Point-of-Care HbA1c Screening Predicts Diabetic Status of Dental Patients

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Abstract

Purpose: Mutual production of proinflammatory cytokines causes a deleterious cyclic relationship between uncontrolled diabetes and periodontal disease. The prevalence of diabetes is escalating out of control. Early detection of pre-diabetes and diabetes may respectively prevent or delay disease onset and eliminate or decrease complications. The dental office offers an opportune site for diabetes screening. This study investigated the ability to precisely screen previously unidentified dental patients for diabetes and pre-diabetes.

Methods: In this predictive correlational study, participants were chosen by convenience sampling, and were included based on self-proclaimed risk factors. A point-of-care (POC) fingerstick HbA1c screening identified participants for confirming venous HbA1c laboratory screenings. Kendall's tau analyzed the relationship between POC HbA1c results and classification as diabetic or pre-diabetic based on laboratory HbA1c results. Chi Square, Likelihood Ratio, Cramer's V and Lambda compared the expected and observed results.

Results: Of the 104 diabetes risk questionnaires completed, 75 participants were included in the POC screening. Of these, 34 (71% female and 29% male) had HbA1c levels at or above the American Diabetes Association's (ADA) recommended 5.7% cut-point for pre-diabetes. Three participants were less than age 44, 10 were 44 to 57, and 21 were over 57. Laboratory results categorized 6 participants as normoglycemic and 28 with HbA1c greater than or equal to 5.7%. Kendall's tau ($p=0.004$) determined POC results can predict diabetic or pre-diabetic laboratory group assignment. Pearson's chi-square ($p=0.004$), Likelihood ratio ($p=0.004$) and Cramer's V ($p<0.001$) concluded a relationship existed between group assignment based on POC HbA1c results and those of subsequent laboratory HbA1c results; Lambda ($p=0.145$) did not.

Conclusion: Within the limits of this study, it was established that a safe and minimally invasive dental chair-side POC HbA1c screening unveiled previously unidentified diabetic and pre-diabetic patients.

Keywords: diabetes mellitus type 2, periodontal diseases, diagnosis, diabetes complications, periodontal atrophy

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Introduction

Disease Prevalence

In 2010, the Centers for Disease Control and Prevention (CDC) reported that 25.6 million (11.3%) of all Americans aged 20 or older were diabetic or undiagnosed diabetic and 79 million were pre-diabetic.[1] A recently composed model based on U.S. Census projections, current diabetes and pre-diabetes prevalence, and predicted diabetes incidence calculates that the prevalence of diabetes in 2050 may be as high as 33% of the population.[2] Diabetes is a chronic disease with no cure. As the seventh leading cause of death in the U.S., a major cause of heart disease and stroke, and an estimated $174 billion annual cost, diabetes is one of the most deadly and costly diseases affecting Americans.[1]

Bio Mechanism of Diabetes

Diabetes is a disease characterized by an abnormal level of glucose in the blood.[3] This is caused by the lack of insulin production or an inability of the body to utilize insulin, also known as insulin resistance.[3] Ideally insulin, a hormone that is only produced in the pancreas, transports glucose from the bloodstream into muscles for energy production.[3]

Historical Perspective

As early as 1983, research involving the Pima Indians of Arizona determined the deleterious effect of diabetes mellitus on periodontal tissues.[4] By 1991, it was determined that not only were diabetics 3-times more likely to develop periodontal

disease, but that diabetes mellitus was a risk factor for periodontal disease independently of age and gender.[5] By the mid-1990s, studies had determined that the oral flora was the same for diabetics as non-diabetics, so research turned to biological mechanisms of host response.[6] First hypothesized in 1992, then confirmed by several studies between 1996 and 2010, proinflammatory cytokines as a result of periodontal infections were found to be positively correlated with hyperglycemia in diabetics.[7-16]

Today, after years of research, it is known that the relationship between diabetes and periodontal disease is bidirectional, affected by risk factors and promoted by a biochemical cascade of events (Figure 1).[3,7-16] Blood accumulations of advanced glycation end products (AGEs) in persons with prolonged hyperglycemia and of lipopolysaccharides (LPS) from the lyses of periodontal bacteria, stimulate macrophages to secrete the proinflammatory cytokines tumor necrosis factor-alpha (TNF-α), interleukin-1 (IL-1), and interleukin-6 (IL-6).[10] These cytokines lead to the destruction and retarded healing of periodontal tissues and to insulin resistance.[10] Either disease is less likely to be well controlled if the other one is not.

