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The Detection of Pre-Diabetic Patients in the Dental Setting

Hamda AlMesmar[1], Nadia Saleh[2], Shiamaa AlMashhadani[2*] and Khaled Farghali[3]

Affiliation

[1]Director of Dental Services Department, Dubai Health Authority, United Arab Emirates
[2]Assistant Director of Dental Services Department, Dubai Health Authority, United Arab Emirates
[3]Head of General Dentistry Section, Dubai Health Authority, United Arab Emirates

[*]**Corresponding author:** Shiamaa AlMashhadani, Specialist Senior Registrar Dental Public Health specialist, Dubai Health Authority, United Arab Emirates, Tel: 00971551038706, E-mail: ssalmashhadani@dha.gov.ae

Abstract

Pre-diabetes is a serious health condition where blood sugar levels are higher than normal, but not high enough yet to be diagnosed as type 2 diabetes. Pre-diabetes puts one at an increased risk of developing type 2 diabetes and heart disease.

Methodology: A cross-sectional study was carried out on 384 patients aged 20-70 years old, attending the dental clinics to assess the risk for diabetes, using the FINDRISC (Finnish Diabetes Risk Score) questionnaire, HbA1c blood test and a periodontal examination.

Results: The mean age of participants was 38.90 ± 10.74. 32.3% were categorized as no risk, 46.6% low risk, while 19% and 2.1% moderate and high risk of developing diabetes respectively. Tests for serum HbA1c Level showed 46.1% had normal HbA1c followed by 18.0% and 3.6% were pre-diabetic and diabetic respectively. 19.3% of participants had periodontal pockets measuring more than 4mm and 15.9% measuring more than 6mm.

Conclusion: The study has proven to be useful in identifying patients at high-risk of developing diabetes. Controlling and managing periodontal disease could be a new aspect to include in the standards for diabetes care. Dental settings could be a successful platform to carry out the screening and risk stratification of pre-diabetic patients.

Keywords: Oral health, Pre-Diabetes, Diabetic, FINDRISC, HbA1c, Periodontal, Screening, Oral-Systemic.

Abbreviations: FINDRISC-Finnish Diabetes Risk Score, WHO-World Health Organization, IDF-International Diabetes Federation, UAE-United Arab Emirates, MENA-Middle East and North Africa region, DHA-Dubai Health Authority, CDC-Centers for Disease Control and Prevention, CPITN-Community Periodontal Index of Treatment Needs, NHANES-National Health and Nutrition Examination Survey, OGT-Oral Glucose Tolerance Tests, CAL-Clinical Attachment Loss, IGT-Impaired Glucose Tolerance, PPD-Periodontal Probing Depth

Introduction

Diabetes in all its forms imposes unacceptably high physical, social and economic burden on the communities and countries at all income levels. Pre-diabetes is a serious health condition where blood sugar levels are higher than normal, but not high enough yet to be diagnosed as type 2 diabetes. Pre-diabetes puts one at an increased risk of developing type 2 diabetes, heart disease, and stroke [1].

The risk factors for Pre-diabetes include:

- Being overweight
- Being 45 years or older
- Having a parent, brother, or sister with type 2 diabetes
- Being physically active less than 3 times a week
- Ever having gestational diabetes (diabetes during pregnancy) or giving birth to a baby who weighed more than 9 pounds
- Having Polycystic Ovary Syndrome
- Race and ethnicity (certain races are more prone)

Diabetes in the UAE

World Health Organization (WHO)-Diabetes country profiles, 2016 illustrate that Diabetes accounts to 3% mortality all ages in the UAE

[2]. Figures from the International Diabetes Federation (IDF) reveal that, in 2017, 17.3% of the United Arab Emirates (UAE) population between the ages of 20 and 79 had type 2 diabetes. There are over 1 million people living with diabetes in the UAE, placing the country at 15th place worldwide for age-adjusted comparative prevalence. Trends also indicate that the prevalence of diabetes in the UAE is rising at a faster rate than both the MENA region (Middle East and North Africa region) and the rest of the world. Rapid economic growth, sedentary lifestyles and unhealthy diets characteristic to the UAE are all risk factors, leading to the number of people with diabetes expecting to double to 2.2 million by 2040 [3].

Diabetes in Dubai

Additionally, Dubai Diabetes Survey conducted by Dubai Health Authority (DHA) in 2017 reported the total prevalence of Diabetes amongst Emiratis in Dubai is 19%, while the undiagnosed diabetes cases amongst Emiratis accounts to 11% and the prevalence rate of pre-diabetes amongst Emiratis is 18.6% [4]. This alarmingly high percentage undoubtedly represents a worrying indication about the future impact of diabetes as a major threat in Dubai.

