# *Patient Awareness of Association of Diabetes and Periodontal Disease*

Neel Shimpi, BDS, MM, PhD[1]
Ingrid Glurich, PhD[1]
Dixie Schroeder, MBA[1]
Callahan Katrak, BA[1]
Po-Huang Chyou, PhD[1]
Amit Acharya, BDS, MS, PhD[1]

*This cross-sectional study sought to assess the current awareness, knowledge, and behavior regarding diabetes mellitus (DM) and periodontal disease (PD) association among a convenience sample of patients from a large Wisconsin-based integrated medical-dental health care organization serving largely rurally based communities. An anonymous 10-question survey was distributed at regional medical and dental centers of dental and medical clinics of a single health care institution over a 4-week period, to achieve a cross-sectional sampling of patients aged 18 to 80 years. Among 946 respondents, 616 were female. Patient-reported periodicity for dental visits was highest between 6 months and 1 year (56.4%). Respondents reporting "poor-fair" knowledgeability surrounding DM–PD association correlated with highest interest in learning more about DM–PD relationship (p <.0001). While over 80% of respondents correctly answered questions about gum disease symptomology and contribution of oral health practices on diabetes prevention, only 51% knew that PD affected blood sugar control. Willingness to comply with medical screening conducted by dental providers for diseases affecting oral health was indicated by 44% of respondents (p < .0001). Study results indicated that knowledgeability levels among patients surrounding the effect of PD on DM needed improvement. Strategic educational interventions targeting improved health literacy among patients may further promote prevention of DM–PD complications. Health literacy gaps remain to be addressed in patient understanding of the importance of detecting and managing dysglycemia for maintenance of periodontal health, creating opportunities for patient education.*

**Keywords:** *health literacy; health promotion; oral health; patient education; surveys; quantitative evaluation; rural health*

## INTRODUCTION

Periodontal disease (PD) and diabetes mellitus (DM) are two chronic conditions that have achieved epidemic proportions globally (NCD Risk Factor Collaboration,

[1]*Marshfield Clinic Research Institute, Marshfield, WI, USA*

***Authors' Note:*** *The authors thank Yvonne Cerne from Center for Oral and Systemic Health (COSH) at Marshfield Clinic Research Institute (MCRI) for her assistance with formatting the survey tool. The authors would like to also thank Aloksagar Panny from Center for Oral and Systemic Health, MCRI, for his assistance with preparation of the data sets for analysis. None of the authors have any direct or indirect financial incentives associated with the conduct of the study or publication of study findings. None of the authors have any personal relationship with other people or organizations that could inappropriately influence/bias their work. This study was funded by Delta Dental of Wisconsin, Marshfield Clinic Research Institute, and Family Health Center of Marshfield, Inc. Address correspondence to Amit Acharya, Executive Director, Center for Oral and Systemic Health, Marshfield Clinic Research Institute, 1000 North Oak Avenue, Marshfield, WI 54449, USA; e-mail: acharya.amit@marshfieldresearch.org.*

**Health Promotion Practice**
May 2020 Vol. 21, No. (3) 464–472
DOI: 10.1177/1524839918801909

2016). Prevalence of PD is reported to affect one third of the U.S. population with prevalence rising as high as 65% in disparity populations (Eke et al., 2015). DM affects approximately 415 million people worldwide with prevalence expected to achieve 642 million by 2040 (Ogurtsova et al., 2017). PD has been implicated in contributing to DM progression and associated complications (Borgnakke, Ylostalo, Taylor, & Genco, 2013; Casanova, Hughes, & Preshaw, 2014; Corbella, Francetti, Taschieri, De Siena, & Fabbro, 2013; Genco & Genco, 2014; Wang, Jen, Chou, & Lei, 2014). Patient awareness surrounding bidirectional associations between DM and PD is important to actively engage them in preventive health practices involving risk factor modification by adopting effective oral health-related and self-management of chronic and other conditions affecting their health status (Albert et al., 2012).

Lack of patient health literacy can be a hidden barrier to care because it may prevent patient engagement and result in negative health-related outcomes (Caruso et al., 2018; Egbert & Nanna, 1996; Martin, Williams, Haskard, & Dimatteo, 2005). Poorer health outcomes documented in association with insufficient health literacy include higher hospitalization rates, increased health care costs, and reduction in quality of life consequential to chronic disease progression (MacLeod et al., 2017). Especially in patients with chronic illnesses, such as DM and PD, oral-systemic health literacy is important for optimal management of the diseases, because the patient must proactively and effectively engage in daily self-care including oral health care (U.S. Department of Health and Human Services Oral Health Coordinating Committee, 2016). According to the Centers for Disease Control and Prevention report of 2014, 27.8% of the U.S. population has undiagnosed diabetes (Centers for Disease Control and Prevention, 2017). Nasseh, Greenberg, Vujicic, and Glick (2014) projected that the effect of chairside screening for chronic conditions such as DM, hypertension, and hypercholesterolemia in dental offices could result in annual cost savings to health care systems of $42 million to $102.6 million (Nasseh, Greenberg, Vujicic, & Glick, 2014). Integrated interdisciplinary care models involving multidisciplinary approaches and patient's feedback are critical for effective patient-centered care delivery (Acharya, Shimpi, Mahnke, Mathias & Ye, 2017; Shimpi, Schroeder, Kilsdonk, Chyou, Glurich, & Acharya, 2016; Shimpi, Schroeder, Kilsdonk, Chyou, Glurich, Penniman, et al., 2016).