Purpose of Screening

Early detection of pre-diabetes or diabetes may slow or prevent the complications of diabetes, including periodontal disease.[17,18] National organizations and initiatives emphasize that infrequent screening limits diabetes prevention and treatment, while general population screenings have been shown to reduce the prevalence of diabetes and its adverse outcomes.[19-25] This relationship between screenings and diabetes demonstrates the need for an increase in screening strategies, approaches and locations. According to the Centers for Disease Control and Prevention (CDC), 61% of U.S. citizens aged 18 to 64 visited a dentist in 2010.[23] Using a predictive equation, dental patients who had never been diagnosed as diabetic, yet reported diabetic risk factors in the NHANES III study had a 27 to 63% chance of being diabetic.[26] Borrell's primary conclusion was that the dental office could be a prime location to identify diabetes.[26]

Screening Methods

In a comparison of diabetes diagnostic tests, the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) reports that diabetes is traditionally diagnosed by a fasting plasma glucose test (FPG), a random plasma glucose test (RPG) or an oral glucose tolerance test (OGTT).[27] All require a confirmation test at a later date.[20,27] The FPG and OGTT diagnose diabetes and pre-diabetes but require fasting.[28] The RPG test does not require fasting, but it is only diagnostic in symptomatic individuals.[27] The OGTT requires 2 measurements of plasma glucose levels, the first after a minimum 8 hour fast and immediately before ingestion of a liquid glucose solution, and the second measurement is taken 2 hours post-glucose ingestion.[27] It has been known as the gold standard even though it is less convenient than the FPG.[29]

Figure 1: Diabetes Risk Factors

- Impaired Glucose Metabolism
- Age over 45
- Family History of Diabetes
- Obesity
- Physical Inactivity
- Low HDL Cholesterol
- High Triglycerides
- High Blood Pressure
- Periodontal Disease
- History of Gestational Diabetes
- Race/Ethnicity
  - African American
  - Hispanic
  - American Indian
  - Pacific Islander
  - Asian Americans

Another diabetes diagnostic tool is glycosylated hemoglobin, commonly referred to as HbA1c, which is an irreversible complex which forms when glucose binds to the hemoglobin in red blood cells in an overabundance of glucose and an absence (or reduction) of insulin.[30] The concentration of HbA1c in the blood is a marker of glucose control over the previous 2 to 3 month period, which is the lifespan of the red blood cell. Point-of-care (POC) and laboratory HbA1c screenings do not require fasting and they are not affected by diet or exercise.[31]

Periodically, international diabetes experts appointed by the American Diabetes Association (ADA), the European Association for the Study of Diabetes and the International Diabetes Federation meet to make recommendations for the diagnosis and treatment of diabetes. The 1997 committee recommended against the use of the HbA1c assay for diabetes diagnosis based on a lack of instrument standardization and calibration techniques.[30] The 2003 committee conceded standardization, but upheld this recommendation based on other disadvantages.[30] The 2008 committee was the first to recommend the use of laboratory HbA1c to diagnose diabetes because it reliably captures the chronic glucose exposure, is a better biological marker for diabetes, relates well to the risk for vascular com-

plications, has superior stability over blood glucose assays and has several technical advantages over other diagnostic methods.[30]

Purpose of Study

This study investigated the ability to accurately screen previously unidentified dental patients for diabetes and pre-diabetes using a chair-side HbA1c screening method compared to a laboratory HbA1c screening method. The hypothesis tested was: A POC HbA1c screening will reliably identify dental clients who have self-proclaimed diabetes risk factors, as diabetic or pre-diabetic when compared to a laboratory HbA1c screening method.

