Status Update on Translation of Integrated Primary Dental-Medical Care Delivery for Management of Diabetic Patients

Ingrid Glurich, PhD; Gregory Nycz; and Amit Acharya, BDS, PhD

Escalating prevalence of both diabetes and periodontal disease, two diseases associated with bi-directional exacerbation, has been reported. Periodontal disease represents a modifiable risk factor that may reduce diabetes onset or progression, and integrated models of cross-disciplinary care are needed to establish and manage glycemic control in affected patients. An ad-hoc environmental scan of current literature and media sought to characterize factors impacting status of integrated care models based on review of the existing evidence base in literature and media surrounding: (1) current cross-disciplinary practice patterns, (2) epidemiological updates, (3) status on risk assessment and screening for dysglycemia in the dental setting, (4) status on implementation of quality metrics for oral health, (5) care model pilots, and (6) public health perspectives. The survey revealed: escalating prevalence of diabetes and periodontitis globally; greater emphasis on oral health assessment for diabetic patients in recent medical clinical practice guidelines; high knowledgeability surrounding oral-systemic impacts on diabetes and growing receptivity to medical-dental integration among medical and dental providers; increasing numbers of programs/studies reporting on positive impact of emerging integrated dental-medical care models on diabetic patient healthcare access and health outcomes; a growing evidence base for clinically significant rates of undiagnosed dysglycemia among dental patients reported by point-of-care pilot studies; no current recommendation for population-based screening for dysglycemia in dental settings pending a stronger evidence base; improved definition of true periodontitis prevalence in (pre)/diabetics; emerging recognition of the need for oral health quality indicators and tracking; evidence of persistence in dental access disparity; updated status on barriers to integration. The potential benefit of creating clinically-applicable integrated care models to support holistic management of an escalating diabetic population by targeting modifiable risk factors including periodontitis is being recognized by the health industry. Cross-disciplinary efforts supported by high quality research are needed to mitigate previously- and newly-defined barriers of care integration and expedite development and implementation of integrated care models in various practice settings. Implementation of quality monitoring in the dental setting will support definition of the impact and efficacy of interventional clinical care models on patient outcomes.

Keywords: Diabetes; Delivery of healthcare—integrated; Mass screening; Periodontitis; Risk assessment

Overview

Despite designation of periodontal disease (PD) as a complication of type 2 diabetes mellitus (T2DM) and recognition of bidirectional exacerbation of the two diseases by underlying inflammatory processes,¹ siloed oral-medical healthcare and management of patients with T2DM persists. Evidence presented in this environmental scan increasingly supports recognition by all stakeholders that there is a

growing need for implementing integrated dental-medical care approaches to healthcare delivery in the context of diabetic care. Epidemiological evidence reveals achievement of epidemic status globally for both conditions^{2,3} in the framework of current models of care, while a growing evidence base underlines both the need and plausibility of establishing new integrated healthcare delivery models for chronic disease management of these complex diseases, as

Corresponding Author: Amit Acharya, BDS, PhD, Director, Center for Oral and Systemic Health, Marshfield Clinic Research Institute, 1000 N. Oak Avenue, Marshfield, WI 54449, Email: acharyaa@marshfieldclinic.org, Tel: +1 (715) 389-4460, Fax: +1 (715) 221-6402

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Table 1. Current definitions of type diabetes mellitus and pre-diabetes.

Glycemic Parameter	T2DM	Pre-Diabetes
Hemoglobin A1C (HbA1C)	≥6.5%	5.7-6.4%
Fasting plasma glucose (FPG)	≥126 mg/dl (7.0 mmol/L)	100-125mg/dl (5.6-6.9 mmol/L)
Oral glucose tolerance test (OGTT)	≥200 mg/dl (11.1mmol/L)	140-199 mg/dl (7.8-11.0 mmol/L)

Adapted from: American Diabetes Association. Standards of medical care in diabetes-2015 abridged for primary care providers Clin Diabetes 2015;33:97-111²

summarized in this scan. This report sought to update the current status and progress in advancing establishment of models for integrated oral-dental healthcare delivery for patients with, or at risk for, diabetes.