Few studies have examined patient understanding of the potential impact of PD on DM. The current study undertook assessment of patient knowledge surrounding relevance of periodontal health to effective glycemic management by conducting a survey study in a convenience sample of patients of a health care organization with a regional network of medical and dental clinic within a service area serving rural communities in central and northern Wisconsin. The environmental scan of this population was undertaken to assess whether lack of oral-systemic health literacy surrounding the DM–PD relationship represents a potential gap to address especially among subpopulations at higher risk for DM and other chronic conditions that may be affected by poor oral health.

Study results would inform the need for development of appropriate educational materials and identification of most appropriate venues to target the intended audience in order to achieve proactive literacy promotion. Knowledge of patient literacy levels would also guide provider-to-patient interaction and present opportunities for implementing appropriate educational initiatives.

## METHOD

A cross-sectional study design was applied that targeted a convenience sample. Self-administered surveys were distributed to patients presenting to the front desk staff for appointments in 13 regional primary care medical center and 10 regional dental center waiting rooms of Marshfield Clinic Health System (MCHS) in central and northern Wisconsin over a 4-week period in December 2015, January and April 2016, and for 2 weeks in July 2017. The demographic of respondents included patients of the health care system, largely residing within the service area of the health care system. MCHS is one of the largest multispecialty group practices in the country with more than 700 physicians, 40+ dental providers, and 7,600+ employees who are involved in patient care, research, and medical education. There are more than 52 medical centers throughout the MCHS service area. Family Health Center of Marshfield. Inc, a federally qualified health center that serves low-income, underinsured, and uninsured people, partners with MCHS in provision of integrated dental care delivery to more than 55,000 unique dental patients through its 10 regional dental centers. All patients between 18 and 80 years of age presenting to the front desk staff for appointments were approached for completing the survey and hence the survey targeted a convenience sample not driven by a defined sample size. Because the study was conducted as an anonymous survey, it was granted exemption status from oversight under the section 45 CFR 46.101(b)(2) as determined by the Marshfield Clinic Research Institute Institutional Review Board.

A paper-based questionnaire in the English language comprising 10 questions analyzing awareness of the

DM–PD association was developed at a fifth-grade reading level. The goal of the study was to use the survey instrument to capture relevant demographics, awareness of diabetes and gum disease association, opinions on chairside screening by the dental providers, and periodicity with respect to dental visits. Demographic questions included respondents' age range, gender, and educational level. No health-related data were solicited surrounding PD or DM status. Patients were asked to indicate timing of their most recent dental visit to capture dental care–seeking behavior. Knowledgeability/awareness assessment was tested by four questions related to diabetes and periodontal disease. Attitude-related questions captured opinions on willingness to have dental providers conduct medical screening for diseases that may affect oral health, such as diabetes and high blood pressure. Responses to awareness and opinion questions were formatted with yes/no/not sure options. Evaluation of content and face validity was performed by four experts in from the fields of dentistry, medicine, and statistics prior to dissemination. The survey tool was piloted by 20 patients randomly selected for readability and time required for completion of the questionnaire before disseminating to the study population. Time for completion was estimated at 3 to 5 minutes.

Completed surveys were collected and placed in envelop by the front desk staff and routed/mailed to the research team at the end of the survey administration period. Survey responses were entered into a REDCap database and included no patient identifiers (Harris et al., 2009). Only unique checked answers by the respondents to the multiple-choice questions were included in analyses. For example, if the patient checked more than one option for a question, the response was not included in the analysis. Interrater reliability was calculated and reported based on percentage agreement for 10% of data entered into the REDCap database.

Descriptive statistics were used to summarize the data. Chi-square test was performed to compare the difference in responses (percentages) based on the respondents' age (stratified into three tiers: 18-40, 41-60, and 61-80 years), gender, educational level (stratified into three tiers: Grades 9-11 or lower [EduLevel1], high school/associate degree [EduLevel2], and bachelor's and higher [EduLevel3]), and the rate of respondents' understanding of relationship between diabetes and gum disease (stratified into three categories: poor/fair, good, and very good/excellent). All data analyses were carried out using SAS Version 9.4, English. A $p$ value $<.05$ was used to claim existence of a significant association between the variables.

## RESULTS

The data were entered and accuracy was confirmed.

### *Participant Demographics*

A total of 946 patients completed the survey. Interrater reliability of entry of 10% of data into the REDCap was 98.98%. Figure 1 shows the characteristics of participants who responded to the survey.