Methods and Materials

Participants were chosen from a dental hygiene school (site #1) and a private practice (site #2) in this 2-armed, predictive correlational study. Protocol approval was obtained from the Eastern Washington University Institutional Review Board (IRB) for Human Subjects Research committee. The investigators were held to stringent ethics, procedures and confidentiality. The Washington State Department of Health Office of Laboratory Quality Assurance issued a medical test site certificate of waiver license for use of the POC HbA1c screening kit (A1CNow+®, Bayer Healthcare, LLC), because it is a Food and Drug Administration (FDA) waived test as determined by the Clinical Laboratory Improvement Act (CLIA) of 1988.

To achieve statistical significance, a power analysis determined that a minimum of 21 laboratory results were required for valid research. Consequently, a goal to obtain 30 participants with elevated POC HbA1c results was established. Based on this goal and results of previous self-proclaimed diabetes risk factor research,[32] it was expected that between 95 and 112 at-will participants would need to complete the diabetes risk questionnaire in order to obtain sufficient numbers of participants meeting inclusion criteria (Table I).

The diabetes risk questionnaire was developed by the researcher based on Heikes[32] validated diabetes risk algorithm and used with permission (Bowman, personal communication, August 2010). Participants were excluded from screening if they had previous positive blood glucose tests, hemoglobin traits or conditions that would potentially produce aberrant HbA1c results, insufficient diabetes risk, or factors that increase screening risk to the participant or the researcher (Figure 2).

A total of 75 participants met the inclusion criteria and subsequently signed an IRB approved informed consent. Age, gender and ethnicity data were collected

Table I: Comparison of Expected and Observed Sample Numbers

	Expected (Average)	Observed (% of expected)
Questionnaires completed	95 to 112 (103.5)	104 (100)
POC screenings	57 to 111 (84)	75 (89)
POC results ≥5.7%	30	34 (113)
Lab results ≥5.7%	30	28 (93)
Normoglycemic	0	6
Drop Out	0	0 (100)

Figure 2: Questionnaire Exclusion Criteria

1. Previous diagnosis of diabetes or pre-diabetes
2. Previous abnormal blood glucose tests
3. Abnormal hemoglobin traits
4. Rx use of corticosteroids
5. Age less than 44 years old with a waist size less than 38.4 inches
6. Between the ages of 44 and 57 with a waist size less than 38.4 inches and no first degree blood relatives with diabetes.
7. History of blood borne infections or blood disorders
8. Rx or OTC use of blood thinners including aspirin

Table II: ADA's HbA1c Recommended Cut Points

Status	% HbA1c
Normoglycemic	< 5.7
Pre-diabetes	5.7 - 6.4
Diabetes	> 6.4

to describe the sample and determine generalization of the research results in relationship to demographics published by the ADA. The participant's blood pressure was measured and recorded since elevated blood pressure is common in diabetics. With good laboratory practices and standard precautions, calibrated co-investigators obtained a fingerstick blood droplet using a single-use, sterile, retractable lancet (Figures 3A-3C). Trained in the proper storage, handling and technique for using the POC HbA1c screening kit, co-investigators acquired POC HbA1c results (Figure 4A-D) and made laboratory screening referrals for those with results at, or above, the ADA's recommended pre-diabetes cut point (Table II). POC and laboratory results were assigned to diabetic categories according to the ADA's

