 23.0. Armonk, NY: IBM Corp.).

RESULTS

Descriptive Data

Frequency of Periodontal Diseases

This study was conducted on 750 patients: 404 females (53.9%) and 346 males (46.1%) and their age range was 16–78 years (mean±SD, 38.6±9.4 years) where 538 patients (71.7%) did not suffer from any disease with the most common disease being hypertension (18.9%) followed by diabetes mellitus (9.4%). Gingivitis was the most frequent periodontal disease, with 297 patients (39.6%) followed by 285 patients diagnosed as periodontitis stage I (38%) and 153 patients diagnosed as periodontitis stage II (20.4%). The frequency of stage III was 1.6% with 12 patients while only 3 patients were diagnosed as periodontitis stage IV showing the least frequency (0.4%). All patients diagnosed with periodontitis stages III and IV were grade B, with a moderate rate of progression where the percentage of bone loss divided by age ranged from 0.39 to 0.94.

Dental History, Oral Health Behaviour and Self-assessment

Frequency and distribution of dental history findings, oral health behaviour and self-assessment among patients are shown in Table 1. All patients who cleaned their teeth used toothbrush and toothpaste ($n = 697$); whereas 38.6% of them reported using the dental floss, 31.6% used wooden toothpicks and the least commonly used tools were plastic toothpicks (1.3%), mouthwash (0.7%) then Miswak/chew stick (0.3%).

Univariate Analysis

The association between periodontal diseases and gender, education, residence, medical history, frequency of cleaning, smoking and alcohol consumption is shown in Table 2. The frequency of periodontal diseases was significant among age, gender and education ($p < 0.001$). The highest mean age was found in patients with periodontitis stage IV (52±5.2) and lowest mean age in patients with gingivitis (34.8±8.7) ($p < 0.001$). Males showed high frequency of periodontitis stage II while females demonstrated high frequency of periodontitis stage IV ($p < 0.001$). All cases with periodontal stage IV had no formal schooling, however gingivitis was the most frequent periodontal disease in patients who had completed college/university or had postgraduate degree ($p < 0.001$). With regard to residence, there was no statistically significant association with periodontal diseases ($p = 0.566$). There was a statistically significant association between medical history and periodontal diseases ($p < 0.001$) with gingivitis being the most frequent disease among patients with free medical history, while the most frequent diseases among patients with hypertension was periodontitis stages III and IV (33.3%) and in patients with diabetes mellitus was periodontitis stage IV (33.3%).

There was a statistically significant association between periodontal diseases and frequency of cleaning teeth ($p < 0.001$). All patients with periodontitis stage IV never cleaned their teeth, while patients who clean their teeth once a month showed highest frequency of periodontitis stage III and patients who clean their teeth at least twice a day showed the highest frequency of gingivitis. There was also a statistically significant ($p < 0.001$) association between periodontal diseases and different methods of teeth cleaning. In patients with gingivitis

Table 1 Frequency of dental history, oral health behavior and self-assessment findings among study patients

Dental history	*n* = 750	%
History of dental trauma		
Yes	297	39.6
No	453	60.4
Number of natural teeth in the participants' mouth		
10–19 teeth	8	1.1
20 teeth or more	742	98.9
Dental pain or discomfort in the past 12 months		
Yes	233	31.1
No	446	59.5
I do not know	70	9.3
No answer	1	0.1
Time of last dental visit		
Less than 6 months	37	4.9
6–12 months	197	26.3
>1 year and <2 years	204	27.2
>2 years and <5 years	245	32.7
5 years or more	26	3.5
Never received dental care	41	5.5
Reason of last dental visit		
Consultation/advise	5/709	0.7
Pain or trouble with teeth, gums or mouth	463/709	65.3
Treatment/follow-up treatment	116/709	16.4
Routine check-up/treatment	122/709	17.2
Do not know/do not remember	3/709	0.4
Oral health behaviour		
Frequency of cleaning teeth		
Never	53	7.1
Once a month	78	10.4
2–3 times a month	112	14.9
Once a week	116	15.5
2–6 times a week	103	13.7
Once a day	127	16.9
Twice or more a day	161	21.5
Oral health self-assessment		
Very good	222	29.6
Good	198	26.4
Average	258	34.4
Poor	71	9.5
Very poor	1	0.1

