

The Outcomes of the Dental Patients' Screening for Diabetes Mellitus

Viktoriya N. Naumova¹, Yuliya A. Makedonova^{2*}, Dmitriy V. Mikhalchenko¹,
Kahramon E. Shomurodov³, Elena E. Maslak⁴

1. Department of Propaedeutics of dental diseases, Faculty of Dentistry, Volgograd State Medical University, Russia.
2. Department of Dentistry of the Institute of Dentistry, Volgograd State Medical University, Russia.
3. Department of maxillofacial surgery, Tashkent State Dental Institute, Uzbekistan.
4. Pediatric Dentistry Department, Volgograd State Medical University, Russia.

Abstract

The aim of our research was to study the results of diabetes mellitus (DM) screening in dental patients in a dental clinic. Two models of DM screening during a routine dental examination in a dental clinic were evaluated in the study. The first screening model was the questioning of the participants (N = 216) for DM risk assessment followed by the referral of the patients with DM risk to their physicians for diagnostic. The second screening model included the same questioning of 441 periodontal patients with and without hyperglycemia history, identifying the patients at high and very high DM risk for the immediate glucose measuring in gingival crevicular blood (GCB) using a self-monitoring device. Glucose levels of GCB and finger stick blood (FSB) were measured in 15 patients with DM. The patients with glucose level in GCB ≥ 7.8 mmol/l were referred to their physicians for a diagnosis. The patients' compliance with the referrals and the physicians' feedback were assessed. The proportions (%), 95% Confidence Intervals (CI), mean values with standard error ($M \pm m$), and Pearson correlation coefficient (r) were calculated. Chi-square test was used to assess the differences at p -value 0.05.

According to the first screening model about 30% of dental patients were identified as having high risk of DM development. The compliance of DM-risk patients with the referrals to their physicians was less than 50%. The hyperglycemia was diagnosed in 24.2% (95% CI 9.5-18.6%) patients who were referred to the physicians. The second screening model revealed 33.3% (95% CI 29.1-37.9%) periodontal patients being at high DM risk. The increased GCB glucose levels were found in 38.1% (95% CI 30.6-46.2%) of them. The correlation between glucose levels in GCB and FSB was high ($r = 0.879$, $p < 0.0001$). The patients with the increased glucose level in GCB were referred to their physicians and all of them followed the recommendations. The hyperglycemia (associated with prediabetes or DM) was diagnosed in 67.9% (95% CI 54.8-78.6%) of the referred patients. Also, the GCB glucose test revealed poor glycemic control in every second diabetic patient.

So, both studied screening models are feasible for identification of dental patients with high risk of DM development. However, questioning of periodontal patients followed by glucose measuring in GCB using glucometer significantly increased the patients' compliance with the referrals to the physicians and elevated the rate of hyperglycemia diagnosing. The second screening model helps not only to identify hyperglycemia among dental patients with no diabetes history but also to control glycemia in DM patients.

Clinical article (J Int Dent Med Res 2020; 13(3): 1071-1080)

Keywords: Dental patients, diabetes mellitus, screening, patients' compliance.

Received date: 21 June 2020

Accept date: 20 July 2020

*Corresponding author:

Yuliya A. Makedonova,
Department of Dentistry of the Institute of Dentistry, Volgograd
State Medical University, Russia.
E-mail: mihai-m@yandex.ru

Introduction

Diabetes mellitus (DM) is the metabolic disorder widely spread in the world. In 2015 about 340-536 million people aged 20-79 years, mostly living in low- and middle-income countries, had DM. According to the prognosis, diabetes

prevalence will have risen to 521-829 million people by 2040. Diabetes affects social, financial and health care systems due to its high levels of prevalence, complications, mortality and health expenditure¹.

It is well known that approximately half of the patients suffering from DM or prediabetes remain undiagnosed in globe^{2,3}. The prevalence of DM was 6.2% according to the subjects' self-reported data and increased to 17.3% when diabetes was clinically assessed⁴.

DM has adverse effects on general health and leads to severe complications. Periodontitis is one of the complications ("sixth major complication") of DM. A systematic review with meta-analysis by Nascimento et al. demonstrated that DM in adults increased the risk of onset and progression of periodontitis by 86%⁵. Currently, DM is recognized as an important course modifying factor which should be included into a clinical diagnosis of periodontitis as a descriptor^{6,7}. Peri-implant inflammation may arise due to advanced glycation end products which are accumulated in peri-implant tissues in pre-diabetic and diabetic patients⁸. This can contribute to the increase of implant failure in diabetic patients⁹.

It is established by scientific evidence that "two ways" relationship exist between periodontitis and DM¹⁰. Periodontitis and DM are considered as comorbid pathologies^{11,12,13,14}. DM plays an important role in the pathogenesis of periodontitis, whereas periodontitis affects the diabetes course¹⁵. The prevalence of DM is about twice higher in patients with periodontitis compared to the subjects without periodontitis¹⁶. Periodontal treatment can improve glycemic control in diabetic patients¹⁷. So, cooperative efforts of medical and dental professionals are necessary to manage patients with periodontitis and DM¹⁸.