Figure 3A: POC Fingerstick Preparation

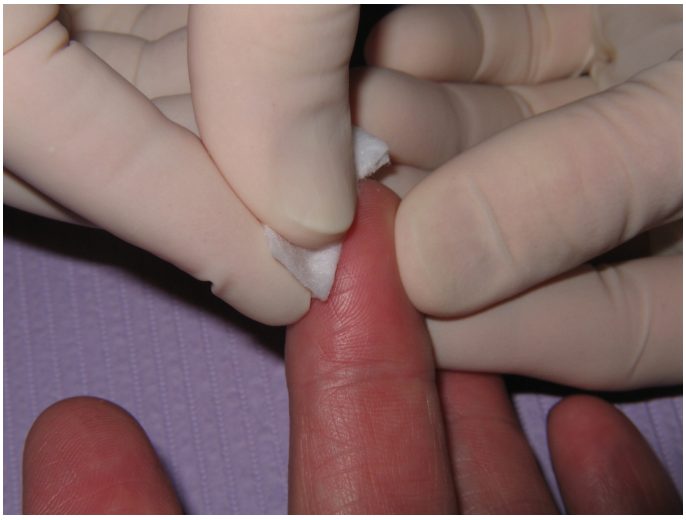


Figure 3B: Use of the Disposable, Sterile, Retractable Lancet

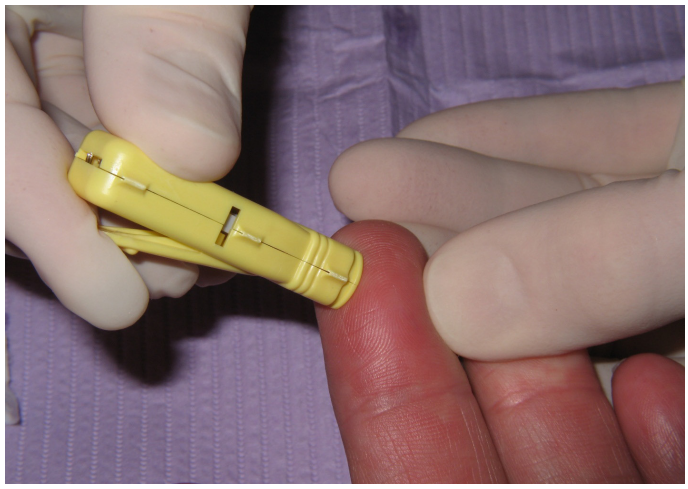
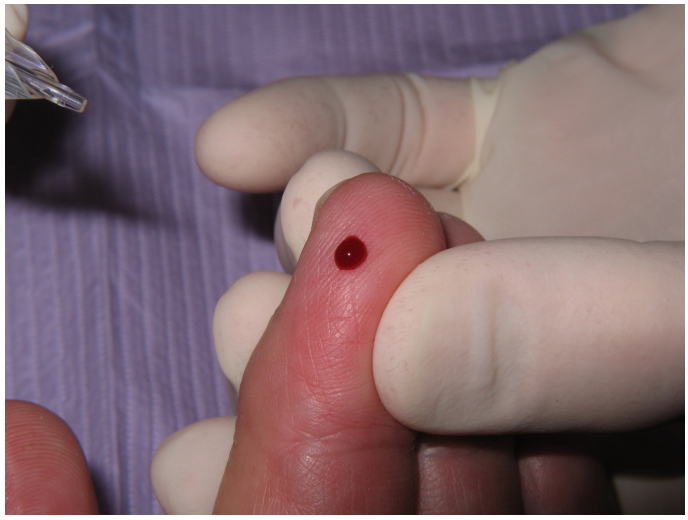


Figure 3C: Capillary Blood Droplet



standard of clinical care cut points (Table II). Laboratory results were delivered to participants concurrent with nutritional and diabetes educational counseling and referral to a licensed medical professional.

Two rounds of statistical tests were conducted in SPSS software (Version 19) following suggested guidelines.[33] In the first round, Kendall's tau, a nonparametric statistical test, evaluated whether the POC results could predict laboratory result group assignment, i.e. diabetes or pre-diabetes, because it measures the association between values of rank order and group membership when data is ranked and the results are not normally distributed. In the second round, 4 additional statistical tests evaluated the results for significance ($p \leq 0.05$). The Chi Square statistical tests measured the differences between the expected and observed laboratory groups - the Likelihood ratio compared the frequencies of expected and observed groups, Cramer's V measured the strength of association between the expected and the observed groups and Lambda measured the proportional reduction in error when one group predicts the other, i.e. POC diabetic category predicting the laboratory diabetic category.