Table 2 Univariable analysis† modeling the association of gender, residence, education, medical history, frequency of cleaning teeth, smoking and alcohol consumption distributions *n* (%) with different periodontal disease severity

	Gingivitis (*n* = 297)	Periodontitis stage I (*n* = 285)	Periodontitis stage II (*n* = 153)	Periodontitis stage III (*n* = 12)	Periodontitis stage IV (*n* = 3)	*p*	Effect size (v)
Gender							
Male	99 (33.3)	131 (46.0)	111 (72.5)	5 (41.7)	0 (0.0)	< 0.001*	0.295
Female	198 (66.7)	154 (54.0)	42 (27.5)	7 (58.3)	3 (100.0)		
Residence							
Urban	182 (61.3)	172 (60.4)	90 (58.8)	5 (41.7)	1 (33.3)	0.566	0.062
Rural	115 (38.7)	113 (39.6)	63 (41.2)	7 (58.3)	2 (66.7)		
Education							
No formal schooling	20 (6.7)	40 (14.0)	46 (30.1)	4 (33.3)	3 (100.0)	<0.001*	0.251
Less than primary school	0 (0.0)	1 (0.4)	0 (0.0)	0 (0.0)	0 (0.0)		
Primary school	20 (6.7)	39 (13.7)	22 (14.4)	4 (33.3)	0 (0.0)		
Secondary school	54 (18.2)	102 (35.8)	53 (34.6)	3 (25.0)	0 (0.0)		
High school	36 (12.1)	40 (14.0)	20 (13.1)	1 (8.3)	0 (0.0)		
College/University	141 (47.5)	59 (20.7)	12 (7.8)	0 (0.0)	0 (0.0)		
Postgraduate degree	26 (8.8)	4 (1.4)	0 (0.0)	0 (0.0)	0 (0.0)		
Medical history							
Free	243 (81.8)	194 (68.1)	93 (60.8)	7 (58.3)	1 (33.3)	< 0.001*	0.197
Hypertension	36 (12.1)	60 (21.1)	41 (26.8)	4 (33.3)	1 (33.3)	< 0.001*	0.155
Diabetes	17 (5.7)	33 (11.6)	19 (12.4)	1 (8.3)	1 (33.3)	0.022*	0.115
Hypotension	1 (0.3)	0 (0.0)	1 (0.7)	0 (0.0)	0 (0.0)	0.699	0.048
Cancer	1 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1.000	0.045
Frequency of cleaning teeth							
Never	11 (3.7)	7 (2.5)	30 (19.6)	2 (16.7)	3 (100.0)		
Once a month	12 (4.0)	33 (11.6)	26 (17.0)	7 (58.3)	0 (0.0)		
2–3 times a month	36 (12.1)	51(17.9)	23 (15.0)	2 (16.7)	0 (0.0)		
Once a week	22 (7.4)	65 (22.8)	28 (18.3)	1 (8.3)	0 (0.0)	< 0.001*	0.320
2–6 times a week	36 (12.1)	40 (14.0)	20 (13.1)	1 (8.3)	0 (0.0)		
Once a day	45 (15.2)	53 (18.6)	29 (19.0)	0 (0.0)	0 (0.0)		
Twice or more a day	135 (45.5)	22 (7.7)	4 (2.6)	0 (0.0)	0 (0.0)		
Smoker	22 (7.4)	71 (24.9)	96 (62.7)	3 (25.0)	0 (0.0)	< 0.001*	0.467
Alcohol consumption	6 (2.0)	37 (13.0)	56 (36.6)	3 (25.0)	0 (0.0)	< 0.001*	0.374

Notes: *Significant at $p \leq 0.05$. † Each model includes only one independent variable (predictor).

the most frequent method of interdental cleaning was the dental floss (62.6%), while 80% of patients having periodontitis stage III used wooden toothpicks. However, no statistically significant association was observed between periodontal diseases and plastic toothpicks, mouth wash or Miswak/ chew stick consumption (p = 0.073, 0.353, 1.0, respectively).