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Oral Health Consequences of Diabetes

Of late, there is an ample evidence to explain the two-way relationship between diabetes and periodontal disease. The primary cause of periodontal disease is "plaque" that contains pathogenic bacteria that cause inflammation of the gums, leading to the destruction of tooth-supporting periodontal tissues. Physiologically active substances associated with the inflammation are released from periodontal pockets and then delivered to all parts of the body, where they increase insulin resistance. Additionally, the hyperglycemic state weakens the immune function which protects the body from bacterial infection, leading to easy development and progression of periodontal disease.

Considering the facts and figures expressed above, there is a dire need to develop an effective screening tool to be able assess the risk for diabetes and direct the efforts towards its prevention across Dubai. Since the natural history for diabetes is well understood and it is detectable in the preclinical stage, it is wise to devise a cost-effective, safe and acceptable screening tool that could be easily and widely used in any environment. Diabetes risk calculation can be performed by several health professionals in different settings, of which a dental office could be an ideal site to carry it out as the former caters to patients of all age groups with varied medical backgrounds. More so, the nature of dental treatments mandates multiple visits for most patients, and dental professionals easily develop a rapport with the patients and thus it is conceived feasible to administer a simple, chair-side screening tool for diabetes in the dental offices setting across Dubai. Consequently, if this tool proves accurate and can detect the affected patients, it will prove very valuable not only to prevent the progression of active diabetes, but also limit its complications.

On a similar line, the Centers for Disease Control and Prevention (CDC) also suggest that the dental office may be a useful setting in which to identify individuals with undiagnosed Pre-diabetes or diabetes. However, no study has been conducted so far to estimate the risk for diabetes in the population of Dubai; especially in a dental setting. This is the first study of this kind in Dubai

Aim of the study

To detect the individuals who are at high risk of developing diabetes and correlate with their clinical periodontal disease status.

Materials and Methods

A cross-sectional study was carried out in a primary health center of DHA to assess the risk for diabetes, using the Finnish Diabetes Risk Score (FINDRISC) questionnaire followed by the HbA1c blood test stipulated only for the patients identified to be at risk. However, the periodontal examination was carried out for all the patients regardless of the risk category (**Figure 1**).

Sample design and Subjects

A simple random sample of the population visiting the dental clinic of Al Mizhar Primary Health Centre was chosen for this study. Both females and males aged 20-70 years were included from the morning and afternoon shifts of dental clinics at the above mentioned health center. Patients sitting in the waiting area of dental clinics were approached and if found interested, a written consent was given to them to be signed and the entire procedure was explained. A total of 20 participants refused to participate; the response rate was 95%. Later, consent forms were given to a total of 400 participants, out of whom 16 were excluded.

Exclusion criteria

- Patients previously diagnosed with diabetes, Pregnant females and
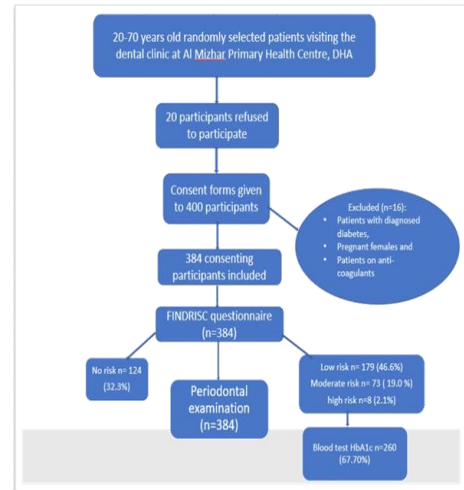- Patients taking anti-coagulant medications.

Figure 1: Flowchart depicting the procedure of sample selection and clinical examination.

Finally, 384 consenting participants were included in the study. The subjects were screened over a period of 12 months, with 32 patients screened each month; divided over five days a week (around 6 patients per day) in the dental setting of Al Mizhir Primary health center, DHA, Dubai. The screening was accomplished daily based on the availability of the sample with the required criteria.

The Questionnaire

A screening chart that was simple, practical, non-invasive and inexpensive namely FINDRISC was used. FINDRISC has been successfully implemented as a practical screening instrument to assess diabetes risk and to detect undiagnosed type 2 diabetes in diverse populations.

FINDRISC questionnaire is a validated risk assessment tool to predict type 2 diabetes. It estimates the probability of a person to develop diabetes within the next 10 years. It requires no laboratory testing and uses age, Body Mass Index (BMI), physical activity, vegetable and fruit intake, medical treatment of hypertension, history of hyperglycemia and family history to determine risk of developing diabetes [5].

After procuring the consent forms and completing the registration formalities, each patient was given a FINDRISC questionnaire (appendix 1), which takes 2-3 minutes to complete. The questionnaire has eight scored questions, with the total test score providing a measure of the probability of developing type 2 diabetes. The results categorize the participant as high risk, moderate risk, low risk or no risk individual. Resultantly, patients falling in the no risk category received a report on their condition and given printed advice and tips on how to stay healthy (**Table 1**) [6].