Results

From the 104 diabetes risk questionnaires completed, 75 individuals were identified for inclusion in the study (Table III), who were predominately Caucasian, female, older than 57 years, having a waist size larger than 38.4 inches and weighing over 168 pounds. Few were shorter than 5 foot 3 inches and slightly less than one-third of the participants had diabetic first degree blood relatives. The POC screening better identified participants with more notable diabetes characteristics than the diabetes risk questionnaire (Table III). Study results mirrored national statistics for the percentage of diabetics by age group and for the blood pressure of diabetics.

As shown in Table I, laboratory screening results confirmed POC screening results for 28 of the 34 participants at or above the cut point between normal glycemic and pre-diabetic blood levels. Those participants were directed to seek medical evaluation and consultation. Researchers made up to 3 attempts to obtain details of medical follow-ups. Of referred participants, 82% responded to these attempts. One respondent with a laboratory result greater than 6.5% (the cut point between diabetes and pre-diabetes) and one with a laboratory result in the pre-diabetes category reported that the medical provider recommended lifestyle changes and a re-evaluation in 4 and 6 months, respectively. Another participant with laboratory results in the diabetic range was encouraged to make lifestyle changes and was prescribed Metformin, a drug that decreases the amount of glucose absorbed from food and increases the body's response to insulin.

Figure 4A: Filling the Blood Collector

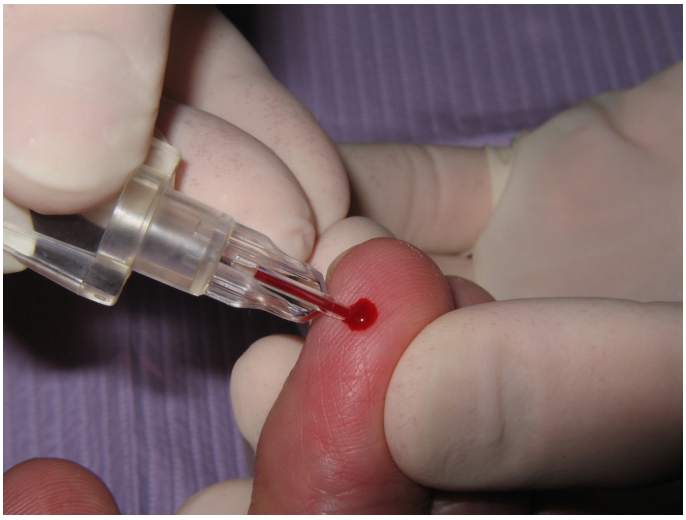


Figure 4B: Placing the Blood Collector into the Sampler Body

Figure 4D: POC Screening Result Digitally Displayed on the Test Monitor after 5 Undisturbed Minutes

Figure 4C: Transfer of the Blood Solution to the Test Cartridge in the Test Monitor

A total of 45% of respondents did not follow up with a medical provider. The remaining 45% were reassured by a medical provider that the laboratory results were of no consequence (Table IV).

Statistical analysis was completed with data combined from the 2 research sites because they were not found to be statistically different. Table V illustrates the abnormal distribution in the association between the POC ranked values and the laboratory result assignment into its respective diabetes category. In the first round of statistical analysis (Table VI), the result value (0.439) and significance ($p<0.05$) of Kendall's tau indicate that the POC HbA1c screening result prediction is statistically significant for the subsequent laboratory diabetes category assignment.

More POC results in the diabetic and pre-diabetic range were observed than expected, but fewer laboratory results in the diabetic and pre-diabetic range were observed than expected (Table I). In the second round of statistical analyses (Table VII), 3 of the 4 tests executed to analyze an association between the POC and the laboratory screening results demonstrated statistical significance: Chi Square ($p=0.004$), Likelihood ratio ($p=0.004$) and Cramer's V ($p<0.001$). Lambda ($p=0.145$) was the exception and did not show statistical significance. The study found that POC screening results could predict normal, pre-diabetic or diabetic group membership as confirmed by subsequent laboratory HbA1c screenings.