Majority of the respondents [75.1% (709/944)] reported an EduLevel2 (high school/associate degree), while 15.5% (146/944) reported EduLevel3 (⩾BA degree) and 9.4% (89/944) reported EduLevel1 (⩽Grades 9-11). Proportionately more respondents between 18 and 40 years old reported EduLevel2 (high school/associate degree), compared with respondents in the older age tiers. By contrast, a higher percentage of respondents in the 61 to 80 years tier possessed an EduLevel3 (⩾BA degree) compared with respondents among the younger age tiers. While a greater percentage of females reported EduLevel2 as compared to males (80% vs. 67%, respectively,) a slightly higher percentage of males reported EduLevel3 compared to females (20% vs. 13%, respectively), and EduLevel1 (13% of males vs. 7% of females). Differences by gender across the three EduLevel tiers were statistically significant ($p < .0001$).

### *Dental Visit Behavior Question*

Approximately 76% of respondents reported periodicity of their last dental visit to be 1 year or less, with moderately higher attendance among females 58% versus males 53% indicating ⩽6 months and 21% of females versus 18% of males indicating a visit in the past 7 months through 1 year ($p < .0634$). Figure 2 summarizes the duration assigned by the respondents when asked about the last dental visit stratified with respect to age.

Respondents attending dental visits in the past 6 months favored an older demographic with 63% who reported this periodicity aligned with the 61 to 80 years age tier.

### *Knowledgeability/Awareness*

The percentage distribution of responses by the patients regarding the question: "How would you rate your understanding of the relationship between diabetes and gum disease" (Survey Q8) was 20% (186/936) "poor," 32% (297/936) "fair," 28% (265/936) "good," 14% (129/936) "very good," and 6% (59/936) "excellent." Approximately half of the respondents (51%)