Oral health may reflect the signs of many systemic diseases. Hence, screening dental patients for systemic diseases including DM can improve the dentists' role in its early diagnosis and long-term complications prevention^{19,20}. Strong association of pre-diabetes and diabetes with periodontal disease is the base of DM screening implementation in dental offices. Many people visit dentists due to high oral diseases prevalence (caries and periodontal disease prevalence in adults is nearly 100%) every year, but the same people do not attend the health

professionals and are not aware of their diabetes risk or status. Meanwhile, about 70% of urban adults have one or more diabetes risk factors²¹. Among people who do not attend general practitioners about 30% have high risk for prediabetes and about 15% have increased hemoglobin A1c (HbA1c) levels. So, it is warranted to apply risk assessment screening strategies in dental settings. Early recognition of DM risk may encourage dental patients to take action for the prevention of prediabetes progression to diabetes. On the other hand, screening of diabetic patients might make them visit a diabetologist for treatment which could diminish the risk of diabetes-related complications²². The study results of Leung et al. demonstrated that low-income middle-aged to elderly dental patients with type 2 DM had poor diabetic control, worth oral health, more advanced periodontal attachment loss and more missed teeth compared with patients without diabetes. Therefore, it is feasible to offer adults the opportunity for diabetes screening in dental offices.

Screening dental patients with the questionnaire of the Centers for Disease Control and Prevention, USA, revealed about 27% of the subjects with previously unknown hyperglycemia²⁴. Meanwhile, 61% of dental patients reported that they had never knowingly been screened or tested for diabetes. However, 82% patients of primary care dental clinics and 72% patients of general dental practice had willingness to be screened for diabetes²⁵.

Many tests have been suggested for DM screening in dental settings. Lalla et al. demonstrated that the presence of $\geq 26\%$ teeth with deep pockets or ≥ 4 missing teeth correctly identified 72% of pre-diabetes or diabetes cases among the patients screened for diabetes by fasting plasma glucose test or HbA1c test in clinical setting²⁶.

The test on glucose measuring in gingival crevicular blood (GCB) is most often considered as a feasible screening tool for determining prediabetes and DM because of its comparability with systemic blood glucose concentration²⁷. Many people with diabetes or abnormal blood glucose levels are unaware of their condition; therefore, the results of GCB test may help timely referrals of dental patients to general medical practitioners. The glucose level of GCB was compared with the glucose level in finger stick

blood (FSB). However, the results were conflicting^{28,29}.

A screening model for diabetes mellitus in patients with periodontitis was developed and applied in dental settings by Su et al.³⁰. An older age, high body-mass index, European background, high cholesterol level, previous periodontal treatment, increased number (%) of teeth with mobility and gingival recession were recognized as the factors significantly associated with diabetic status. The results of DM screening help dentists to motivate their patients to visit an endocrinologist³¹.

Therefore, the bidirectional connection of DM and periodontitis, high proportions of people with undiagnosed prediabetes and DM, the probability to provide DM screening by chairside tests during a routine periodontal examination emphasize the dentists' role in early prediabetes and diabetes identification.

The aim of our research was to study the results of diabetes mellitus screening in dental patients in a dental clinic.

Materials and methods

The study was conducted in the dental clinic of Volgograd State Medical University. The permission of Regional Ethic Committee (Protocol No. 209, 09 February 2015) had been obtained before the study. All the study participants wrote the informed consents for DM screening. Two models of DM screening during a routine dental examination in a dental clinic were compared. The first screening model envisaged the questioning of the participants (N = 216) for DM risk assessment. The second screening model included the same questioning of periodontal patients (N = 441) followed by GCB glucose measuring in those (N = 147) who were identified at high and very high DM risk (assessed by questioning).

The patients' questioning was provided according to Questionnaire for Prediabetes and type 2 DM Risk Assessment described in the Standards of specialized diabetes care³². The questionnaire consists of 8 questions about age, Body Mass Index (BMI), waist circumference, eating habits, physical exercise, taking medicaments for hypertension decrease, patients' history of glucose blood levels, and family diabetes history. The results of the questioning were evaluated in points (table 1).

The risk of type 2 DM development during the nearest 10 years was assessed as low, slightly elevated, moderate, high and very high according to the sum of the points. The diet consultation, life style change, and glucose blood level measuring were recommended for all the patients. The patients with moderate, high and very high risk of type 2 DM were referred to their physicians. The compliance of the patients with the referral and the feedback from the physicians were assessed.