The frequency of smoking in the present study was 25.6%. The mean±SD of number of cigarettes smoked per day was 19.9±4.2. The frequency of alcohol drinking was 13.6% having one drink per day. There was a statistically significant ($p < 0.001$) association between periodontal diseases and both smoking and alcohol consumption with the highest frequency observed in patients with

periodontitis stage II. While all patients with periodontitis stage IV were non-smokers and did not drink alcohol.

OHIP-14 Questionnaire

Distribution of the responses to OHIP-14 questionnaire are presented in Table 3. The total mean±SD OHIP-14 values reported by all participants were 13.48±9.83, where the highest score was reported by patients with periodontitis stage II (15.5±9.5), while the lowest values were found in patients with periodontitis stage III (6.8±10.4). Further statistical analysis revealed a significant difference ($p < 0.001$) between mean OHIP-14 scores in patients with different periodontal diseases. Pair-wise comparisons of OHIP-14 values between the diseases revealed that there was no significant difference ($p > 0.05$) between patients with gingivitis, periodontitis stages I and II, as well as between patients with periodontitis stages III and IV. Correlation between periodontal parameters and OHIP-14 scores are shown in Table 4. Current analysis showed a statistically significant ($p < 0.001$) direct correlation between CAL, RD, PI and OHIP-14 scores with an increase in CAL, RD and PI associated with an increase in OHIP-14 scores and vice versa. However, no significant correlation was found between PD, BoP and OHIP-14 scores ($p = 0.058$ and 0.789, respectively).

Multivariate Analysis

Ordinal Regression Analysis

For multivariate analysis, ordinal logistic regression analysis was used to determine significant predictors of periodontal diseases. Ordinal regression model was constructed using periodontal disease as an ordinal dependent variable on the following scale: gingivitis = 1, periodontitis stage I = 2, periodontitis stage II = 3, periodontitis stage III = 4 and periodontitis stage IV = 5. Medical history, dental history, oral health self-assessment, frequency of cleaning teeth, time since last dental visit, smoking, drinking alcohol and OHIP-14 scores were the independent variables. The model was adjusted for the following covariates: gender, age, educational level and residence. Model fitting was tested by several methods; first was the statistically significant −2 Log Likelihood test (−2 Log Likelihood = 1208.6, $p < 0.001$), Pearson's Chi-square test ($\chi^2 = 1734.1$, $p = 1.000$) and Deviance test ($\chi^2 = 1205.8$, $p = 1.000$). Pseudo R-square tests results were as follows: Cox and Snell = 0.593, Negelkerke = 0.548 and McFadden = 0.296. High values of these tests indicate good model fit. Although McFadden's test showed a value less than 0.5, all other test results indicated a model that was fit to describe the relationship between independent and dependent variables. Results of the regression model showing the statistically significant predictors are presented in Table 5.

Education, OHIP-14 score, non-smoking and non-alcohol drinking were found to be significant negative predictors of periodontal disease. Where an increase in level of education, high scores of OHIP-14, an increase in frequency of non-smokers and non-alcohol drinking was associated with lower stage of periodontal disease. On the other hand, never to clean the teeth and cleaning the teeth once a month were found to be significant positive predictors of periodontal disease. Where subjects who never cleaned their teeth and those who clean their teeth once a month would have higher stages of periodontal disease.