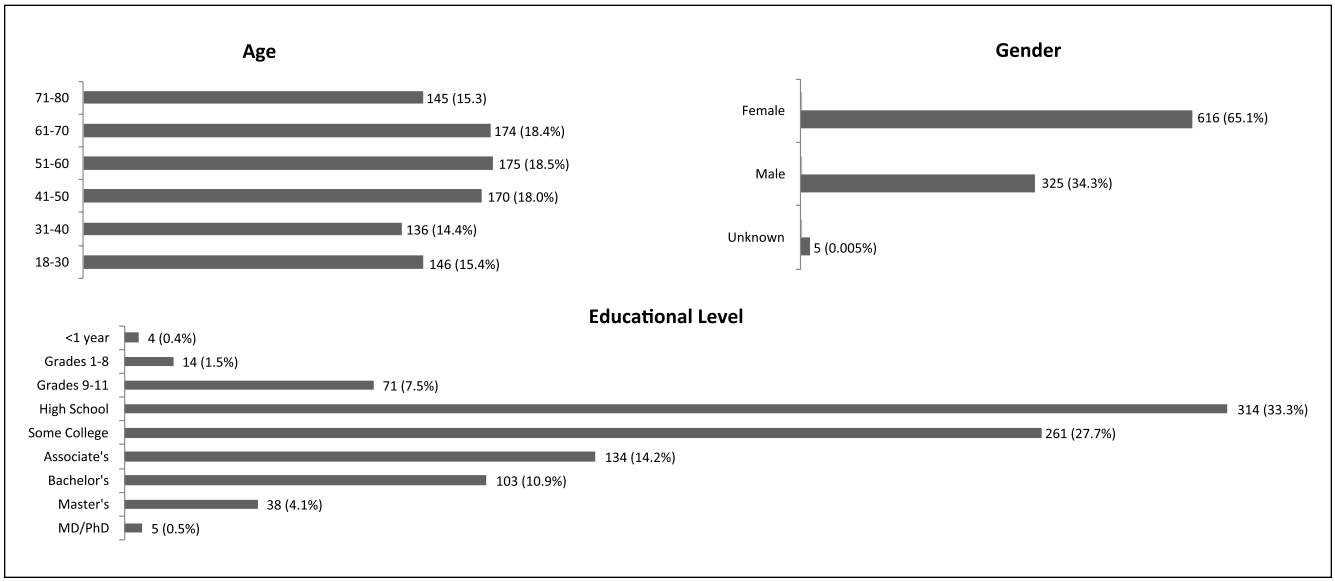


**FIGURE 1 Characteristics of Participants Who Responded to the Survey**

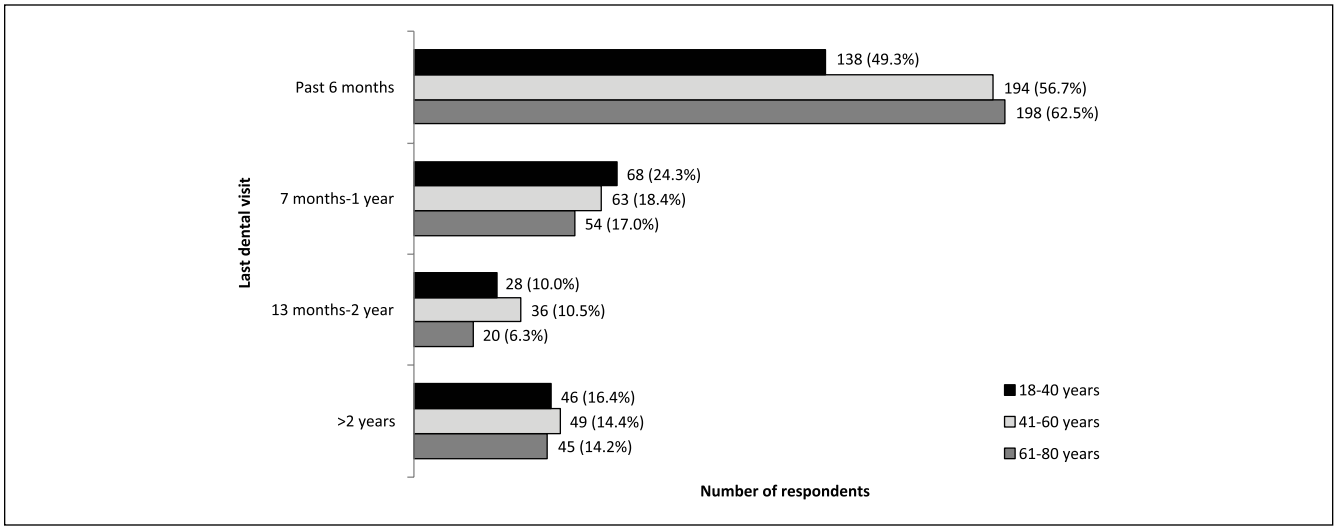


**FIGURE 2 Summary of the Duration Assigned by the Respondents When Asked About the Last Dental Visit Stratified With Respect to Age**

were aware that gum disease could increase blood sugar levels (Survey Q5), with recognition of this relationship directly correlated with advancing age 48% among Age Tier 1 (<40 years), 47% in Age Tier 2 (41-60 years), and 59% among Age Tier 3 (61-80 years; $p = .0016$). Warning signs of gum disease (Survey Q6) were correctly selected by 88% (804/913) of the respondents. Knowledge surrounding warning signs of gum disease paralleled educational level with approximately 95% (132/139) of EduLevel3 (≥BA degree) correctly selecting symptomology (swollen gums, gum recession, and loose teeth) compared to 89% (611/689) reporting EduLevel2 (high school/associate degree) and 73% (61/84) reporting EduLevel1 (≤Grades 9-11; $p < .0001$). Frequency of patients with a dental visit in the past 6 months corresponded to EduLevel1 (≤Grades 9-11) = 41% (36/88), EduLevel2 (high school/associate degree) = 56% (396/704), and EduLevel3 (≥BA degree) = 67% (97/145).

Similarly, lower EduLevel was associated with those reporting that their most recent dental visit was >2 years earlier: EduLevel1 (≤Grades 9-11) = 26% (23/88), EduLevel2 (high school/associate degree) = 14% (101/704), and 11% (16/145; $p = .0018$). Interventions, including oral health interventions, that could prevent or delay DM progression (Survey Q7) were correctly answered by 85% (782/922) of respondents. Respondents who reported their knowledge as "very good/excellent" (91.4% [170/186]) or "good" (88.6% [232/262]) surrounding the PD and DM association (Survey Q8) correctly selected proactive oral hygiene measures that support DM prevention with a higher frequency compared to patients who reported poor/fair knowledge (80.1% [375/468]; $p = .0133$). Female respondents also ranked their knowledge surrounding proactive oral hygiene measures that support DM prevention more highly than male participants (88% vs. 79%, respectively). Table 1 shows the distribution of self-reported information surrounding warning signs of gum disease and relative understanding of oral health interventions that promote prevention of DM. Eighty-eight percent correctly selected symptomology associated with gum disease (Survey Q6) and 85% correctly identified oral hygiene practices that support prevention of DM onset or progression, including regular dental visits. However, only 21% of study participants reported "very good, or excellent" knowledgeability surrounding the relationship between DM and PD (Survey Q8).

### *Opinions*

Approximately 38% (351/936) of respondents indicated interest in acquiring more information about the relationship between DM and PD (Survey Q9; $p < .0001$). Male respondents (42%) more frequently indicated an interest in learning more about the relationship between diabetes and oral health than female respondents (35%; $p = .0295$). Interest in learning more about the DM–PD relationship also correlated with increasing age with 29% of respondents in Age Tier 1 (18-40 years), 39% of respondents in Age Tier 2 (41-60 years), and 44% of respondents in Age Tier 3 (61-80 years), responding affirmatively to this question ($p < .0006$).

Table 2 illustrates the willingness reported by respondents to increase knowledgeability surrounding DM–PD association, stratified by age and educational level. Willingness to have dental provider conduct medical screening (Survey Q10) was directly proportional to the extent of knowledgeability level self-reported by respondents.