Questions	Answers	Points	
What is your age?	< 45 years	0	
	45-54 years	2	
	55-64 years	3	
	> 65 years	4	
What is your BMI? BMI = weight, kg / (height, m) ²	< 25 kg/m ²	0	
	25-30 kg/m ²	1	
	30 kg/m ²	3	
What is your waist circumference?	For men < 94 cm	For women < 80 cm	0
	94-102 cm	80-88 cm	3
	>102 cm	> 88 cm	4
How often do you eat vegetables, fruits or berries?	daily	0	
	not every day	1	
Physical exercise daily for 30 minutes or 3 hours weekly	yes	0	
	no	2	
Have you ever taken regular medication for decreasing blood pressure?	no	0	
	yes	2	
Have you ever been found to have a higher blood glucose (sugar) level than normal (during pregnancy, well-being or routine examination)?	no	0	
	yes	5	
Did your relatives have type 1 or type 2 diabetes?	no	0	
	yes, grandfather / grandmother, uncle / aunt, or cousins	3	
	yes, parents, brother / sister or own child	5	
The outcome evaluation			
Sum of the points	Risk level of type 2 DM development during the nearest 10 years	Probability of type 2 DM development	
< 7	Low risk, 1 of 100	1%	
7-11	Slightly elevated, 1 of 25	4%	
12-14	Moderate, 1 of 6	17%	
15-20	High, 1 of 3	33%	
> 20	Very high, 1 of 2	50%	

Table 1. The Questionnaire for Prediabetes and type 2 DM Risk Assessment and rules for the outcome evaluation.

In periodontal patients with high or very high risk of DM (identified by questioning) GCB glucose measuring was provided in the dental clinic. The GCB was taken using periodontal probe from the anterior site which had bleeding on probe. The blood sample was placed on a test strip of a self-monitoring device. Glucometer One Touch Select (Jonson & Jonson) was used for blood glucose measurement.

For the validation of GCB use for blood glucose levels measuring, glucose levels of FSB were measured using the same glucometer in 15 patients with DM. The correlation between glucose levels in GCB and FSB was assessed and the difference between mean-values of glucose levels in tested samples was evaluated.

After the GCB glucose measuring, all the patients with glucose level ≥ 7.8 mmol/l were referred to their physicians. The patients' compliance with the referrals and the feedback from the physicians were assessed.

Statistical analysis was performed using Microsoft Excel software (Excel 2016, Microsoft Corporation, Washington DC, USA). The proportions (%), 95% Confidence Intervals (CI), mean values with standard error ($M \pm m$), and Pearson correlation coefficient (r) were calculated. Chi-square test was used to assess the differences at p -value 0.05.

Results

The results of the first screening model demonstrated that questioning the dental patients is a reliable technique for identifying DM risk in population. Questioning 216 dental patients revealed the risk of type 2 DM in the most participants (table 2). Moderate risk, which might be connected with prediabetes, was identified in 54 of 216 (25.0%, 95% CI 19.7-31.2%) patients, high and very high risks, which might be connected with type 2 DM, were found in 66 of 216 (30.6%, 95% CI 24.8-37.0%) patients. Moderate to severe periodontitis was revealed in all the patients with increased risk of DM.

Risk of type 2 DM	Number (%) of the patients, N=216			Chi-square test	
	n	%	95% CI	χ^2	p-value
Low	70	32.4	26.5 – 38.9	31.0370	< 0.0001
Slightly elevated	26	12.0	8.3 – 17.1		
Moderate	54	25.0	19.7 – 31.2		
High	32	14.8	10.7 – 20.2		
Very high	34	15.7	11.5 – 21.2		

Table 2. The results of dental patients' questioning for screening the risk of type 2 DM.

One hundred and twenty patients with increased DM risk (from moderate to very high) were referred to their physicians, but only 54 (45.0%, 95% CI 36.4-53.9%) of them followed this recommendation. After the examination by the physicians, including random blood glucose and HbA1c measuring in a laboratory, hyperglycemia was diagnosed in 29 of 54 (53.7%, 95% CI 40.6-66.3%) patients. Therefore, among all questioned participants the rate of undiagnosed DM identification was 13.4% (95% CI 9.5-18.6%), among those with the revealed DM risk – 24.2% (95% CI 17.4-32.5%).

The second screening model was aimed at evaluating a 2-step technique for the identification of the patients with undiagnosed DM and diabetic patients with poor control of glycemia. The 441 dental patients aged 35-65 years with moderate to severe periodontitis, including those with previously diagnosed DM, were questioned using the Questionnaire for Prediabetes and type 2 DM Risk Assessment³². Among the participants 147 of 441 (33.3%, 95% CI 29.1-37.9%) were identified at high and very high DM risk; 39 of 147 (26.5%, 95% CI 20.1-34.2%) patients reported on hyperglycemia history.

All 147 patients were screened (in dental setting) by GCB glucose test using glucometer. In 15 DM patients FSB glucose measuring was also performed using the same glucometer. The correlation between glucose levels of FSB and GCB was high ($r = 0.879$, 95% CI 0.6671-0.9593, $p < 0.0001$). The difference between mean-values of glucose levels in FSB and GCB samples was not significant statistically (8.67 ± 0.56 and 7.89 ± 0.41 respectively, $p = 0.2710$).

The increased glucose level (from 7.8 to 15.2 mmol/l) in GCB was revealed in 56 of 147 (38.1%, 95% CI 30.6-46.2%) screened patients (table 3). Among them the increased blood glucose levels were firstly found in 34 of 56 (60.7%, 95% CI 47.6-72.4%) patients; 22 of 56 (39.3%, 95% CI 27.6-52.4%) patients reported that hyperglycemia had been previously revealed by their FSB tests.