Discussion

Data from NHANES III public use files reveals that self-reported diabetes risk factors determines diabetes in 27 to 53% (40% average) of the cases.[26] Of the 75 at-will research participants who demonstrated sufficient self-reported risk factors, 28 (37%) were confirmed as diabetic or pre-di-

Table III: Percent of Questionnaire vs. POC Result Qualified Participants with Diabetes

	Questionnaire Qualified			POC Qualified		
	Total	Site #1	Site #2	Total	Site #1	Site #2
No. of Participants	75	33	42	34	16	18
% Male	28	18	36	29	12.5	44
% Female	69	76	64	71	87.5	56
% Unknown	3	6	-	-	-	-
% Caucasian	93	91	95	94	87.5	100
% Hispanic	4	3	5	3	6	-
% Native American	1	3	-	3	6	-
% African American	1	3	-	-	-	-
% <44 years	13	15	12	9	6	11
% 44 to 57 years	32	18	43	29	25	33
% >57 years	56	67	45	62	69	56
% Waist >38.4"	59	52	64	68	50	83
% Unknown waist	3	6	-	3	6	-
% Weight >168 lbs.	73	70	76	68	62.5	72
% Height <5'3"	15	12	17	26	19	33
% Increased Activity						
<1/month	9	9	10	12	6	17
1/month	7	9	5	9	12.5	6
2 to 3x/month	7	6	7	6	6	6
1 to 2x/week	21	18	24	29	25	33
3 to 4x/week	24	15	31	26	19	33
5 to 7x/week	16	9	21	3	-	6
No response	16	34	2	-	-	-
% Family History DM	31	30	31	35	25	44

Table IV: Follow-Up Results

				Physician's Recommendation		
Lab Results	Number of Participants	No Response	No Follow–Up	Rx & Lifestyle Modification	Lifestyle Modification and 4 to 6 month Evaluation	No Concern
Site #1 5.7 to 6.4	12	1	3	-	-	8
Site #1 >6.4	-	-	-	-	-	-
Site5#2 5.7 to 6.4	14	5	7	-	-	2
Site #2 >6.4	2	-	-	1	1	-
Total 5.7 to 6.4	26	6	10	-	-	10
Total >6.4	2	-	-	1	1	-

abetic by POC screening followed by subsequent laboratory screenings.

Inclusion criteria involved age, weight, height, waist size, ethnicity and family history. To improve the sample, the inclusion criteria could have been significantly tightened to contain only those at or over 45 years of age, especially if body mass index (BMI) was equal to or greater than 25 kg/m and/or either treated or untreated sustained blood pressure was greater than 135/80 mm Hg.[21] BMI and weight gain are good inclusion criteria - according to Mokdad, they are major risk factors with an unfortunate prolonged delay between them and the onset of diabetes.[34] Including socioeconomic status would have been advantageous since Link et

al found that it may be more indicative of undiagnosed diabetes than ethnicity.[35]

Exclusion criteria included previous diabetes or pre-diabetes diagnosis, pregnancy, abnormal hemoglobin traits, history of blood-borne infections, use of corticosteroids, or over-the-counter (OTC) or prescription blood thinners, such as aspirin or Coumadin, respectively. Staying true to exclusion criteria utilized in previous research, such as only previous diabetes or pre-diabetes diagnosis, pregnancy or abnormal hemoglobin traits, would also improve the sample.[17,21,25,26] To the knowledge of the researchers, no other research excluded participants with a history of blood-borne infections or the use of blood thinners. The IRB required these exclusions. The researchers assume that the exclusion of those with a history of blood-borne infections was to protect research participants and researchers from cross contamination. According to the CDC's 2011 Diabetes Fact Sheet, in 2004 heart disease and stroke were respectively listed on 68% and 16% of diabetes-related death certificates of those age 65 and older,[1] and blood thinners are frequently recommended for a history of vascular disease, which is often concurrent with diabetes.[36,37] An assumption could be drawn that there exists a likelihood that undiagnosed diabetic and pre-diabetic individuals may be self-medicating with OTC blood thinners or may be taking a prescription blood thinner for vascular disease under the direction of a physician. Excluding these individuals from screening decreases the sample size, therefore decreasing the power of the study and, furthermore, allows for the possibility of not identifying previously undiagnosed diabetes and pre-diabetes.