Approach

An ad hoc environment scan was undertaken to descriptively characterize current status/outlooks for integration of oral health into primary care delivery, with focus on diabetic care. Ad hoc environmental scans are cross sectional surveys undertaken at unspecified frequency, for the purpose of reviewing the current relevant evidence base across a range of sources in an attempt to ascertain the current state of the art surrounding the specific topic under focus. Such scans are conducted to collect information that may inform future planning of various vested stakeholders.

Figure 1 summarizes resources and relevant topics that were explored through key word searches utilizing MESH terminology to identify relevant publications and online resources with respect to characterizing current state of the art in achieving integrated oral-medical care delivery to patients with dysglycemia or diabetes.

Discussion

Current Interdisciplinary Practice Patterns: Does Oral Health Factor into Current Clinical Practice Guidelines (CPGs) and Position Statements Surrounding T2DM Management?

Updated standards of medical care were defined by American Diabetic Association (ADA) in 2015, informed by critical evaluation of the current evidence-base, including updates to current diagnostic criteria for T2DM and prediabetes (summarized in Table 1).⁴ New recommendations included testing at any age for individuals meeting overweight/obesity criteria with one or more risk factor and all patients by age 45 years. Through 2015, guidance relative to oral health and diabetes largely consisted of recommendation by a physician for an annual oral examination. Notably, the 2016 guidelines published by the ADA more prominently featured attention to oral health in diabetic patients. As part of establishment of the medical history, comprehensive diabetes medical evaluation should include: 'presence of common comorbidities including dental disease; recommendations for preventative care services including dental referrals' (page 23)⁵ and 'referrals to dentists for comprehensive dental and periodontal examination as a component of initial care management' (tables 3.1 and 3.2 on page S24).⁵ On page S31,⁵ under the subheading of

'Periodontal Disease' the guidelines note the potential for 'increased severity of PD' in diabetic patients and negative impacts on diabetes outcomes but noted that positive impact on diabetes outcomes in response to PD treatment 'remains controversial', citing outcomes of a 2013 systematic review of the current evidence base.⁶ These recommendations underline recognition of a need for better cross disciplinary care coordination for diabetic patients. Current guidelines do not presently include recommendations surrounding oral health management for gestational diabetes or oral health considerations in hospitalized patients with diabetes. The National Diabetes Education Initiative's⁷ treatment guideline repository surrounding diabetes has included links to these latest ADA standards.

Recommendations surrounding integrated care teams for management of diabetic patients featured in the Diabetes Mellitus Comprehensive Care Plan,⁸ jointly published by American Association Clinical Endocrinologists and American College of Endocrinology (2015), promotes inclusion of diabetes educators/dieticians on care teams based on evidence documenting efficacy of nutritional therapy in glycemic control maintenance and reduction of comorbid risk in randomized clinical trials. However, guidelines for nutritional intervention address neither the central importance of oral health to nutritional intake nor the impact of untreated PD on glycemic control and are silent on oral health provider representation on the integrated care teams proposed for comprehensive diabetic care delivery. Recent CPGs and position papers issued by cardiovascular societies^{9,10} mainly defined therapeutic targets based on evidence from clinical trials, similarly remaining silent on evidence implicating a role for untreated periodontitis in sustaining dysglycemia⁶ and irrefutable statistics identifying cardiovascular diseases as the leading cause of mortality among diabetic patients.¹¹