## DISCUSSION

The present study evaluated awareness of patients toward associations between PD and DM. Collectively, the data suggested that while patients had good understanding of gum disease and preventive measures, lower rates of knowledgeability surrounding PD and DM across the surveyed population were evident. The percentage of respondents attending a dental visit in the past 6 months correlated directly with increasing EduLevels. Similarly, respondents with no dental visit for more than 2 years also paralleled EduLevels with highest levels reported for EduLevel1 and lowest in EduLevel3. Differences in dental visit frequency across EduLevels achieved statistical significance ($p = .0018$). Overall, 43.6% (409/939) reported a dental visit more than 6 months. These rates are slightly lower than those reported in a recent study by Naghibi Sistani, Virtanen, Yazdani, and Murtomaa (2017), which reported a rate of 63.2%. The findings of their study also showed that oral health literacy was lower in patients with infrequent dental visits (Naghibi Sistani et al., 2017).

Respondents who self-reported their knowledge surrounding the question "How would you rate your understanding of the relationship between diabetes and gum disease?" (Survey Q8) as poor/fair were more interested in learning about the relationship as compared to respondents who rated their knowledge as good or very good/excellent ($p < .0001$), and males were more likely to indicate interest than females. The current study also noted a trend indicating that understanding the relationship between diabetes and gum disease (Survey Q8) was higher among older respondents compared to those in younger age tiers. The investigators posit that since rates of DM emergence increase with age, relatively older populations are more likely to have gained heightened awareness about the potential relationships between DM and PD during health care encounters if symptomologies of dysglycemia or PD emerged. However, the current study did not solicit information regarding DM or PD status from participants, and this would need to be examined in future initiatives.

In the present study, the rate of respondents who were positively disposed to dental providers conducting medical screening that included diabetes and high blood pressure as examples (Survey Q10) was approximately 44% across all tiers irrespective of the level of knowledgeability surrounding the DM–PD association reported by participants. Results suggest that despite the relatively high levels of literacy surrounding DM and PD association ascertained by survey analysis,

**TABLE 1**
**Distribution of Self-Reported Information Surrounding Warning Signs of Gum Disease (PD) and Steps to Prevent DM With Respect to Understanding of PD–DM Association**

| | *Self-Reported Knowledgeability Surrounding Gum Disease and Diabetes* | | | |
|---|---|---|---|---|
| *Options* | *Poor/Fair,* N = *458* | *Good,* N = *262* | *Very Good/ Excellent,* N = *186* | p |
| Warning signs of gum disease | | | | |
| Red, swollen, and bleeding gums | 7.9% (36/458) | 6.9% (18/262) | 6.5% (12/186) | .8534 |
| Gums are pulled away from the teeth | 0.9% (4/458) | 0.4% (1/262) | 1.1% (2/186) | |
| Loose teeth and/or change in bite | 0.2% (1/458) | 0.8% (2/262) | 0.5% (1/186) | |
| All the above | 87.3% (400/458) | 89.7% (235/262) | 87.6% (163/186) | |
| None of the above | 3.7% (17/458) | 2.3% (6/262) | 4.3% (8/186) | |
| | N = *468* | N = *262* | N = *186* | |
| Steps to prevent DM | | | | |
| Learn what to eat to keep your blood glucose levels under control | 14.5% (68/468) | 9.2% (24/262) | 6.5% (12/186) | .0133 |
| Brush and floss your teeth every day | 1.3% (6/468) | 1.2% (3/262) | 0.5% (1/186) | |
| Visit your dentist at least once in 6 months | 1.5% (7/468) | 0.8% (2/262) | 0.5% (1/186) | |
| All the above | 80.1% (375/468) | 88.6% (232/262) | 91.4% (170/186) | |
| None of the above | 2.6% (12/468) | 0.4% (1/262) | 1.1% (2/186) | |

NOTE: DM = diabetes mellitus; PD = periodontal disease.

over half of respondents do not perceive a value in integrated oral-medical care delivery to patients at risk for diabetes. By contrast, Rosedale and Strauss (2012), who conducted a survey on willingness among dental patients ($n$ = 120) to undergo glycemic screening that included the HbA1C testing approach and gingival crevicular blood collection in a dental setting, reported that 90% of patients in their study were open to medical screening in a dental setting. While patients in their study found the concept novel, most also opined that such screening should remain the patient's choice.

Compared to a similar survey study conducted by Bahammam (2015) that gauged awareness of the capacity for PD to adversely affect blood sugar level control among Saudi respondents with diabetes, the current study found higher levels of knowledge across the comparable age groups (46% vs. 22%, respectively). However, Bahammam also observed the association between higher educational level and higher level of awareness of diabetes and PD association.

Effective patient education requires a combined approach involving input from both health care providers and patients in preparing effective educational resources and programs. Notably, some studies have shown that health care providers, including both dental and medical providers who perform oral examinations, were more likely to advise their patients about oral and systemic disease conditions (Manski, Hoffmann, & Rowthorn, 2015). In prior studies, we similarly found that patients who visited dental clinics regularly had high rates of knowledgeability surrounding the DM–PD association potentially attributable to patient education provided by the health care providers during health care encounters (Shimpi, Schroeder, Kilsdonk, Chyou, Glurich, & Acharya, 2016; Shimpi, Schroeder, Kilsdonk, Chyou, Glurich, Penniman, et al., 2016).