Using the HbA1c assay for diabetes status has limitations including conditions that reduce the red blood cell turnover rate like hemolytic anemia, chronic malaria, major blood loss and blood transfusions, all of which give false results, or abnormal hemoglobin traits (i.e., sickle cell anemia) that interfere with some HbA1c assay methods.[30] Because the POC kit used in this study had been shown to be 99.3% accurate,[38] it was anticipated that the same number of participants would be categorized as pre-diabetic and diabetic from both the POC and laboratory assays; however, in this study only 28 of the 34 (82.4%) positive POC results were confirmed by laboratory results. One explanation might be that the kit used in this study was standardized to the Diabetes Control and Complications Trial (DCCT) assay in a National Glycohemoglobin Standardization Program (NGSP) certified laboratory[39] and the laboratory processing the confirming screenings was not.

Table V: Cross Tabulation of POC and Laboratory Results

Count	Lab HbA1c			Totals
	<5.7%	5.7 to 6.4%	>6.4%	
POC HbA1c				
5.6	0	1	0	1
5.7	4	4	0	8
5.8	1	3	0	4
5.9	0	8	0	8
6.0	1	3	0	4
6.1	0	2	0	2
6.2	0	2	0	2
6.3	0	0	0	0
6.4	0	1	0	1
6.5	0	2	0	2
6.6	0	0	0	0
6.7	0	0	1	1
6.8	0	0	0	0
6.9	0	0	1	1
Total	6	26	2	34

Table VI: Round 1 Statistical Analysis

	Value	Std. Error	CV	p–Value
Kendall tau	0.439	0.120	2.842	0.004
Number of valid cases	34	-	-	-

National statistics indicate that 67% of diabetics, as defined with laboratory screening results of HbA1c of 6.4% or greater, have blood pressure equal to or greater than 140/90 or are taking hypertensive medications.[40] Similarly, 2 participants in this study having laboratory screening results of 6.4% or greater had systolic measurements of 130 or more, while only 1 had diastolic measurements greater than 80. The participant with elevated systolic and diastolic blood pressure was also taking hypertensive medication.

The prevalence of diagnosed and undiagnosed diabetes is low until age 40, when it increases to 10.8%, through age 59, and is 23.1% in those aged 60 and older.[1] That is a ratio of 2.14 diabetics over the age of 59 for every one between the ages of 40 and 59. Of the 34 participants identified as diabetic or pre-diabetic in this study, 3 were less than age 44, 10 were aged 44 to 57, and 21 were over the age of 57. This study identified a ratio of 2.11 diabetic and pre-diabetic participants over the age of 57 for every one between the ages of 44 and 57. While this study's age categories were different than those of the national statistics, the ratio of diabetics in the highest age range compared to those in the mid-range of ages was very similar.

Table VII: Round 2 Statistical Analysis

	Value	DF	Std. Error	CV	p–Value
Number of valid cases	34	-	-	-	-
Chi Square	34.253	4	-	-	0.004
Likelihood Ratio	15.635	4	-	-	0.004
Cramer's V	0.710	-	-	-	<0.001
Lambda Average POC HbA1c dependent Lab HbA1c dependent	 0.364 0.667 0.250	-	 0.186 0.272 0.153	 1.458 1.458 1.458	 0.145 0.145 0.145

Table VIII: Population Statistics: Percentages of Ethnicities at Greatest Risk of Diabetes

	U.S. Census Bureau	County Census Site #1	County Census Site #2	Site #1 Study Results	Site #2 Study Results
Non-Hispanic Black	12.32	1.7	1.1	0.03	-
Hispanic/Latino American	12.55	4.5	38.3	0.03	0.05
Asian Americans	3.64	2.1	0.9	-	-
Pacific Islanders	0.14	0.4	0.1	-	-
American Indian/Alaska Native	0.88	1.5	1.2	0.03	-