Historically, few medical CPGs have addressed dental considerations. The International Diabetes Federation 2009 guideline acceded that despite 'variable quality' surrounding evidence of links between oral-systemic disease, adverse impact of oral disease on quality of life, and cost effectiveness of prevention were compelling drivers for integrating oral care into diabetic management.¹² The guideline promoted education of diabetic patients by providers on oral hygiene and awareness of xerostomia risk (dry mouth). Both the 2013 consensus report of the Joint European Federation for Periodontology and American Academy of Periodontology

workshop on periodontitis and systemic diseases¹³ and meta-analysis of the impact of periodontal treatment on hemoglobin A1c levels (HbA1C),¹⁴ concluded that guideline provision surrounding periodontal care in diabetic patients was supportable and associated with efficacy, and was further supported by meta-analysis of level A clinical trial evidence

demonstrating moderate reduction in HbA1c and inflammatory biomarker levels and improvement in oral indices post intervention.¹⁵ The American Academy of Oral Medicine also advanced evidence-based CPGs that include recommendations for optimizing clinical interventions to reduce risk of PD, caries, and oral infection in patients with

Table 2. Sample healthcare models adopting integration of oral care into primary care or summaries of strategic approaches to integrated care for high risk patients.

Objective	Population/Design	Outcomes to Date	Reference
Provide a practical framework for integrating medical dental care in diabetic management	Review	Recommended: oral screening to identify oral hallmarks of PD; monitoring of modifiable risk factors associated with T2DM development; further evaluation of POC screening; referral to medical PCP; implementing inter-professional education for medically complex patient management; train PCP to identify oral disease/ refer for dental care.	Elangovan ⁶⁶
Define role of the dental professional in identifying patients at risk for pre-diabetes/diabetes	Review	Reviewed risk factors and dental provider role in identifying at-risk patients, providing care education and mediating triage to medical care.	Lalla ⁶⁷
Explore informatics engagement to optimize integrated care in various healthcare settings supported by interoperable trans-European communication platform(s)	Health Service Platform Architecture and End User service development to support T2DM management including: vitals monitoring, glucose sensing, feedback capacity, risk assessment, event/alarm management, insulin dosing decision support , capturing nutrition, pharmacological treatment tracking with mobile tablets platform compliant with Medical Device Directives.	Study is in progress	Spanakis ⁶⁸
Operationalize an ICM encompassing specialty care, oral health, imaging, pharmacy and hospital care to in family health center-based primary care context	Family Health Center population	Overview of accomplishing dental integration through colocation of services into primary care and capacity building through training of medical PCPs on dental issues	Olayiwola ⁶⁹
Characterize current practice patterns for integrating dental practitioners into the medical home model. Study focused on identifying best practices and education on strategic initiatives for medical-dental home set-up.	Environmental scan	Four models were defined. State was canvassed to determine which practice patterns were in place. Challenges identified included patient/provider education, impact on staffing and staff, workflow and integrating private practices.	Oral Health Commission ⁷⁰
Define an ICM algorithm	California residents	Algorithm defined.	Diabetes Coalition ⁷¹

PD, Periodontal disease; T2DM, Type 2 diabetes mellitus; POC, Point-of-care; PCP, Primary care provider; ICM, Integrated care model

Figure 1. Overview of search strategy used to perform environmental scan.

xerostomia, diabetes, chronic obstructive pulmonary disease, and congestive heart failure.¹⁶ Gradually, just under half the states in the United States have incorporated some mention of oral care into CPGs for diabetic care (predominantly, recommendation for annual dental examination), citing C-level evidence and outcomes reported in initial trials performed with modest sample sizes demonstrating modest improvements in glycemic indices in response to nonsurgical periodontal intervention (Table 2).

Substantial barriers to integrated dental-medical healthcare delivery surrounding diabetes have been previously delineated and progress on resolution is summarized in Table 3. Additional barriers identified in the course of this environmental scan and outlined subsequently herein include:

- Underestimation of true rates of periodontal disease when full mouth periodontal assessment was not applied;
- Lack of definition of best practices for PD risk assessment exacerbated by underlying diabetic pathophysiology or pharmacological diabetic management;
- Variability in tracking and reporting of dental care access and outcomes of surveillance approaches as challenges to achieving ICMs in disparity populations.