Diagnostic test	Normal	Pre-diabetes	Diabetes
HbA1c (%)	<5.7	5.7-6.4	≥ 6.5
Fasting Plasma Glucose (mg/dL)	<100	100-125	≥ 126
Oral Glucose Tolerance Test (mg/dL)	<140	140-199	≥ 200

Table 1: CDC recommendations for Pre-diabetes and diabetes identification.

HbA1c Blood Test

Next, patients at the high risk, moderate risk or low risk categories were requested to take a finger-prick blood sample collection for in-office HbA1c testing with Metrika A1c Now (Bayer Health Care, Sunnyvale, CA), as rapid one-step test. It takes five minutes for the

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results to appear and the reference HbA1c values were followed as per the CDC guidelines.

Periodontal Examination and Charting

Five dentists and five assistants were involved in the examination, which were trained and calibrated before initiating the data collection. All the patients attended their usual appointment and a periodontal charting was done for them after filling out the FINDRISC forms and the blood test. Community Periodontal Index of Treatment Needs (CPITN) was used for the periodontal evaluation. Three indicators of periodontal status are used for this assessment [7]:

- Presence or absence of gingival bleeding
- Supra or sub-gingival calculus
- Periodontal pockets-subdivided into shallow (4-5mrn) and deep (6mm or more).

A specially designed lightweight probe with a 0.5mm ball tip was used, bearing a black band between 3.5 and 5.5mm from the ball tip.

Sextants: The mouth is divided into sextants defined by teeth numbers 18-14, 13-23 24-28,38-34, 33-43 and 44-48. A sextant should be examined only if there are two or more teeth present and not indicated for extraction. When only one tooth remains in a sextant, it should be included in the adjacent sextant.

Statistical Analysis: For the purpose of inter-examiner reliability, the Kappa coefficient (Cohen's Kappa) was used as a measure of agreement between the examiners. 10% of the sample was extracted and measured and a value of 0.6 was recorded which shows good agreement.

The collected data were loaded into Microsoft excel and thereafter proof reading was done. Statistical analysis was carried out using IBM-SPSS version 24. All the categorical variables were expressed as proportion and continuous variables as means and standard deviation. To know the association between socio-demographic factors and FINDRISC score, HbA1c and periodontal health, the Pearson chi square and contingency coefficients were used. Pearson correlation was used to figure out the correlation between FINDRISC score, HbA1c levels and periodontal measurements. Further, to find out the factors influencing the periodontal charting, regression analysis was performed keeping the periodontal scores as the dependent variable. The predicted probabilities were calculated for periodontal scores, later receiver curve was also drawn to know the specificity and sensitivity of the periodontal scores based on the predicted probabilities values. The significance level was fixed at P<0.05 with 95% confidence interval throughout.

Ethical Approvals: Approval from Ethical Committee for Scientific Research, Dubai Health Authority was obtained.

Results

Distribution of the Study Participants

Out of a total of 384 subjects interviewed, majority 71.6% (275) were female participants and 61.2 % (235) were local population. The mean age of the participants was 38.90 ± 10.74 and a large proportion i.e. 52.9% (203) belonged to 20-40 years, while 44.55% (171) belonged to 41-60 years age group. In relation to health conditions of the participants, 87.5% (336) were healthy individuals (**Table 2 and Figure 2**).

All the 384 participants completed the FINDRISC questionnaire, of which 32.3% (124) participants were categorized as having no risk followed by 46.6% (179) participants were with low risk of developing diabetes, while 19% (73) and 2.1% (8) of them were having moderate and high risk of developing diabetes respectively. Further, a total of

Factors	Categories	Frequency	Percentage
Nationality	Local	235	61.2
	Non-Local	149	38.8
Gender	Male	109	28.4
	Female	275	71.6
Age	20-40 Years	203	52.9
	41-60 Years	171	44.5
	61and above	10	2.6
Health Condition	Normal	336	87.5
	Hypertension	22	5.7
	Hyperlipidemia	7	1.8
	Hypothyroidism	3	0.8
	Hyperthyroidism	5	1.3
	Others	11	2.9

Table 2: Distribution of the study population according to the demographic factors and health condition.
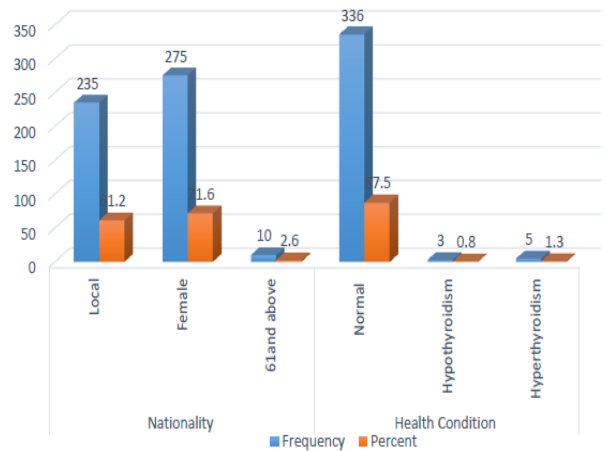

Figure 2: Distribution of the study participants according to the Demographic factors and health condition.