Based on U.S. Department of Agriculture Rural Health Research Center rural-urban commuting area codes designation (http://depts.washington.edu/uwruca/), the participants in this study were surveyed in rurally based health care institutions. A study by Zahnd, Scaife, and Francis (2009) reported relatively comparable health literacy rates between rural and urban populations, with 14.3% and 13.7% below basic literacy rates, respectively. These rates reflected the 14% rate reported in 2003 by the only National Assessment of Adult Literacy ever conducted in the

**TABLE 2**
**Willingness Reported by Respondents to Increase Knowledgeability Surrounding DM–PD Association, Stratified by Age and Educational Level**

| | *Willingness to Have Dental Providers Conduct Medical Screening for Diseases That May Affect Oral Health* | | | |
|---|---|---|---|---|
| *Options* | *Yes* | *No* | *Not Sure* | p |
| Age, years | | | | |
| 18-40 | 43.8% (123/281) | 25.6% (72/281) | 30.6% (86/281) | .6267 |
| 41-60 | 46.4% (159/343) | 27.1% (93/343) | 26.5% (91/343) | |
| 61-80 | 41.3% (131/372) | 29.0% (92/372) | 29.7% (94/372) | |
| Gender | | | | |
| Male | 43.7% (142/325) | 27.4 % (89/325) | 28.9% (94/325) | .9745 |
| Female | 44.0% (269/371) | 27.2% (166/371) | 28.8% (176/371) | |
| Educational level | | | | |
| EduLevel1: Grades 9-11 or less | 29.2% (26/89) | 42.7% (38/89) | 28.1% (25/89) | .0006 |
| EduLevel2: High school/some college/ associate degree | 43.5% (306/704) | 26.7% (188/704) | 29.8% (210/704) | |
| EduLevel3: Bachelor degree and higher | 54.8% (80/146) | 20.6% (30/146) | 24.7% (36/146) | |
| Self-reported data for understanding of DM–PD relationship | | | | |
| Poor/fair | 42.9% (207/483) | 21.7% (105/483) | 35.4% (171/48) | <.0001 |
| Good | 43.6% (115/264) | 31.4% (83/262) | 25% (66/262) | |
| Very good/excellent | 47.1% (107/187) | 36.4% (68/187) | 16.6% (31/187) | |

NOTE: DM = diabetes mellitus; PD = periodontal disease.

United States (National Center for Education Statistics, 2003). Zahnd et al. (2009) concluded that lower health literacy found in rural population can be explained by known confounders. A study by Paasche-Orlow, Parker, Gazmararian, Nielsen-Bohlman, and Rudd (2005) reported weighted prevalence of low literacy levels of 26% (95% confidence interval [22, 29]). Poor health literacy in the current study surrounding DM and PD associations were reported by approximately 20% of the population, similar to those reported by Zahnd et al. (2009) and the National Assessment of Adult Literacy survey (National Center for Education Statistics, 2003). Notably, in the present study, while health behaviors and measured knowledgeability surrounding DM and PD appeared high, respondents' self-assessment of their knowledge regarding relationships between PD and DM was ranked much lower, suggesting that opportunities exist for health care professionals to improve health literacy of patients on this relationship across the surveyed communities.

This study has some limitations. The level of stratification of variables of interest (e.g., age, education levels) was somewhat subjective. With respect to generalizability, information provided by the respondents was anonymously self-reported and hence our ability to validate findings is limited. Since it was focused on quantitative assessment of knowledge, awareness of patients in context of PD–DM, the survey tool validation was limited to face and content validity. The majority of the data were collected from participants at sites with an integrated medical-dental clinic infrastructure supported by an integrated medical-dental record. Knowledge, attitude, and perceptions may differ as a function of the health care environment where patients received care. Patient experience may differ across organizations where health care access is differently structured. Literacy levels among this patient population were predominantly (75%) EduLevel2 (high school/associate degree). Notably, the highest levels of participants who reported EduLevel3 (⩾BA degree) fell into the highest age tier, and thus impact of education is potentially limited in this study and would require further investigation to validate present findings. The survey was available only in English. Potential participants of Hispanic ethnicity who spoke mainly Spanish were unable to complete the survey,

so information may not be generalizable to this subpopulation. The refusal rate, race, and ethnicity were not tracked by the survey. Because the survey was anonymous and voluntary, there was a possibility that a person could have taken the survey more than once. Finally, impact of personal health history on knowledgeability and opinion was not assessable because medical/dental status was not solicited from participants. Collection of such data may be of value in future studies.