Surveillance Issues and Impact on Screening

Epidemiological characterization of periodontitis and diabetes over time has been associated with under-estimation of prevalence of both conditions and may impact on recommendations surrounding screening in the future. Since 1999, National Health and Nutrition Examination Survey data have been used to calculate PD prevalence in the absence of

state/local surveillance data. Introduction of full-mouth periodontal examination, replacing previous partial-mouth periodontal assessment as the gold standard in 2009, identified systematic under-estimation of periodontitis prevalence by 50%–60%.¹⁷ Updated case definitions for population-based surveillance of periodontitis (2012) incorporated definition of a new mild periodontitis category expanding on existing definitions for moderate and severe disease, effectively increasing total prevalence estimates by 31%.¹⁸ Subsequently, updated prevalence estimates of periodontitis (2015)² following full-mouth periodontal examination implementation and application of the updated case definitions are estimated at 46% in US adults (~65 million people), with nearly 9% affected by severe periodontitis. Periodontitis prevalence was highest in Hispanic, non-Hispanic Black, and non-Hispanic Asian populations (63.5%, 59%, and 50%, respectively) and positively associated with increasing age, male gender, and socio-economic indicators, with nearly a two-fold difference in prevalence based on economic tier or level of education.

Similarly, prevalence estimates of diabetes have varied, largely due to recent shifts in stringency of criteria used to classify diabetic and prediabetic status, effectively increasing by 75% the number of individuals newly categorized as diabetic across the spectrum of age between 1988 to 2010.¹⁹ Based on current definitions, one in three persons is projected to have diabetes by 2030, while dynamic modelling predicted 25% to 28% prevalence by 2050.³ In light of data demonstrating

association between periodontitis and chronic systemic conditions,^{20,21} these new prevalence estimates compellingly promote revisiting screening, intervention and effective inter-disciplinary ICMs.

A 2015 report by the Wisconsin Department of Health Services underlines that the widely-quoted ‘70%’ frequency estimate for ‘an annual dental visit’ by the US population based on Behavioral Risk Factor Surveillance Survey²² data does not apply to disparity populations, reporting that approximately 50% of adults with incomes below \$50,000 were in need of dental care.²³ The modest increase in access (from 34% to 40%) reported in Wisconsin in 2009 for low-income populations noted mainly in counties located within the overlapping Marshfield Clinic/Family Health Center Service Area, was partially attributable to a strategically-established, integrated medical-dental healthcare delivery system inclusive of regional dental infrastructure established to mitigate access barriers for low income and under- or uninsured populations.²⁴

Current Screening Trends

Practice patterns for oral and medical healthcare delivery reflect sustained siloing of medical and dental healthcare delivery models and their respective independent reimbursement systems. Currently, four organizational juxtapositions have been modelled relative to implementation of Integrated Care Model (ICM)-based care delivery, including

Table 3. Identified barriers to achieving integrated oral-medical healthcare integration and delivery in management of patients with T2DM.

<ul style="list-style-type: none"> • Siloed medical and dental healthcare practice models and parallel payer reimbursement policies • Lack of research on best practices for achieving integration and research defining outcomes associated with models testing integration and implementation. • Low/ no emphasis on oral health in most CPGs attributable on lack of • Level A evidence demonstrating oral infection/inflammation as causal to diabetes exacerbation • Lack of inclusion of oral examination as an incorporated measure for quality tracking and capture of oral health data in most commercial EHRs • Low oral health literacy among diabetic patients, especially among disparity populations • Barriers to dental care access, especially for disparity populations • Lack of research on best practices for cross-disciplinary screening, tools and cost is lacking, contributing to low provider acceptability • Lack of research defining impact on clinical workflow of oral health integration into diabetic management
<ul style="list-style-type: none"> • Underestimation of true rates of periodontal disease occurring when full mouth periodontal assessment is not applied. • Lack of definition of best practices for PD risk assessment exacerbated by underlying diabetic pathophysiology or pharmacological diabetic management • Variability in tracking and reporting of dental care access and outcomes of surveillance approaches as challenges to achieving ICMs in disparity populations

The table summarizes previously identified barriers to dental-medical integrated care model implementation. Additional barriers to achievement of ICMs presented in this report are shown in shaded fields.