Discriminant Analysis and Prediction Equation for Classifying Periodontal Disease among Egyptian Population Using Age, PD, CAL, RD, BoP and PI as Predictors

A discriminant analysis was conducted to predict periodontal disease (gingivitis = 1, periodontitis stage I = 2, periodontitis stage II = 3, periodontitis stage III = 4 and periodontitis stage IV = 5) using data of age, PD, CAL, RD, BoP and PI of all study

Table 3 Frequencies (*n*) and percentages (%) for OHIP-14 questionnaire results (*n* = 750)

OHIP-14 dimensions	Never	Hardly ever	Occasionally	Fairly often	Very often
Functional limitation					
1. Have you had trouble pronouncing any words because of problems with your teeth, mouth or dentures?	578 (77.1)	139 (18.5)	28 (3.7)	5 (0.7)	0 (0.0)
2. Have you felt that your sense of taste has worsened because of problems with your teeth, mouth or dentures?	481 (64.1)	180 (24.0)	81 (10.8)	7 (0.9)	1 (0.1)
Physical pain					
3. Have you had painful aching in your mouth?	235 (31.3)	83 (11.1)	402 (53.6)	27 (3.6)	3 (0.4)
4. Have you found it uncomfortable to eat any foods because of problems with your teeth, mouth or dentures?	238 (31.7)	83 (11.1)	387 (51.6)	39 (5.2)	3 (0.4)
Psychological discomfort					
5. Have you been self-conscious because of your teeth, mouth or dentures?	264 (35.2)	105 (14.0)	341 (45.5)	31 (4.1)	9 (1.2)
6. Have you felt tense because of problems with your teeth, mouth or dentures?	274 (36.5)	112 (14.9)	309 (41.2)	46 (6.1)	9 (1.2)
Physical disability					
7. Has your diet been unsatisfactory because of problems with your teeth, mouth or dentures?	261 (34.8)	78 (10.4)	344 (45.9)	56 (7.5)	11 (1.5)
8. Have you had to interrupt meals because of problems with your teeth, mouth or dentures?	255 (34.0)	76 (10.1)	347 (46.3)	67 (8.9)	5 (0.7)
Psychological disability					
9. Have you found it difficult to relax because of problems with your teeth, mouth or dentures?	261 (34.8)	90 (12.0)	334 (44.5)	60 (8.0)	5 (0.7)
10. Have you been a bit embarrassed because of problems with your teeth, mouth or dentures?	280 (37.3)	99 (13.2)	337 (44.9)	33 (4.4)	1 (0.1)
Social disability					
11. Have you been a bit irritable with other people because of problems with your teeth, mouth or dentures?	424 (56.5)	140 (18.7)	162 (21.6)	23 (3.1)	1 (0.1)
12. Have you had difficulty doing your usual jobs because of problems with your teeth, mouth or dentures?	429 (57.2)	138 (18.4)	162 (21.6)	20 (2.7)	1 (0.1)
Handicap					
13. Have you felt that life in general was less satisfying because of problems with your teeth, mouth or dentures?	498 (66.4)	78 (10.4)	165 (22.0)	9 (1.2)	0 (0.0)
14. Have you been totally unable to function because of problems with your teeth, mouth or dentures?	497 (66.3)	74 (9.9)	166 (22.1)	13 (1.7)	0 (0.0)

participants. The analysis resulted in the following equation:

$$D = 0.001Age + 0.459PD + 4.786CAL + 0.395RD + 0.003BoP - 0.981PI - 6.772$$

The discriminate functions at group centroids (group means) were –7.263, 2.391, 7.711, 18.79 and 23.415 for gingivitis, periodontitis stage I, stage II, stage III and stage IV, respectively. This indicates that a patient with a score close to any of the previous scores will be classified as having the corresponding stage of periodontal disease.