32.3% (124) were exempted from the blood test as they were at a low risk from the FINDRISC questionnaire and the remaining participants were tested for serum HbA1c Level. Accordingly, 46.1% (177) participants had normal HbA1c followed by 18.0% (69) and 3.6 % (14) participants were Pre-diabetic and diabetic respectively. All the participants were subjected to periodontal charting and it was observed that 19.3% (74) participants had a pocket measuring more than 4mm and 15.9% (61) had periodontal pocket measuring more than 6mm (**Table 3 and Figure 3**).

	Categories	Frequency	Percentage
FINDRISC	No Risk	124	32.3
	Low risk	179	46.6
	Moderate risk	73	19
	High risk	8	2.1
HbA1c	No blood Test	124	32.3
	Normal	177	46.1
	Pre-diabetic	69	18
	Diabetic	14	3.6
Periodontal status	Normal	249	64.8
	Attachment loss >3mm	74	19.3
	Attachment loss >6mm	61	15.9

Table 3: Distribution of the study population according to the FINDRISC, HbA1c and Periodontal Scores.

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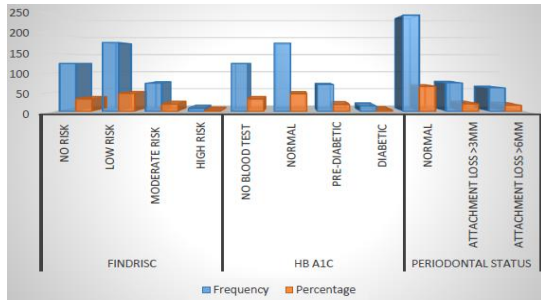
Figure 3: Distribution of the study participants according to FINDRISC, HbA1c and Periodontal Condition.

Association between Demographic Factors and FINDRISC Score

With respect to nationality, local participants had greater scores of FINDRISC questionnaire as compared to the non-local participants with 52.3% (123) vs. 37.6% for low risk, 19.6% (46) vs. 18.1% (27) for moderate risk and 2.6% (6) vs. 1.35(2) high risk scores respectively. Also, female participants had a higher FINDRISC score compared to male participants with 20.4% (56) vs. 15.6% (17) for moderate risk score, while 2.9% (8) of the females had a high-risk score whereas no male subjects were found with FINDRISC score of high risk. In terms of age, higher the age of the participant, greater is the FINDRISC score with 60% (6), 33.9% (58) and 4.4% (9) of the high-risk score for the 20-40 years, 41-60 years and 61 years and above group respectively.

FINDRISC Score									
	No Risk		Low Risk		Moderate Risk		High Risk		P Value
	n	%	n	%	n	%	n	%	
Nationality									P=0.008
Local	60	25.5	123	52.3	46	19.6	6	2.6	
Non-Local	64	43	56	37.6	27	18.1	2	1.3	
Gender									P=0.054
Male	40	36.7	52	47.7	17	15.6	0	0	
Female	84	30.5	127	46.2	56	20.4	8	2.9	
Age									P=0.00
20-40 Years	82	40.4	112	55.2	9	4.4	0	0	
41-60 Years	42	24.6	63	36.8	58	33.9	8	4.7	
61+years	0	0	4	40	6	60	8	2.1	
Health condition									P=0.796
Normal	109	32.4	153	45.5	66	19.6	8	2.4	
Hypertension	9	40.9	10	45.5	3	13.6	0	0	
Hyperlipidemia	1	14.3	6	85.7	0	0	0	0	
Hyperthyroidisms	3	100	0	0	0	0	0	0	
Hypothyroidism	1	20	3	60	1	20	0	0	
Others	1	9.1	7	63.6	3	27.3	0	0	

Note: P value =Pearson chi square and Contingency Coefficient.
Table 4: Association between the Demographic Factors and FINDRISC Score.