T2DM, Type 2 diabetes mellitus; CPG, Clinical Practice Guidelines; EHR, Electronic health record; PD, Periodontal disease; ICM, Integrated care model

feasibility of health screening. Relative success of screening and implementation of ICMs is largely defined by the proximity of the medical and dental practices and degree to which they are integrated. Implementation of ICMs was predicted to be most highly effective in fully-integrated medical-dental systems with integrated health records and referral systems. Moderate integration was projected for co-located medical-dental practices or for those with a primary care provider service focus. Challenges to integration increased proportionally with decreased: (a) relational connections, (b) primary care provider focus and (c) proximity of the dental and medical settings. In the latter juxtaposition, projections included that highly disconnected providers reliant on a 'cooperation/ collaboration' as the operative model, were least likely to implement effective ICMs.²⁵

Notably, screening for diabetes in primary care settings including dental settings and oral examination in the medical setting are not currently-recommended standards of care, despite increasing prevalence of both PD and T2DM. United States Preventive Service Task Force cited lack of a sufficient evidence base to support screening for diabetes in 2008,²⁶ and re-review by United Kingdom's parallel National Institute for Health Research in 2013 continued to support relegation of 'dental recall for oral health screening' for diabetics to the 'static list' for the next 5 years.²⁷ Consequently, dental screening remains absent from current algorithms published by the Institute for Clinical Systems Improvement²⁸ guiding diagnosis, management, and quality tracking parameters for adults with diabetes. Notably, a 2014 review concluded that, based on evidence-based support and demonstrated cost-effectiveness, screening of high-risk dental patients was defensible.²⁹

Quality Assessment Status

'Guideline Advantage', jointly-established by the ADA, American Heart Association, and American Cancer Association, proposes an interdisciplinary approach to develop effective, evidence-based guidelines and scientific statements in the context of meaningful use to achieve standardized quality measures for clinical care delivery within the scope of state-of-the-art technology in outpatient settings.³⁰ However, guidelines for integrated point-of-care (POC) across the siloed primary care settings present barriers to their incorporation into standard practice. Whereas the 2015 Health Effectiveness Data Information Set measures issued by the National Committee for Quality Assurance³¹ included annual HbA1c and lipid panel assessment, and screening for nephropathy, retinopathy, and hypertension, quality measures tracking oral health remained absent despite:

- (1) identification of periodontitis as an early complication³² and independent risk factor for diabetes;³³
- (2) evidence demonstrating bidirectional exacerbation between periodontitis and diabetes supported by systematic reviews;¹

- (3) evidence of modest reductions in HbA1c following PD treatment demonstrated in some studies;^{4,34-36}
- (4) documentation of higher oral pathogen prevalence in prediabetic patients without periodontitis.³⁷

A recent study also proposed periodontitis as an independent risk factor contributing to hyperlipidemia.³⁸ Increasingly, revisiting current paradigms for ICM-based delivery in medical- dental settings is critical, timely, and responsive to patient-centric care.

Newly-published accountable care organization quality performance standards released in January 2015³¹ surrounding diabetic care include only: 'HbA1c: poor control' and 'all-cause unplanned admission.' Stated rationale for their inclusion is 'provision of coordinated patient-centered management, improved population health, and lower cost' and a vision wherein 'incentivized providers collaborate to optimize the best system of care by partnering appropriately.' Notwithstanding, standards for oral health integration remain largely absent.

Future Directions in Screening

Recent pilot studies have begun to explore prevalence of undiagnosed diabetes, prediabetes, and dyslipidemia in clinical dental settings (Table 4). Moreover, recent field trials of integrated care delivery models (ICM) implemented in various healthcare settings have been reported with some examples cited in Table 2. These studies have examined feasibility and reliability, quality assurance,³⁹ acceptability,⁴⁰ and challenges associated with POC screening. Deterrents to POC screening to date include cost; reimbursement structures; requirement for dental practices to address Clinical Laboratory Improvement Amendment (CLIA) certification; POC HbA1c sensitivity (estimated at ~65%);⁴¹ variability of glucometer accuracy;⁴² and operator competency training/tracking requirement³⁹ for POC screening. These collectively contribute potential for high false positive rates and low patient/provider acceptability.