Table 4 Results of Spearman's' correlation coefficient for the correlation between periodontal parameters and OHIP-14 scores

Parameters	Correlation coefficient (ρ)	*p*
PD and OHIP-14	–0.069	0.058
CAL and OHIP-1	0.136	< 0.001*
RD and OHIP-14	0.149	< 0.001*
BOP and OHIP-14	0.010	0.789
PI and OHIP-14	0.135	< 0.001*

Note: *Significant at $p \leq 0.05$

Table 5 Results of ordinal regression analysis model showing significant predictors of periodontal disease

Variable	Regression coefficient (b)	Standard error (SE)	*p*	95% CI
Education	–0.272	0.054	< 0.001*	–0.377, –0.166
Never clean teeth	2.298	0.447	< 0.001*	1.442, 3.173
Clean teeth once a month	2.034	0.399	< 0.001*	1.252, 2.816
OHIP-14	–6.980	2.313	0.003*	–11.512, –2.447
Non-smoking	–0.968	0.280	0.001*	–1.517, –0.420
Non-alcohol drinker	–0.710	0.309	0.021*	–1.315, –0.105

Note: *Significant at $p \leq 0.05$

Table 6 Classification results based on the discriminate function of predicting periodontal disease from age, PD, CAL, RD, BoP and PI

Periodontal disease	Observed	Predicted					Percentage correct
		Gingivitis	Periodontitis stage I	Periodontitis stage II	Periodontitis stage III	Periodontitis stage IV	
Gingivitis	297	293	3	1	0	0	98.7
Periodontitis stage I	285	1	284	0	0	0	99.6
Periodontitis stage II	153	0	0	153	0	0	100.0
Periodontitis stage III	12	0	0	0	11	1	91.7
Periodontitis stage IV	3	0	0	0	0	3	100.0
Overall percentage correct							99.2

Classification results based on the previous discriminant function are shown in Table 6 and the overall correct classification was 99.2%.

DISCUSSION

Understanding the epidemiology of periodontal diseases is essential in planning preventive strategies. Improvements in population survey methodologies have been the most important developments in epidemiology in the last decade (Eke *et al.*, 2020). Nevertheless, the previously conducted epidemiologic studies used a wide range of case definitions which had a profound impact on the reported disease prevalence in different populations. Hence, the use of a standard definition for periodontal disease has been strongly recommended (Susin *et al.*, 2014). Consequently, this investigation implemented the new classification of periodontal disease in the patients' diagnosis, with well-defined clinical entities based on a multidimensional staging and grading system (Caton *et al.*, 2018; Papapanou *et al.*, 2018; Tonetti *et al.*, 2018). This hospital-based cross-sectional study aimed at determining the frequency and predictors of periodontitis in an Egyptian adult population extracted from the outpatients at Faculty of Dentistry, Cairo University. The present population sample was believed to be an appropriate representative for the target adult population in Egypt being one of the largest hospitals in Egypt with a population of 223,200 patients/year. Besides, most of the cross-sectional studies investigating prevalence of periodontal disease were hospital-based rather than population-based studies owing to the frequency of consultations at hospital settings (Bouziane *et al.*, 2020).

This hospital based cross-sectional study demonstrated that gingivitis was the most frequent periodontal disease (39.6%) which was consistent with previous studies observing high prevalence of gingivitis in the Arab countries (Ababneh *et al.*, 2012; Alshammari, 2017; Mostafa & El-Refai, 2018). The frequency of patients with periodontitis stage I was 38%, followed by stage II (20.4%), stage III (1.6%) and stage IV (0.4%). Previous cross-sectional studies investigated the prevalence of periodontal diseases in developing countries. Kazadi *et al.* (2017) surveyed 404 subjects attending the dental hospitals of Kinshasa city, DR Congo and found that 79.7% had chronic periodontitis, while only 10.9% were diagnosed with aggressive periodontitis. In another cross-sectional study, Abbass *et al.* (2019) examined 343 adults from the Faculty of Dentistry, Cairo University, and private clinics, and reported that 70.8% of the respondents had stage I and 15.2% had stage II, while only 4.4% and 2.05% had stages III and IV periodontitis, respectively. Other studies in underdeveloped countries demonstrated that the prevalence of aggressive periodontitis was 5.5% in Brazil (Susin & Albandar, 2005) and 3.5% in Sudan (Elamin *et al.*, 2010). Furthermore, a recently published systematic review reported a 1.6% pooled prevalence for aggressive periodontitis worldwide, with the highest pooled prevalence found in Africa (4.2%), which supports the current observations (Bouziane *et al.*, 2020). More recently, Germen *et al.* (2021) conducted a cross-sectional study in Istanbul, Turkey and evaluated the 2018 European Federation of Periodontology/American Academy of Periodontology (EFP/AAP) classifications of epidemiological studies in terms of periodontitis severity, prevalence and associated risk factors. The authors showed that based on CAL, the frequency and severity of staging was stage I (41%), stage II (25%) and stages III–IV (34%).