## CONCLUSION

We found few studies conducted in the United States that examined patient health literacy surrounding interaction of diabetes and PD. With only half of the participants reporting awareness of PD to increase blood sugar levels and characterizing their knowledge surrounding relationship between PD and DM as "poor to fair," our study findings suggested low awareness surrounding links between diabetes and oral disease risk among the study respondents, with relatively limited interest in education surrounding links between oral health and diabetes across patients surveyed. Our findings further support that incorporation of chairside medical screening across the State may require further patient education to promote acceptance of integrated care delivery to populations with dysglycemia. Screening for dysglycemia in the dental setting remains an important alternative best practice to identify presence of potential systemic diseases especially in populations who may have lower health literacy. The evidence base supports that such health screening has the potential to increase the quality of care by promoting disease prevention while lowering health care costs (Glurich, Nycz, & Acharya, 2017; Glurich, Schwei, Lindeberg, Shimpi, & Acharya, 2018). The data in this study have help set baseline literacy rates surrounding DM–PD associations across a largely rural population. This study may serve as a model that may be extended to future surveys of populations surrounding knowledge of other oral–systemic relationships in other statewide and national health care organization settings to determine whether regional variability exists. Such surveys may also be useful in gauging patient receptivity to integrated health delivery practices based on analysis of health literacy levels. Strategic educational interventions by health care providers targeting heightened health literacy among patients should include endorsement of integrated care delivery including promotion of the potential value of conducting glycemic screening to detect dysglycemia. Such educational practices may further advance opportunities for prevention of diabetes progression and diabetic and oral disease complications, thereby increasing patient perception of value in integrated care delivery for patients with dysglycemia. Moreover, initiatives and educational tools to increase provider and patient health literacy are under development and being explored in currently ongoing studies by our study team. Studies in other populations are needed to confirm current findings.

## REFERENCES


Acharya, A., Shimpi, N., Mahnke, A., Mathias, R., & Ye, Z. (2017). Medical care providers' perspectives on dental information needs in electronic health records. *The Journal of the American Dental Association, 148*(5), 328-337. doi:10.1016/j.adaj.2017.01.026

Albert, D. A., Ward, A., Allweiss, P., Graves, D. T., Knowler, W. C., Kunzel, C., . . . Lalla, E. (2012). Diabetes and oral disease: Implications for health professionals. *Annals of the New York Academy of Sciences*, *1255*, 1-15. doi:10.1111/j.1749-6632.2011.06460.x

Bahammam, M. A. (2015). Periodontal health and diabetes awareness among Saudi diabetes patients. *Patient Preference and Adherence*, *9*, 225233. doi:10.2147/PPA.S79543

Borgnakke, W. S., Ylostalo, P. V., Taylor, G. W., & Genco, R. J. (2013). Effect of periodontal disease on diabetes: Systematic review of epidemiologic observational evidence. *Journal of Periodontology, 84*(4 Suppl.), S135-S152. doi:10.1902/jop.2013.1340013

Caruso, R., Magon, A., Baroni, I., Dellafiore, F., Arrigoni, C., Pittella, F., & Ausili, D. (2018). Health literacy in type 2 diabetes patients: A systematic review of systematic reviews. *Acta Diabetologica*, *55*(1), 1-12. doi:10.1007/s00592-017-1071-1

Casanova, L., Hughes, F. J., & Preshaw, P. M. (2014). Diabetes and periodontal disease: A two-way relationship. *British Dental Journal*, *217*, 433-437. doi:10.1038/sj.bdj.2014.907

Centers for Disease Control and Prevention. (2017). *National diabetes statistics report, 2017: Estimates of diabetes and its burden in the United States background*. Retrieved from https://www.cdc.gov/diabetes/pdfs/data/statistics/national-diabetes-statistics-report.pdf

Corbella, S., Francetti, L., Taschieri, S., De Siena, F., & Fabbro, M. D. (2013). Effect of periodontal treatment on glycemic control of patients with diabetes: A systematic review and meta-analysis. *Journal of Diabetes Investigation*, *4*, 502-509. doi:10.1111/jdi.12088

Egbert, N., & Nanna, K. M. (1996). Health literacy : Challenges and strategies. *Online Journal of Issues in Nursing*, *14*(3). doi:10.3912/OJIN.Vol14No03Man01. Retrieved from http://ojin.nursingworld.org/MainMenuCategories/ANAMarketplace/ANAPeriodicals/OJIN/TableofContents/Vol142009/No3Sept09/Health-Literacy-Challenges.html

Eke, P. I., Dye, B. A., Wei, L., Slade, G. D., Thornton-Evans, G. O., Borgnakke, W. S., . . . Genco, R. J. (2015). Update on prevalence of periodontitis in adults in the United States: NHANES 2009 to 2012. *Journal of Periodontology*, *86*, 611-622. doi:10.1902/jop.2015.140520

Genco, R. J., & Genco, F. D. (2014). Common risk factors in the management of periodontal and associated systemic diseases:

The dental setting and interprofessional collaboration. *Journal of Evidence-Based Dental Practice* (14 Suppl.), 4-16. doi:10.1016/j.jebdp.2014.03.003