This study agreed with Ealovega et al that an increase in opportune screening does not improve the rate of preventive and therapeutic diabetic treatments; although, the reason in each study had vast differences.[41] Ealovega et al found physicians are unlikely to follow up with a person who has abnormal results whereas this study discovered that either patients did not seek early medical intervention or most physicians did not uphold the ADA's recently revised diabetes cut points as listed in (Table II).[41]

This study addresses the Healthy People 2020 diabetes objective D-15: Increase the proportion of persons with diabetes whose condition has been diagnosed.[22] It also fosters a collaborative foundation among health care providers as suggested by Jahn who stressed the importance of diabetes-sensitive quality care of dental patients by way of collaboration with other dental and medical providers.[42] Jahn also feels this collaboration may lead to an improved understanding of the perio-systemic relationship - as indicated in the Institute of Medicine's report: Health Professions Education: A Bridge to Quality, collaboration brings out the strengths of each discipline.[43]

This study paves the way for additional research to evaluate time and cost effectiveness, sources of remuneration for screening services, and surveys of patients and physicians to assess desire and appreciation of diabetes screening in the dental office. Replicating this study with a larger sample size and/or a more culturally diverse sample would increase the ability to generalize the results to the entire population (Table VIII). Using periodontal disease indicators and more standard inclusion and exclusion criteria, in addition to a POC HbA1c screening as in a study by Lalla et al would improve the percentage of correctly identified dental patients with pre-diabetes and diabetes.[44]

As early as 1999, the Agency for Healthcare Research and Quality (AHRQ) began investing in strategies to improve the translation of research findings into clinical practice grounded on the fact that it takes up to 2 decades for research to become the everyday norm.[45] Translation of research into dental practice may be a limitation of this study if responses are similar to those given by dentists surveyed by Kunzel et al, who not only lacked knowledge but also lacked desire, responsibility or confidence to change practice and address diabetes in the dental office.[46] If this research is translated into dental practices, a limitation may result from individuals not pursuing follow-up care or physicians not translating the most current ADA standards of medical care in diabetes into their practices.[20]

The practical implication of this research is that it answers a call to action by increasing screening strategies, approaches and locations and, in turn, decreases the prevalence of diabetes and its adverse outcomes.[41] Phillips et al stated "diabetes prevention and care are limited by lack of screen-

ing."[25] The screening in this study, if adopted universally, could lead to early detection of pre-diabetes or diabetes and consequently slow or prevent the complications of diabetes.[17,18] Theoretically, this study implies that any office, in any location, with any population could include diabetes screening in their daily routines.

Conclusion

The POC diabetes screening used in this study is quick, easy and welcomed by dental patients. Because diabetes is a risk to the oral and systemic health of an individual, the Standards for Clinical Dental Hygiene Practice recommends the evaluation of diabetes in the systematic collection, analysis and documentation of patient assessments.[47]

The purpose of screening in the dental office is not to diagnose diabetes, but to refer for medical diagnoses and treatment to improve systemic and oral outcomes.[48] Medical and dental professionals are challenged to stay abreast of the ever changing flood of evidence in the literature regarding the severity of diabetes and the bidirectional relationship between diabetes and periodontal disease. Medical-dental education and collaborations for improved systemic and oral health of the population can be fostered via diabetes screening in the dental office.

Susan D. Franck, RDH, MS was a graduate student in the Master of Science in Dental Hygiene degree program at Eastern Washington University (EWU) at the time of the study. Rebecca L. Stolberg, RDH, MS, is the EWU Dental Hygiene Department Chair, Bachelor's and Master's degree director and clinical instructor. Lisa A. Bilich, RDH, MEd, is an assistant professor and 2nd year clinic lead in the Department of Dental Hygiene at EWU. Laurie E. Payne, MS, RD, CDE, BC-ADM, is a Diabetes Educator for INHS Community Wellness, a division of Inland Northwest Health Services (INHS).

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