Hyperglycemia history	Number of the screened patients	The patients with GCB glucose level $\geq 7,8$ mmol/l		The patients with prediabetes or DM confirmed by physicians	
		n	% (95% CI)	n	%, 95% CI
Yes	39	22	56.4 (41.0-70.7)	22	100 (85.1-100)
No	108	34	31.5 (23.5-40.7)	16	47.1 (31.4-63.3)
Total	147	56	38.1 (30.6-46.2)	38	67.9 (54.8-78.6)

Table 3. The results of GCB glucose measuring in the dental patients with and without DM history.

The participants with the increased glucose level in GCB were referred to their physicians and all (100%) of them followed the recommendation. The endocrinological examination confirmed hyperglycemia associated with prediabetes or DM in 38 of 56 (67.9%, 95% CI 54.8-78.6%) referred patients. The physicians confirmed DM diagnosis in all 22 patients with hyperglycemia history. Firstly diagnosed

prediabetes or DM was found in 16 of 34 (47.1%, 95% CI 31.4-63.3%) patients without hyperglycemia history.

In relation to the total number of the patients screened by GCB glucose test, the prediabetes or DM was confirmed by the physicians in every fourth participant (25.8%, 95% CI 19.4-33.5%): among the patients with hyperglycemia history – in every second (56.4%, 95% CI 41.0-70.7%) one, among those without such a history – in every sixth (14.8%, 95% CI 9.3-22.7%) one, table 4.

Hyperglycemia history	Number of the screened patients	The patients with prediabetes or DM confirmed by physicians		
		n	%	95% CI
Yes	39	22	56.4	41.0-70.7
No	108	16	14.8	9.3-22.7
Total	147	38	25.8	19.4-33.5

Table 4. Prediabetes or DM confirmation among screened participants.

Discussion

Timely diabetes diagnostic is the key point of complications prevention. Undiagnosed DM is widely spread in the world and new strategies for diabetes screening are needed. DM and periodontitis are closely interconnected³³. Borrell et al. assessed self-reported data and periodontal status of dental patients and suspected undiagnosed diabetes in 27-53% of those who had family diabetes history, hypertension, high cholesterol levels and the signs of periodontal disease³⁴. Chandrupatla et al. interviewed dental patients aged 35-55 years and revealed high risk of DM in 38% of them³⁵. So, dental office may give an opportunity to screen patients for diabetes risk, but further referral to endocrinological examination is obligatory for DM diagnosis. The Questionnaire of the Centers for Disease Control and Prevention to identify periodontal patients for hyperglycemia screening was used by Mataftsi et al. Then, using HbA1c measurement in capillary blood, hyperglycemia was revealed in 25% of tested subjects³⁶. Herman et al. developed logistic models to identify risk factors for dysglycemia in the patients of dental practices using a questionnaire about gender, hypertension, dyslipidemia, lost teeth, BMI or random capillary glucose. This chair-side screening, with or without random FSB

glucose test, identified 30% patients aged ≥ 30 years at high risk for dysglycemia³⁷. Similar study of Tantipoj et al. showed hyperglycemia in 33.8% of the examined dental patients. The significant associations of hyperglycemia with older age, family diabetes history, overweight and obesity, and severe periodontitis were found³⁸.

We applied DM screening for dental patients using the questionnaire recommended by Dedov et al.³² and revealed moderate to very high diabetes risk in 55.6% (95% CI 48.9-62.0%) of the participants. A lower proportion (35%) of dental patients with the positive test for DM risk (assessed by Find-Risk questionnaire) was revealed in the study of Ziebolz et al. The efficacy, sensitivity and specificity of the questionnaire were confirmed for DM screening in dental patients during routine check-ups in a private practice. However, only 55% of the patients with DM risk followed the dentists' recommendations and visited a diabetologist. This finding limited the value of the screening though blood glucose changes were noticed in 56% of those who visited a diabetologist³⁹. In our research the patients screened by questioning had lower compliance (45%, 95% CI 36.4-53.9%) with the recommendation to visit their physicians for blood glucose and HbA1c measuring and diabetes diagnosis. Meanwhile, the level of confirmation of blood hyperglycemia was similar (53.7%, 95% CI 40.6-66.3%) in the patients who visited a physician. Therefore, patients' questioning in dental practices can be useful for diabetes mellitus screening, but its effectiveness is restricted by the patients' compliance with the dentists' recommendations to visit a physician or a diabetologist. Patients from community clinics had much higher compliance with referrals to physicians than those from private dental clinics⁴⁰. It should be noted that low patients' compliance with different dentists' recommendations is a common finding in the other studies^{41,42}.