HbA1c Values									
	No Blood Test		Normal		Pre-diabetic		Diabetic		P Value
	n	%	n	%	n	%	n	%	
Nationality									P=0.002
Local	60	48.4	116	65.5	47	68.1	12	85.7	
Non-Local	64	51.6	61	34.5	22	31.9	2	14.3	
Gender									P=0.008
Male	40	32.3	36	20.3	27	39.1	6	42.9	
Female	84	67.7	141	79.7	42	60.9	8	57.1	
Age									P=0.00
20-40 Years	82	66.1	95	53.7	24	34.8	2	14.3	
41-60 Years	42	33.9	75	42.4	42	60.9	12	85.7	
61 and Above Years	0	0	7	4	3	4.3	0	0	
Health condition									P=0.635
Normal	109	87.9	150	84.7	64	92.8	13	92.9	
Hypertension	9	7.3	10	5.6	2	2.9	1	7.1	
Hyperlipidemia	1	0.8	4	2.3	2	2.9	0	0	
Hyperthyroidisms	3	2.4	0	0	0	0	0	0	
Hypothyroidism	1	0.8	4	2.3	0	0	0	0	
Others	1	0.8	9	5.1	1	1.4	0	0	

Note: P value =Pearson chi square and Contingency Coefficient
Table 5: Association between the Demographic Factors and HbA1c Score.

The health condition of the participants had no significant association with the risk scores assessed by the FINDRISC questionnaire, however, only 1 subject with hypothyroidism (19.6%) and 3 subjects (27.3%) with other health conditions showed a moderate risk for diabetes (**Table 4 and Figure 4**).
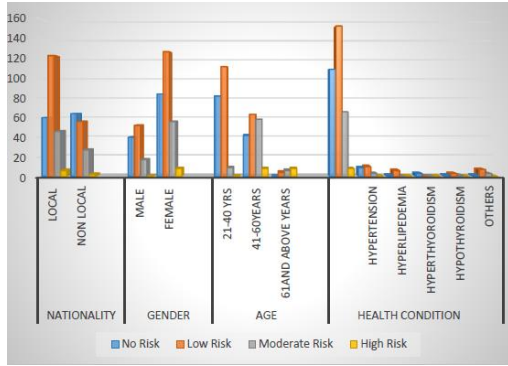
Figure 4: Association between demographic factors and FINDRISC scores.

Association of Demographic Factors with Serum Hba1c Levels

The association of demographic factors with an HbA1c level showed fashion similar to that of FINDRISC Score. A total of 68.1% (47) and 85.7% (12) of the local participants had Pre-diabetic and diabetic levels of HbA1c compared to 31.9% (22) and 14.3% (2) of non-local Participants. Next, 60.9% (42) of the females were in the Pre-diabetic stage compared to 39.1% (27) of the males. Likewise, 57.1% (8) females and 42.9% (6) males were diabetic stage of HbA1c levels. With respect to age, 60.9% (42) belonging to 40-60 years were Pre-diabetic compared to the younger age group which is 34.8% (24), also 85.7% (12) participants had diabetes level of HbA1c compared to the younger counterparts 14.3% (2).

The health condition of the participants again posed no significant association with the HbA1c level; however, 2 subjects with hypertension and 2 subjects with hyperlipidemia had Pre-diabetes as measured by HbA1c (**Table 5 and Figure 5**).
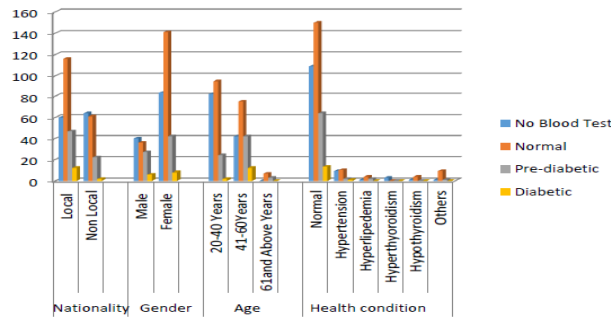

Figure 5: Association between demographic factors and HbA1c levels.

Association of Demographic Factors and Periodontal Condition

Among the subjects having periodontal loss of attachment 82.2% (37) were locals presenting with periodontal pockets more than 4mm compared to 17.8% (8) non-locals, similarly 72.5% (29) locals had a periodontal pocket more than 6mm compared to 27.5% (11) non-locals.

With respect to gender, a greater number of female subjects were observed with periodontal pocket more than 4mm 86.7% (39) vs. 13.3% (6). Similarly, pockets measuring 4mm was found more among the younger adults (20-40) 46.7% (21) vs. 42.2% (19), whereas pockets measuring more than 6mm were more among the older adults (41-60), 67.5% (27) vs. 32.5% (13) (**Table 6 and Figure 6**).

Association of FINDRISC Score, HbA1c Levels and Periodontal Conditions

The presented revealed that a statistically significant association between the periodontal condition and find risk scores as 66.7% (30) and 75% (30) subjects belonging to the low risk group had pockets measuring more than 4mm and 6mm respectively. Next, 11.1% (5) of the subjects in high risk group had pocket more than 4mm.