Glurich, I., Nycz, G., & Acharya, A. (2017). Status update on translation of integrated primary dental-medical care delivery for management of diabetic patients. *Clinical Medicine & Research, 15*(1-2), 21-32. doi:10.3121/cmr.2017.1348

Glurich, I., Schwei, K., Lindeberg, S., Shimpi, N., & Acharya, A. (2018). Integrating medical-dental care for diabetic patients: Qualitative assessment of provider perspectives. *Health Promotion Practice, 19*, 531-541. doi:10.1177/1524839917737752

Harris, P. A., Taylor, R., Thielke, R., Payne, J., Gonzalez, N., & Conde, J. G. (2009). Research electronic data capture (REDCap)—A metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of Biomedical Informatics*, *42*, 377-381. doi:10.1016/j.jbi.2008.08.010

MacLeod, S., Musich, S., Gulyas, S., Cheng, Y., Tkatch, R., Cempellin, D., . . . Yeh, C. S. (2017). The impact of inadequate health literacy on patient satisfaction, healthcare utilization, and expenditures among older adults. *Geriatric Nursing*, *38*, 334-341. doi:10.1016/J.GERINURSE.2016.12.003

Manski, R. J., Hoffmann, D., & Rowthorn, V. (2015). Increasing access to dental and medical care by allowing greater flexibility in scope of practice. *American Journal of Public Health*, *105*, 1755-1762. doi:10.2105/AJPH.2015.302654

Martin, L. R., Williams, S. L., Haskard, K. B., & Dimatteo, M. R. (2005). The challenge of patient adherence. *Therapeutics and Clinical Risk Management*, *1*, 189-199.

Naghibi Sistani, M. M., Virtanen, J. I., Yazdani, R., & Murtomaa, H. (2017). Association of oral health behavior and the use of dental services with oral health literacy among adults in Tehran, Iran. *European Journal of Dentistry*, *11*, 162-167. doi:10.4103/ejd.ejd_332_16

Nasseh, K., Greenberg, B., Vujicic, M., & Glick, M. (2014). The effect of chairside chronic disease screenings by oral health professionals on health care costs. *American Journal of Public Health*, *104*, 744-750. doi:10.2105/AJPH.2013.301644

National Center for Education Statistics. (2003). *National Assessment of Adult Literacy (NAAL)*. Retrieved from https://nces.ed.gov/pubs2006/2006483.pdf

NCD Risk Factor Collaboration. (2016). Worldwide trends in diabetes since 1980: A pooled analysis of 751 population-based studies with 4·4 million participants. *The Lancet*, *387*, 1513-1530. doi:10.1016/S0140-6736(16)00618-8.

Ogurtsova, K., da Rocha Fernandes, J. D., Huang, Y., Linnenkamp, U., Guariguata, L., Cho, N. H., . . . Makaroff, L. E. (2017). IDF Diabetes Atlas: Global estimates for the prevalence of diabetes for 2015 and 2040. *Diabetes Research and Clinical Practice*, *128*, 40-50. doi:10.1016/j.diabres.2017.03.024

Paasche-Orlow, M. K., Parker, R. M., Gazmararian, J. A., Nielsen-Bohlman, L. T., & Rudd, R. R. (2005). The prevalence of limited health literacy. *Journal of General Internal Medicine*, *20*, 175-184. doi:10.1111/j.1525-1497.2005.40245.x

Rosedale, M., & Strauss, S. (2012). Diabetes screening at the periodontal visit: patient and provider experiences with two screening approaches. *International Journal of Dental Hygiene*, *10*, 250-258. doi:10.1111/j.1601-5037.2011.00542.x

Shimpi, N., Schroeder, D., Kilsdonk, J., Chyou, P.-H., Glurich, I., & Acharya, A. (2016). Assessment of dental providers' knowledge, behavior and attitude towards incorporating chairside screening for medical conditions: A pilot study. *Journal of Dentistry and Oral Care Medicine*, *2*(1), 1-7. doi:10.15744/2454-3276.2.102

Shimpi, N., Schroeder, D., Kilsdonk, J., Chyou, P.-H., Glurich, I., Penniman, E., & Acharya, A. (2016). Medical providers' oral health knowledgeability, attitudes, and practice behaviors: An opportunity for interprofessional collaboration. *Journal of Evidence-Based Dental Practice*, *16*(1), 19-29. doi:10.1016/j.jebdp.2016.01.002

U.S. Department of Health and Human Services Oral Health Coordinating Committee. (2016). U.S. Department of Health and Human Services Oral Health Strategic Framework, 2014-2017. *Public Health Reports*, *131*, 242-257. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/26957659

Wang, T.-F., Jen, I.-A., Chou, C., & Lei, Y.-P. (2014). Effects of periodontal therapy on metabolic control in patients with type 2 diabetes mellitus and periodontal disease: A meta-analysis. *Medicine*, *93*(28), e292. doi:10.1097/MD.0000000000000292

Zahnd, W. E., Scaife, S. L., & Francis, M. L. (2009). Health literacy skills in rural and urban populations. *American Journal of Health Behavior*, *33*, 550-557.