The importance of identification of individuals with prediabetes and diabetes in dental offices in order to reduce diabetes related complications is highlighted by Holm et al. Questioning adults with no history of diabetes concerning general health, BMI, waist circumference, fat percentage, and HbA1c level recording was followed by the referral of the patients with HbA1c value above age appropriated level to a physician. The results showed that 3.1% of the patients were identified

as diabetic and 27.1% as prediabetic. The proportion of undiagnosed diabetes and prediabetes was higher among the patients with periodontal disease compared with the ones without it (32.7% and 17.4%)⁴³. Jadhav et al. studied diabetes risk factors (family history of diabetes, hypertension, smoking, loss of teeth and periodontitis) and revealed hyperglycemia (screened by random blood glucose level) in 35.3% of the patients with these risk factors⁴⁴. So, measuring blood glucose level is useful to detect early stages of prediabetes and diabetes, especially in the patients with dental problems⁴⁵. Random blood glucose measurement using a finger-prick test and a glucometer in the patients of a dental clinic revealed that the prevalence of hyperglycemia was about 25%⁴⁶. Non-invasive GCB glucose test was introduced in dental practices to increase the safety and utility of DM screening in dental patients. High level of correlation between HbA1c in GCB and FSB was revealed when blood samples were placed on a special blood collection card and tested in a laboratory⁴⁷. Both the patients and the providers preferred GCB to FSB collection for diabetes screening. The patients considered GCB method as tolerated, convenient and acceptable, the dentists – as a time saving method⁴⁸. Strong correlation was found between the results of glucose measuring in GCB, FSB (determined in a dental office by a glucose self-monitoring device) and intra venous blood (collected at the same time and transferred to a laboratory for measurement with a laboratory glucose analyzer) in diabetic and non-diabetic patients^{16,49}. The correlation level was higher in diabetic patients than in non-diabetic ones⁵⁰ and was not connected with the used gingival sites⁵¹. However, the technique of obtaining a GCB sample is not always feasible and the sites with bleeding on probing (without touching a tooth or gingival margin) are only suitable for screening for diabetes^{52,53}.

Meanwhile, GCB was considered a good source for blood glucose measurement during patients' routine dental visits for identifying potential diabetic patients and this technique is also suitable for routine screening of diabetic patients^{54,55,56}. In our study we also revealed a high level of correlation ($r = 0,879$, 95% CI 0.6671-0.9593, $p < 0.0001$) between glucose levels of GCB and FSB which were measured by a glucometer in the diabetic patients in a dental

clinic. The difference between glucose mean-values of GCB and FSB samples was insignificant. Our results correspond to the finding of Shetty et al. in diabetic and non-diabetic patients⁵⁷.

In contrast, Gupta A et al. obtained a lower correlation coefficient between GCB and peripheral fasting blood: $r = +0.715$ for diabetic patients and $r = +0.619$ for non-diabetic patients⁵⁸. Kandwal and Batra revealed very low correlation between glucose values of blood samples obtained from gingival crevices and finger-prick, which were analyzed by a glucometer in diabetic and systemically healthy dental patients with chronic periodontal disease⁵⁹. Similar data were presented by Müller and Behbehani⁶⁰. In addition, Debnath et al. revealed a significant difference between glucose values of GCB and FSB⁶¹. The differences were explained by mixing gingival blood with gingival crevicular fluid which have their own intensively produced glucose, especially at gingivitis and periodontitis. Trauma, salivation, mastication, inflammation and other stimulations can alter the results of GCB measuring. The authors concluded that gingival crevicular blood cannot be used for screening blood glucose during a periodontal examination. Beyond that, Glurich et al. in their systematic review noticed that the differences in study design and population characteristics did not allow to perform meta-analysis and future research should be conducted for evidence base establishment of glycemic screening in dental settings⁶².

Nevertheless, the non-invasive method of GCB glucose measuring was considered useful for DM screening in dental office setting. Rajesh et al. developed a regression equation for the calculation of capillary blood glucose level based on the GCB glucose level⁶³. Gaikwad et al. recommended screening gingival blood by a self-monitoring blood glucose device during a routine periodontal examination in periodontal patients with no history of DM⁶⁴.

The majority of the results displayed the usefulness of the chairside diabetes screening strategy for periodontal patients. Dental setting was considered an appropriate place for hyperglycemia screening in population. So, the importance of high-risk screening for diabetes and prediabetes in dental offices may be feasible. According to Genco et al., 40.7% of screened dental patients aged over 45 years had HbA1c \geq

5.7% and were referred to physicians, who diagnosed DM in 12.3% of them and prediabetes in 23.3%⁴¹. In our study, the increased glucose level in GCB was revealed in 31.5% (95% CI 23.5-40.7%) dental patients aged 35-65 years with no diabetes history and among them hyperglycemia was confirmed by the physicians in 47.1% (95% CI 31.4-63.3%) cases.

It is well-known that many diabetic patients had poor glycemic control⁶⁵. We screened dental patients with diabetic history and found the increased glucose level of GCB in 56.4% (95% CI 41.0-70.7%) of them. The referral to the physicians helped to confirm DM in all these patients.

Dental patients' compliance with the referrals to the physicians was significantly higher after GCB glucose screening in dental setting comparing to DM risk questioning alone. According to the numbers of the patients who were referred to their physicians, the GCB glucose screening significantly increased the rate of identifying DM patients compared with DM risk questioning alone: 67.9% (95% CI 54.8-78.6%) and 24.2% (95% CI 9.5-18.6%) respectively, $\chi^2 = 8.925$, $p = 0.0028$.