Similarly, 50% (20) of the subjects belonging to Pre-diabetic and 25% (10) subjects belonging to diabetic stage of HbA1c levels were observed with pockets more than 6mm. Additionally, 45.8% (127) of periodontally healthy subjects presented with normal HbA1c levels and 13.7% (38) of periodontally healthy subjects fall in the Pre-diabetic HbA1c category. These observations were statistically significant (**Table 7 and Figure 7**).
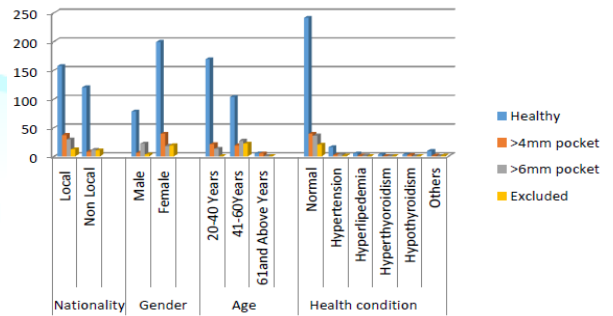

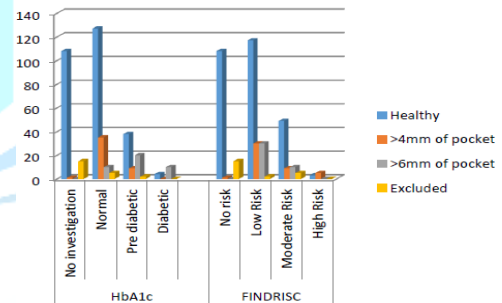**Figure 6:** Association between demographic factors and periodontal condition.

Figure 7: Association between FINDRISC score, HbA1c level and periodontal condition.

Accuracy of Periodontal Measurement

Using the regression model, the sensitivity and specificity periodontal diagnostic was assessed for the periodontal condition which showed 76.4% sensitivity and 82.01% of specificity. In addition, Area Under curve was measured using predictive probabilities of logistic regression for periodontal condition using receiver operating curve that showed a significantly good accuracy of periodontal measurement (**Table 8**).

Relationship between FINDRISC, HbA1c and Periodontal Scores

Further, a correlation matrix was established using the continuous scores of FINDRISC, HbA1c level and predicted probability of periodontal scores. The correlation matrix showed significant relationship between these three variables (**Table 9**).

Periodontal Score									
	Healthy		>4mm pocket		>6mm pocket		Excluded		P Value
	n	%	n	%	n	%	n	%	
Nationality									P=0.000
Local	157	56.7	37	82.2	29	72.5	12	54.5	
Non-Local	120	43.3	8	17.8	11	27.5	10	45.5	
Gender									
Male	78	28.2	6	13.3	22	55	3	13.6	P=0.000
Female	199	71.8	39	86.7	18	45	19	86.4	
Age									
20-40 Years	169	61	21	46.7	13	32.5	0	0	P=000
41-60Years	103	37.2	19	42.2	27	67.5	22	100	
61years and above	5	1.8	5	11.1	0	0	0	0	
Health condition									P=0.938
Normal	241	87	39	86.7	36	90	20	90.9	
Hypertension	16	5.8	2	4.4	3	7.5	1	4.5	
Hyperlipidemia	5	1.8	1	2.2	1	2.5	0	0	
Hyperthyroidisms	3	1.1	0	0	0	0	0	0	
Hypothyroidism	3	1.1	2	4.4	0	0	0	0	
Others	9	3.2	1	2.2	0	0	1	4.5	

Note: P value =Pearson chi square and Contingency Coefficient.
Table 6: Association between the demographic factors and Periodontal Condition.

Periodontal condition									
	Healthy		>4mm of pocket		>6mm of pocket		Excluded		P Value
	n	%	n	%	n	%	n	%	
HbA1c									P=0.000
No investigation	108	39	1	2.2	0	0	15	68.2	
Normal	127	45.8	35	77.8	10	25	5	22.7	
Pre diabetic	38	13.7	9	20	20	50	2	9.1	
Diabetic	4	1.4	0	0	10	25	0	0	
FINDRISC									P=0.000
No risk	108	39	1	2.2	0	0	15	68.2	
Low Risk	117	42.2	30	66.7	30	75	2	9.1	
Moderate Risk	49	17.7	9	20	10	25	5	22.7	

Note: P value=Pearson chi square and Contingency Coefficient.
Table 7: Association between the FINDRISC score, HbA1c Level and Periodontal condition.

Factors	Odds Ratio	95% CI		P value
		Lower	Upper	
Nationality (Local)	3.058	1.457	6.421	0.003
Gender (Male)	0.896	0.431	1.863	0.769
Age (20-40) years	0.239	0.052	1.095	0.065
(41-60) years	0.295	0.066	1.310	0.108
HbA1c	0	0	0.005	0
HbA1c 5.5 to 6.4	0.735	0.079	0.735	0
HbA1c 6.4 and Above	0.734	0.079	0.727	0
FINDRISC Moderate Risk	0.289	0.059	1.413	0.125
High Risk	1.094	1.017	1.508	0.006
	Value	95% C.I.		
PCA	81.50%			
Pseudo R2	27-40%			
Sensitivity of Periodontal charting	76.40%	58.83-89.25		
Specificity Periodontal charting	82.01%	77.42-86.02		

Note: CI-Confidence Interval
Table 8: Regression analysis for periodontal conditions and nationality, age, gender HbA1C and FINDRISC scores.