Notably, a large number of algorithms to predict dysglycemia have been defined by modelling a range of candidate factors as surrogates for, or adjuncts to, biological determination of glycemic levels, with some models incorporating dental parameters as predictors of pre-/T2DM. Model performance varied widely on positive predictive power, and systematic assessment of utility and portability of existing models to other patient populations is pending. A systematic review of current risk prediction models for (pre)/diabetes flagged inappropriate approaches to statistical modelling in the development of some models as a concern, and subsequently limited systematic analyses to only those models developed through application of multivariate logistic regression modeling.⁴³

Other potential screening methodologies are being explored. Review of fasting glucose measures available in health plan

Table 4. Studies piloting estimation of prevalence of dysglycemia in dental settings.

Screening Tools	Population/Sample Size	Estimated Prevalence of Dysglycemia	Reference
Risk modeling for diabetes/pre-diabetes; factors: missing teeth, gender, hypertension body mass index >35kg/m ² , dyslipidemia.	Dental patients ± periodontitis with no diabetes diagnosis; fasting plasma glucose > 110mg/dl N= 1033	30% ; (~20% risk attributed to modeled factors)	Herman ⁷²
Periodontal examination data plus self-reported medical history assessment	N=4830	Undiagnosed T2DM: range: 27-53%	Borrell ⁷³
POC A1C test and self-reported risk factor assessment	N=104	Undiagnosed diabetes: 45%	Franck ⁷⁴
POC A1C test and American Diabetic Association risk survey	≥45 years of age N=1022	Diabetes detection rate: 40% based on A1C screen; (risk survey lacked reliability)	Genco ⁷⁵
POC random plasma glucose test and ≥1 risk factor for diabetes; or diagnosis of diabetes or prediabetes	Dental Practice-Based Research Network (DPBRN) patients N=418	31% outside of normal range: hypoglycemic: 6.7% hyperglycemic: 24%	Barasch ⁷⁶
POC A1C, periodontal examination; self-reported risk factors; number of missing teeth	>30 years (Hispanic) or >40 year non-Hispanic white dental patients N=601	31.8% with prediabetic HbA1C levels 4.2% with potentially undiagnosed T2DM	Lalla ⁷⁷
BMI, waist circumference, fat %, POC HbA1C, health questionnaire, periodontal examination and radiograph	Danish dental patients N=291	27.1% with prediabetic HbA1C levels 3.1% with potentially undiagnosed T2DM	Holm ⁷⁸

POC, Point-of-care; PD, Periodontal disease; T2DM, Type 2 diabetes mellitus; A1C, Hemoglobin A1C; BMI, Body mass index

data effectively identified individuals with high dysglycemia risk.⁴⁴ Non-invasive skin fluorescence spectroscopy has been developed with capacity to measure advanced glycation end products levels associated with diabetes in ~one minute. Initial trials demonstrated higher differential sensitivity compared to all current glycemic laboratory tests.⁴¹ Testing in multi-ethnic populations and larger trials and US Food and Drug Administration approval is pending. A new clinical trial (2014) is evaluating sensitivity of a new saliva-based metabolomic test developed by Weill Cornell Medical College (Qatar) as a screening tool for dyslipidemia based on demonstration of lower levels of anhydroglucitol in saliva of diabetics.⁴⁵ The National Institute for Craniofacial Research and Delta Dental are pursuing saliva-based diabetic screening and improved classification of periodontitis based on evidence supporting multifactorial pathophysiological triggers manifesting a common presentation.⁴⁶ Identifying individuals at higher risk for dysglycemia and refractory forms of periodontitis is especially important and initial capacity of microbiome research to profile genetic signatures of pathogens to distinguish PD profiles has been suggested.⁴⁷ However, such approaches remain exploratory with demonstration of clinical applicability pending.