Therefore, the second model of DM screening during a routine periodontal examination is safe, convenient for patients and feasible for medical care quality improvement. The advantages of the second screening model can be emphasized as following: selection of the target patients' group (patients with periodontal disease which is common for DM patients); prediabetes and diabetes risk assessment by questioning to identify the patients for the next step of screening; non-invasive glucose measuring in GCB to recognize the patients with undiagnosed hyperglycemia and motivate them for the referral to their physicians.

The obtained results correspond to the review of Sultan et al. who noticed that screening for general disease including DM is the obligation of dentists and it is in patients' best interests. However, the screening may be cost-effective when carried out only for high-risk patients⁶⁶. Meanwhile, Neidell et al. stated cost-effectiveness of dysglycemia identification in dental patients during their routine visits of dental offices for initiating prediabetic treatment⁶⁷.

Conclusions

In the limitation of the study we can conclude that both screening models are feasible for the identification of dental patients with high risk of DM development. Dental patients' questioning can reveal a high risk for DM in about 30% of dental patients. However, among these patients the compliance with the referrals to their physicians was less than 50%. The second screening model offered questioning of the target group of periodontal patients followed by glucose measuring in GCB using a glucometer. This screening model increased the patients' compliance with the referrals to the physicians and elevated the rate of revealing hyperglycemia in the screened patients. Moreover, the second screening model helps not only to identify hyperglycemia among dental patients with no diabetes history but also to control glycemia in DM patients.

Acknowledgements

The authors express their gratitude to the local authorities (the Volgograd State Medical University) for their support and contribution to this study.

Declaration of Interest

The authors report no conflicts of interest and the article is not funded or supported by any research grant.

References

1. Ogurtsova K, da Rocha Fernandes JD, Huang Y, Linnenkamp U, Guariguata L, Cho NH, Cavan D, Shaw JE, Makaroff LE. IDF Diabetes Atlas: Global estimates for the prevalence of diabetes for 2015 and 2040. *Diabetes Res Clin Pract.* 2017;Jun;128:40-50. PMID: 28437734 DOI: 10.1016/j.diabres.2017.03.024.
2. Mirahmadizadeh A, Fathalipour M, Mokhtari AM, Zeighami S, Hassanipour S, Heiran A. The prevalence of undiagnosed type 2 diabetes and prediabetes in Eastern Mediterranean region (EMRO): A systematic review and meta-analysis. *Diabetes Res Clin Pract.* 2020;Feb;160:107931. PMID: 31794806. DOI: 10.1016/j.diabres.2019.107931.
3. Ardakani MR, Moeintaghavi A, Haerian A, Ardakani MA, Hashemzadeh M. Correlation between levels of sulcular and capillary blood glucose. *J Contemp Dent Pract.* 2009;Mar 1;10(2):10-7. PMID: 19279967 DOI:10.5005/jcdp-10-2-10.
4. Ziukaite L, Slot DE, Van der Weijden FA Prevalence of Diabetes Mellitus in people clinically diagnosed with periodontitis: A systematic review and meta-analysis of epidemiologic studies. *J Clin Periodontol.* 2018;Jun;45(6):650-662. PMID: 29125699 DOI: 10.1111/jcpe.12839.