Correlations			
	Periodontal condition	HbA1c	FINDRISC
Predicted probability	1	0.760**	0.536*
Hb A1c	0.760**	1	0.7
FINDRISC score	0.536*	0.7	1

Note: **. Pearson Correlation is significant at the 0.01 level (2-tailed).
Table 9: The Correlation matrix between FINDRISC, HbA1c and Predictive probabilities of periodontal condition.

Discussion

Findings from the present study suggest a potential correlation between FINDRISC, HbA1c level and predicted probability of periodontal scores. Emirati participants and females posed a higher risk for diabetes. Female participants presented with more and deeper periodontal pockets too. All the high-risk participants belonged to a higher age group. It was also discerned that statistically significant association exists in terms of nationality, gender and age with FINDRISC score and the diabetic stage. However, the health condition of the participants in this study was found to have no significant association either with the HbA1c level or with the periodontal condition.

Almost two-thirds (67.7%) of the participants in this study were found to have low, moderate or high risk for diabetes and nearly a fifth of the surveyed population posed higher HbA1c levels indicating pre-diabetic or diabetic stages. An alarming proportion i.e. more than a fifth of the

study sample (21.6%) were discovered to be either pre-diabetic or diabetic. Further, of all the pre-diabetic individuals, more than two-thirds (68.1%) were UAE nationals and likewise even amongst the diabetics; a majority (85.7%) were UAE nationals again. A potential explanation for this skewed distribution could be that due to the location of the study was a DHA health center where majority of the patients-cohort is formed by UAE nationals and very few non-nationals, that automatically justifies an overall higher prevalence of these conditions amongst them.

It is noteworthy that occurrence of diabetes was noticed in 3.6% of the study participants, which is much lower than the corresponding value outlined in the USA, UK and Australia being 9.4% 9, 6.6% and 6% respectively, as reported by their national statistics [8,9,10]. Further, in the present study, 20% of the participating Emiratis were found to be pre-diabetic, which is slightly higher than reported by Dubai Diabetes Survey conducted by DHA in 2017 (18.6%) [4]. In contrast, the rate of diabetic Emiratis in this study is only 5.1% which is clearly much lower than the Dubai survey (19%). The prevalence of pre-diabetes in the present study (18%) was slightly lower than that reported by S Maples et al. (19.2 %) and higher than that reported by National Health and Nutrition Examination Survey (NHANES) (17.31%) [11,12]. At the same time the diabetes percentage in the present study (3.6%) was observed to be higher than reported by S Maples et al. (1.2%) and NHANES (1.64%). Al Amiri et al. reported the prevalence of prediabetes, among overweight and obese Emirati children and adolescents in Sharjah as 5.4% and 0.87%, respectively, based on Oral Glucose Tolerance Tests (OGTT), which are much lower than the present study [13].

Unlike certain other studies, the present study revealed significant gender differences in the FINDRISC scores as well as HbA1c values with P=0.054 and P=0.008 respectively; these findings contrast the ones obtained by S Maples et al, and W.H. Herman et al, where no significant gender differences were noticed in the pre-diabetes and diabetes prevalence. Identical to the findings from the NHANES and S Maples et al, age was seen to be significantly associated with the presence of diabetes and pre-diabetes in the present study (P=0.00) [11,12,14].

The findings of this study were consistent with the Wijnand J Teeuw et al, where statistically significant association was found between the HbA1c levels and the periodontal status; and significantly greater number of subjects were spotted with deep pockets (more than 6 mm) in the pre-diabetic and diabetic groups as compared to the subjects with normal HbA1c levels (**Table And Figure 8**). The present study also indicates a highly significant association between the periodontal condition and risk for diabetes and the diabetic stage the p value being P=0.000; which is inconsistent with certain other studies such as Oelisoa Mireille et al. who found no significant association between fasting glucose and bleeding on probing [15,16].

There has been abundant evidence to support that the presence and severity of periodontal disease is highly associated with the diabetic stage and its complications. Severe periodontitis has been found to be associated with poor glycemic control after a 5-year period and subjects with Clinical Attachment Loss (CAL) of at least 6 mm had over six times the risk of poor glycemic control compared to those without it [17]. Additionally, an increase in mean CAL has been associated with an increase in HbA1c. Next, a significant increase in Impaired Glucose Tolerance (IGT) with mean Periodontal Probing Depth (PPD), with each additional millimeter mean PPD corresponding to 0.13% increase in HbA1c has been observed after 10-year follow-up [18]. Later, all studies in subjects with types 1 and 2 diabetes found that those with periodontal disease, especially severe disease, and edentulism, had higher risk for diabetes-related complications than participants without or with mild periodontal disease [19]. Lastly, severity of periodontal disease expressed by clinical attachment loss at follow-up was significantly associated with

development of diabetes over ten years in a study [18]. However, due to their design and nature, cross-sectional studies are limited to only provide information about associations and are thus not able to an establish a causal relationship.