Variations in diagnostic criteria, method of examination and classification of diseases and discrepancies in examiners calibration, might lead to the variations in the prevalence of diseases reported in different countries making it difficult to compare them and significantly undermines the possibility of drawing concrete conclusions (Albandar *et al.*, 2002). Moreover, it is

not possible to compare a case definition to a multidimensional classification that provides a comprehensive assessment of risk indicators and complexity factors (Germen *et al.*, 2021). Nevertheless, results from the current research could offer a major contribution to the periodontal health information of the Egyptian population which can encourage raising awareness and providing preventive measures. Furthermore, analysis of epidemiologic data regarding the frequency of periodontal disease from this investigation could be beneficial for policy makers to provide financial and human resources offering comprehensive screening programmes to assess the oral health and periodontal treatment needs at an early age.

Univariate analysis in this investigation revealed that periodontal diseases were significantly associated with age, gender and education. The highest mean age was observed in patients with periodontitis stage IV. It is well-established that the degree of periodontal destruction increases with increasing age, suggesting cumulative periodontal destruction in susceptible individuals (Genco & Borgnakke, 2013), which is consistent with the present data. Males showed high frequency of periodontitis stage II while females demonstrated high frequency of periodontitis stage IV ($p < 0.001$). Both males and females seem to be affected by periodontitis in the same way. However, data in the periodontal literature remains contradictory, especially regarding aggressive periodontitis, suggesting that genetic variables, attitude to oral health and dental visit behaviour might be the reasons for these gender disparities (Albandar, 2002; Susin & Albandar, 2005; Elamin *et al.*, 2010; Alshammari, 2017). Meanwhile, gingivitis was most frequent in subjects who have completed college/postgraduate studies, whereas all cases with periodontitis stage IV had no formal schooling. Similarly, Torrungruang *et al.* (2005) concluded that the increased incidence of periodontitis in Thailand was substantially correlated with low levels of education. Likewise, in the United States, Borrell *et al.* (2006) recorded those subjects with less high school education were three times more likely to have periodontitis than subjects with higher level of education.

This cross-sectional study observed that hypertension and diabetes mellitus were the most frequent conditions in patients with periodontitis stages III and II respectively. These findings were supported by previous systematic reviews demonstrating that periodontitis was associated with hypertension and antihypertensives and that sufficient periodontal care might even reduce the risk for cardiovascular disease (Martin-Cabezas *et al.*, 2016; Del Pinto *et al.*, 2020; Muñoz Aguilera *et al.*, 2020). Additionally, diabetes mellitus is well-documented as a major risk factor for periodontal disease with an increased risk of tooth loss (Lalla & Papapanou, 2011; Genco & Borgnakke, 2013; Isola *et al.*, 2020). Acknowledgment of the concept of a two-way interaction will challenge endocrinologists and dentists to work together closely in the future when managing patients with both diabetes and periodontal disease (Ghallab *et al.*, 2015; Polak *et al.*, 2020).

Furthermore, patients who have never received dental treatment showed the highest occurrence of stage IV periodontitis. This is in line with previous studies reporting higher incidence of periodontal diseases among those who recorded emergency visits compared to routine visits and confirms that periodic recall visits reduce the risk of periodontitis (Susin & Albandar, 2005; Ababneh *et al.*, 2012; Lertpimonchai *et al.*, 2017; Scannapieco & Gershovich, 2020). The highest frequency of stage III periodontitis was identified in patients who brushed their teeth once a month and all patients with periodontitis stage IV never brushed their teeth. These observations are in accordance with previous studies reporting that daily tooth brushing decreased the prevalence of periodontal disease and subjects who never brush their teeth had 25 times higher odds of developing

periodontitis (Axelsson *et al.*, 2004; Ababneh *et al.*, 2012).