5. Nascimento GG, Leite FRM, Vestergaard P, Scheutz F, López R. Does diabetes increase the risk of periodontitis? A systematic review and meta-regression analysis of longitudinal prospective studies. *Acta Diabetol.* 2018;Jul;55(7):653-667. PMID: 29502214 DOI: 10.1007/s00592-018-1120-4.
6. Jepsen S, Caton JG, Albandar JM, Bissada NF, Bouchard P, Cortellini P, Demirel K, de Sanctis M, Ercoli C, Fan J, Geurs NC, Hughes FJ, Jin L, Kantarci A, Lalla E, Madianos PN, Matthews D, McGuire MK, Mills MP, Preshaw PM, Reynolds MA, Sculean A, Susin C, West NX, Yamazaki K. Periodontal manifestations of systemic diseases and developmental and acquired conditions: Consensus report of workgroup 3 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions. *J Periodontol.* 2018;Jun;89 Suppl 1:S237-S248. PMID: 29926943 DOI: 10.1002/JPER.17-0733.
7. Papanou P.N., Sanz M., Buduneli N., Dietrich T., Feres M., Fine D.H., Flemmig T.F., Garcia R., Giannobile W.V., Graziani F. Periodontitis: Consensus report of workgroup 2 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions. *J. Periodontol.* 2018;89:S173-S182. PMID: 29926951 DOI: 10.1002/JPER.17-0721.
8. Alrabiah M, Al-Aali KA, Al-Sowygh ZH, Binmahfooz AM, Mokeem SA, Abduljabbar T. Association of advanced glycation end products with peri-implant inflammation in prediabetes and type 2 diabetes mellitus patients. *Clin Implant Dent Relat Res.* 2018;Aug;20(4):535-540. PMID: 29624850 DOI: 10.1111/cid.12607.
9. Annibali S, Pranno N, Cristalli MP, La Monaca G, Polimeni A. Survival analysis of implant in patients with diabetes mellitus: a systematic review. *Implant Dent.* 2016;Oct;25(5):663-74. PMID: 27540845 DOI: 10.1097/ID.0000000000000478.
10. Sanz M., Ceriello A., Buyschaert M., Chapple I., Demmer R.T., Graziani F., Herrera D., Jepsen S., Lione L., Madianos P. Scientific evidence on the links between periodontal diseases and diabetes: Consensus report and guidelines of the joint workshop on periodontal diseases and diabetes by the International Diabetes Federation and the European Federation of Periodontology. *Diabetes Res. Clin. Pract.* 2018;137:231-241. PMID: 29208508 DOI: 10.1016/j.diabres.2017.12.001
11. Kopetskiy IS, Pobozhieva LV, Sheveluk YuV. Correlation between periodontitis and systemic diseases. *Lechebnoe Delo.* 2019;2:7-12. [in Russian]. DOI: 10.24411/2071-5315-2019-12106.
12. Maslak EE, Naumova VN. Interdisciplinary cooperation between dentists and endocrinologists for identification and management of diabetes mellitus. *Diabetes Mellitus.* 2019;22(1):35-43. DOI: 10.14341/DM9581
13. Melnychenko DI, Romanenko IG. The correlation between parodontal diseases and pancreatitis. *Crimean Journal of Internal Diseases.* 2017;3:23-26. [in Russian]. <http://crimjtj.ru/Journal.files/34-2017-3/LR-Melnychenko-ParodontalDiseasesPancreatitis.pdf>
14. Orekhova LYu, Atrushkevich VG, Mikhailchenko DV, Gorbacheva IA, Lapina NV. Dental health and polymorbidity: analysis of modern approaches to the treatment of dental diseases. *Parodontologiya.* 2017;22(3):15-17. [In Russ]. <https://www.parodont.ru/jour/article/view/121/121>
15. Graziani F., Gennai S., Solini A., Petrini M. A systematic review and meta-analysis of epidemiologic observational evidence on the effect of periodontitis on diabetes: An update of the EFP-AAP review. *J. Clin. Periodontol.* 2018;45:167-187. PMID: 29277926 DOI: 10.1111/jcpe.12837.
16. Kaur H, Singh B, Sharma A. Assessment of blood glucose using gingival crevicular blood in diabetic and non-diabetic patients: a chair side method. *J Clin Diagn Res.* 2013;Dec;7(12):3066-9. PMID: 24551729 DOI: 10.7860/JCDDR/2013/7705.3854.
17. Preshaw PM, Bissett SM. Periodontitis and diabetes. *Br Dent J.* 2019;Oct;227(7):577-584. PMID: 31605062 DOI: 10.1038/s41415-019-0794-5.
18. Gurav AN. Management of diabolical diabetes mellitus and periodontitis nexus: Are we doing enough? *World J Diabetes.* 2016;Feb 25;7(4):50-66. PMID: 26962409 PMCID: PMC4766246 DOI: 10.4239/wjd.v7.i4.50.
19. Sibyl S, Bennadi D, Kshetrimayum N, Manjunath M. Correlations between gingival crevicular blood glucose and capillary blood glucose: A preliminary report. *J Lab Physicians.* 2017;Oct-Dec;9(4):260-263. PMID: 28966487 PMCID: PMC5607754 DOI: 10.4103/JLP.JLP_141_16.
20. Naumova VN, Mikhailchenko DV, Makedonova YA, Kolesova TV, Denisenko LN. Interdisciplinary collaboration: screening of systemic blood flow at a dental appointment. *Journal of International Dental and Medical Research.* 2020;13(1):216-222. https://pdfs.semanticscholar.org/12ee/50c64a252252a0f59cd97e3adaed5a1fa307.pdf?_ga=2.207055322.83463362.1594831863-195151298.1587919546.
21. Myers-Wright N, Lamster IB, Jasek JP, Chamany S. Evaluation of medical and dental visits in New York City: Opportunities to identify persons with and at risk for diabetes mellitus in dental settings. *Community Dent Oral Epidemiol.* 2018;Feb;46(1):102-108. PMID: 29023928 DOI: 10.1111/cdoe.12334.
22. Estrich CG, Araujo MWB, Lipman RD. Prediabetes and diabetes screening in dental care settings: NHANES 2013 to 2016. *JDR Clin Trans Res.* 2019;Jan;4(1):76-85. PMID: 30596147 PMCID: PMC6299263 DOI: 10.1177/2380084418798818.
23. Leung WK, Siu SC, Chu FC, Wong KW, Jin L, Sham AS, Tsang CS, Samaranyake LP. Oral health status of low-income, middle-aged to elderly Hong Kong Chinese with type 2 diabetes mellitus. *Oral Health Prev Dent.* 2008;6(2):105-18. PMID: 18637388 <https://pubmed.ncbi.nlm.nih.gov/18637388/>.
24. Grigoriadis A, Sorsa T, Räsänen I, Pärnänen P, Tervahartiala T, Sakellari prediabetes/diabetes can be screened at the dental office by a low-cost and fast chair-side/point-of-care aMMP-8 Immunotest. *D.Diagnostics (Basel).* 2019;Oct17;9(4):151. PMID: 31627410 PMCID: PMC6963402 DOI: 10.3390/diagnostics9040151.
25. Creanor S, Millward BA, Demaine A, Price L, Smith W, Brown N, Creanor SL. Patients' attitudes towards screening for diabetes and other medical conditions in the dental setting. *Br Dent J.* 2014;Jan;216(1):E2. PMID: 24413142 DOI: 10.1038/sj.bdj.2013.1247.
26. Lalla E, Cheng B, Kunzel C, Burkett S, Lamster IB. Dental Findings and Identification of Undiagnosed Hyperglycemia. *J Dent Res.* 2013 Oct;92(10):888-92. PMID: 23979781 DOI: 10.1177/0022034513502791.
27. Garton BJ, Ford PJ. Root caries and diabetes: risk assessing to improve oral and systemic health outcomes. *Aust Dent J.* 2012;Jun;57(2):114-22. PMID: 22624749 DOI: 10.1111/j.1834-7819.2012.01690.x.
28. Mydhili Mungara, Rajmohan, Prabu D, Sunayana Manipal, Selva Kumar C. Assessment and correlation of blood glucose levels using gingival crevicular blood, finger-capillary blood and venous blood samples in diabetic and non-diabetic patients. *International Journal of Current Research.* 2016.8(7):35214-35217. <https://www.journalcra.com/article/assessment-and-correlation-blood-glucose-levels-using-gingival-crevicular-blood-finger>.
29. Rosedale MT, Strauss SM. Diabetes screening at the periodontal visit: patient and provider experiences with two screening approaches. *Int J Dent Hyg.* 2012. 10(4):250-258. PMID: 22284167 PMCID: PMC3469730 DOI: 10.1111/j.1601-5037.2011.00542.x.
30. Su N, Teeuw WJ, Loos BG, Kosho MXF, van der Heijden GJMG. Development and validation of a screening model for diabetes mellitus in patients with periodontitis in dental settings. *Clin Oral Investig.* 2020;Jun 15. PMID: 32542584 DOI: 10.1007/s00784-020-03281-w.
31. Engstrom, S., Berne C., Svardsudd K. Effectiveness of screening for diabetes mellitus in dental health care. *Diabet Med.* 2013;30(2):239-245. DOI:10.1111/dme.12009.