Limitations of the Study

- The small sample size of this study defers the extrapolation of the results to whole of Dubai population.
- No information around smoking (duration and frequency) has been recorded, since smoking is a known risk factor for periodontitis and plays a significant role in aggravating the complications caused due to diabetes, it would have been beneficial to do so.

Recommendations

- In light of the findings of this research, the routine application of the FINDRISC tool in the dental setting for the purpose of risk assessment and screening for diabetes and Pre-diabetes is highly recommended.
- It will be more beneficial if information about smoking is also recorded along with other risk factors, since it is a well-known risk factor for periodontal disease and at the same time aggravates the complications caused due to diabetes.
- Non-dental health care providers should be well informed about these results and made aware of the two-way relationship of diabetes and periodontal health to be able to collaborate with them for the purpose of early detection and prevention of the diabetes. The two primary goals of management of Pre-diabetes are lifestyle management to prevent the progression to type 2 diabetes and management of common Pre-diabetes comorbidities, both of which requires the effective contribution of the abovementioned stakeholders [20].
- The confirmation of the blood glucose by other standardized measurements such as OGTT and fasting blood glucose levels along with their clinical correlation would be ideal before initiating any discrete treatment for the diabetic patients, due to the reported overestimation of the blood glucose levels by the HbA1c [21,22].

Conclusions

The Diabetes Risk Score has proven to be very useful in identifying high-risk subjects and exhibits worrying high proportion of Pre-diabetes and diabetes among Dubai population. Filling in the Diabetes Risk Score may encourage a person who gets a high value to have his/her blood glucose measured and also to improve their lifestyle regardless their glucose levels. Additionally, many individuals with a high Diabetes Risk Score may have unrecognized, asymptomatic diabetes and, therefore, may require blood glucose testing for diagnosis, other clinical assessments, and therapy.

This study emphasizes that periodontal disease adversely affects glucose levels and promotes development of Pre-diabetes and diabetes and vice-versa. The results obtained here would affect the patients and families, health care providers, insurance companies, policy-makers and societies in general, due to the high prevalence of both periodontal disease and diabetes in Dubai afflicting immense physical, mental, social and economic consequences. Controlling and managing periodontal disease could be a new aspect to eventually include in the standards for diabetes care. It undoubtedly requires a shift in paradigm for management and prevention of diabetes and its complications. Dental setting could be successful platform to carry out the screening and risk stratification of diabetic patients; those could further be referred to the relevant medical provider for subsequent treatment and follow up.

Acknowledgments

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Appendix 1

Patient questionnaire

Patient Identification number:

Do you have any of the below conditions?
• Diabetic
• Taking drugs affecting your blood (e.g. warfarin, heparin)
• Pregnant

Please answer the following questions:

FINDRISC questionnaire for Diabetes risk assessment

QUESTION	ANSWER		SCORE
Age (years)		<45	0
		45 - 54	2
		55 - 64	3
		>64	4
Body mass index		<25	0
		>25 - 30	1
		>30	3
Waist circumference (cm)		men <94, women <80	0
		men 94 - <102, women 80 - <88	3
		men >102, women > 88	4
Do you usually have at least 30 minutes of physical activity at work and/or during leisure time (including normal daily activity)?		Yes	0
		No	2
How often do you eat vegetables, fruit or berries?		Every day	0
		Not every day	1
Have you ever taken medication for high blood pressure on regular basis?		No	0
		Yes	2
Have you ever been found to have high blood glucose (e.g. in a health examination, during an illness, during pregnancy)		No	0
		Yes	5
Have any of the members of your immediate family or other relatives been diagnosed with diabetes (type 1 or type 2)?		No	0
		Yes: grandparent, aunt, uncle or first cousin	3
		Yes: parent, brother, sister, or own child	5
	TOTAL SCORE:		
	<7:	low risk	
	7-11:	slightly elevated risk	
	12-14:	moderate risk	
	15-20:	high risk	
	>20:	very high risk	

Thank you for your time and cooperation.

For dentist use only
Periodontal screening chart
Right   left

UR6(buccal)	UR1(labial)	UL6(buccal)

LR6(buccal)	LR1(lingual)	LL6(buccal)

Measurements based on WHO CPI modified (using periodontal probe)
0= absence of condition   **1= 4-5mm**   **2=6mm or more**