In the present study, patients who were smokers and drank alcohol were mainly diagnosed with periodontitis stage II which is supported by overwhelming evidence from previous studies and systematic reviews confirming that smoking is a significant risk factor for periodontal disease (Susin & Albandar, 2005; Ababneh *et al.*, 2012; Leite *et al.*, 2018; Kanmaz *et al.*, 2020). The current association of alcohol consumption with periodontal disease is also verified by other systematic reviews suggesting that alcohol consumption might be a risk indicator for periodontitis, yet the mechanisms are still unclear (Shepherd, 2011; Wang *et al.*, 2016; Pulikkotil *et al.*, 2020).

Patient-based outcomes have been used to assess subjective perceptions regarding the impact of periodontal disease on the OHRQoL. The current statistical analysis showed that the highest OHIP-14 scores were shown in patients with periodontitis stages I and II, while the lowest scores were reported by patients with stages III and IV which signifies the negative impact of periodontitis on the OHRQoL. This is in accordance with a similar study conducted by Al Habashneh *et al.* (2012) who showed that 63.9% of Jordanian adults with severe periodontitis reported low OHIP-scores. Furthermore, in a recent review, Graziani & Tsakos (2020) concluded that quality of life is significantly influenced by the periodontal health status. The higher the level of periodontitis, the poorer the OHRQoL, especially with symptoms like bleeding, halitosis and mobility. Furthermore, worse perceptions of OHRQoL were demonstrated at lower levels of education with low educational level having an independent negative impact on OHRQoL (Tsakos *et al.*, 2009). The present study also showed that higher level of education was observed in patients with stages I and II as most of them completed high school and university while most patients with periodontitis stage III had completed primary school only and all cases with periodontal stage IV had no formal schooling.

Results from the multivariate analysis showed that education, frequency of teeth cleaning, smoking, alcohol drinking and OHIP-14 scores were significant predictors of periodontal disease. Buset *et al.* (2016) in their systematic review, demonstrated that greater severity and extent of periodontal disease were associated with poorer OHRQoL, which support the current findings. Further understanding of periodontal disease prevalence over the last decades have allowed the identification of significant risk factors that could help target patients for prevention and treatment of periodontal disease (Genco & Borgnakke, 2013). Since periodontitis is a public health problem, it is of great importance that future programmes can now be based on nationally representative data which would facilitate the possibility to reduce prevalence of periodontitis (Eke *et al.*, 2020). Consequently, well-structured oral health education programmes are required to improve awareness through training programmes. Policy makers should give high priority to preventive care especially at an early age and provide preventive and therapeutic public dental care facilities (AlGhamdi *et al.*, 2020).

Discriminant analysis aims at classifying patients into certain categories based upon different measures. In this investigation, the dependent variable (periodontal disease) is a categorical variable with more than two categories so the assumption of using discriminant analysis was fulfilled (Riffenburgh, 2012). Discriminant analysis prediction equation demonstrated that the current study could classify patients into different periodontal disease categories with an overall correct prediction of 99.2%. To the best of the authors' knowledge this is the first cross-sectional study to use the discriminant analysis equation to predict the classification of periodontal disease.

CONCLUSION

Within the limitations of this hospital-based cross-sectional study, it could be concluded that periodontitis stages III and IV showed the least frequency on a sample of adult Egyptian patients compared to stages I and II or to gingivitis. This paves the way for future work to investigate the prevalence of periodontal diseases among the whole Egyptian population. Future epidemiologic studies are recommended to further explore the association between periodontal diseases and their predictors including education, frequency of teeth cleaning, smoking, alcohol drinking and OHIP-14 scores.

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