60. Müller HP, Behbehani E. Screening of elevated glucose levels in gingival crevice blood using a novel, sensitive self-monitoring device. *Med Princ Pract.* 2004;Nov-Dec;13(6):361-5. PMID: 15467312 <http://dx.doi.org/10.1159/000080474>.
61. Debnath P, Govila V, Sharma M, Saini A, Pandey S. Glucometric assessment of gingival crevicular blood in diabetic and non-diabetic patients: a randomized clinical trial. *J Oral Biol Craniofac Res.* 2015; Jan-Apr;5(1):2-6. PMID: 25853040 PMCID: PMC4382503 DOI: 10.1016/j.jobcr.2014.12.004.
62. Glurich I, Bartkowiak B, Berg RL, Acharya A. Screening for dysglycaemia in dental primary care practice settings: systematic review of the evidence. *Int Dent J.* 2018;Dec;68(6):369-377. PMID: 29740815 DOI: 10.1111/idj.12405.
63. Rajesh KS, Irshana R, Arun Kumar MS, Hegde S. Effectiveness of glucometer in screening diabetes mellitus using gingival crevicular blood. *Contemp Clin Dent.* 2016;Apr-Jun;7(2):182-5. PMID: 27307664 PMCID: PMC4906860 DOI: 10.4103/0976-237X.183072.
64. Gaikwad S, Jadhav V, Gurav A, Shete AR, Dearda HM. Screening for diabetes mellitus using gingival crevicular blood with the help of a self-monitoring device. *J Periodontal Implant Sci.* 2013;Feb;43(1):37-40. PMID: 23508055 PMCID: PMC3596633 DOI: 10.5051/jpis.2013.43.1.37.
65. Gazal G. Management of an emergency tooth extraction in diabetic patients on the dental chair. *Saudi Dent J.* 2020;Jan;32(1):1-6. PMID: 31920272 PMCID: PMC6950840 DOI: 10.1016/j.sdentj.2019.07.004.
66. Sultan A, Warreth A, Fleming P, MacCarthy D. Does the dentist have a role in identifying patients with undiagnosed diabetes mellitus? *J Ir Dent Assoc.* 2014; Dec-2015 Jan; 60(6): 298-303. PMID: 25638930 <https://pubmed.ncbi.nlm.nih.gov/25638930/>.
67. Neidell M, Lamster IB, Shearer B. Cost-effectiveness of diabetes screening initiated through a dental visit. *Community Dent Oral Epidemiol.* 2017;Jun;45(3):275-280. PMID: 28145564 DOI: 10.1111/cdoe.12286.