Current Status of Integrating Oral Health into Primary Care Practice

Educational initiatives targeting providers are serving to advance cross-disciplinary awareness to set the stage for integration. The Academy of Dental Learning and Occupational Safety and Health Administration Training issued a continuing education program targeting training of dentists surrounding the dental patient with diabetes recently updated in 2015.⁴⁸ Several recent surveys of medical and dental professionals demonstrated favorable attitudes toward medical-dental care integration for patients with complex disease. Studies evaluating attitudes of PCPs towards medical screening by dental practitioners reported high receptivity and attribution of value.⁴⁰ Reports examining practice behaviors and knowledgeability of dentists and perceived barriers to medical assessment of patients reported: (1) high knowledgeability of dentists regarding relational aspects of oral-systemic disease; (2) willingness to engage risk factor screening, patient education, and collaborative interaction with medical providers; and (3) improved capture rates of glycemic and blood pressure measures in medical histories,

Table 5. Sample of recent studies demonstrating impact of lifestyle intervention or PD intervention in patients with pre-diabetes/T2DM on oral and/or glycemic indices.

Study Description	Population	Outcomes	Reference
Education/counseling applying motivational approaches to achieve lifestyle intervention coupled with instruction on oral hygiene; follow up at 3 & 6 months was conducted. Patients receiving standard care served as controls.	Elderly diabetic patients (Thailand)	Statistically significant reduction in A1C and FPG levels and improved oral indices in interventional group compared to standard care	Saengtipbovorn ⁷⁹
Lifestyle intervention in primary healthcare setting with 2.3 year follow-up	Prediabetic patients aged 30-60 years vs usual care in patients with A1C <5.7 (Japan)	Incidence of T2DM in patients receiving intervention was lower in interventional group than in the usual care group	Sakane ⁸⁰
Examined randomized controlled trials testing efficacy of lifestyle interventions in patients presenting with impaired glucose tolerance	Meta-analysis of randomized controlled trials	7 trials including >5600 patients demonstrated reduced T2DM in patient with IGT	Yoon ⁸¹
Examined glycemic and metabolic outcomes in randomized controlled trials examining impact of periodontal treatment in diabetic patients	Meta-analysis of randomized controlled trials	5 trials including 315 patients showed statistically significant reduction in glycemic indices but not lipid variables	Sgolastra ⁸²

PD, Periodontal disease; T2DM, Type 2 diabetes mellitus; A1C, Hemoglobin A1C; FPG, Fasting plasma glucose; IGT, Impaired glucose tolerance

especially among younger practitioners. Provider perception of low patient acceptance attributable to concerns surrounding additional cost and healthcare access, especially in rural settings, was identified.^{49,50} A 2015 consensus paper providing a framework and recommendations for advancing interprofessional education, multidisciplinary teamwork, and improvement in health literacy surrounding periodontitis is noteworthy.⁵¹

Direct dental treatment costs account for 4.6% of global expenditure (>120 billion in North America alone),⁵² compelling dental-medical practice reintegration in some countries and US states, in response to medical practice redesign accelerated by the 2015 accountable care initiative. Accountable care focus in the context of diabetes has increased quality care and cost reductions through proactive practice re-design.

To date, the most effective clinical management of dysglycemic patients currently defined are aligned with ICMs (examples summarized in Table 5). Successful models implementing dental interventions (examples in Table 1 and 4) may be similarly responsive but require portability assessment. Incorporation of additional patient-centric performance measures to balance current metrics has been promoted⁵³ and quality measure implementation is essential to tracking efficacy of ICM implementation.

Improvement in clinical outcomes was demonstrated by a meta-regression analysis of >100 randomized controlled/uncontrolled trials among diabetic populations in studies incorporating chronic care model components.⁵⁴ Chronic care model components center on integration of adequate resources, evidence-based policies, and operational delivery design of the healthcare institution (to include committed, appropriate primary care provision, patient diabetes self-support education, and availability of electronic health records for data capture and quality tracking). Evidence-based review supported adoption of chronic care components as the ideal infrastructure for achieving successful clinical practice redesign.⁵⁵ Specifically, the following elements were distilled as the most effective contributors to diabetic management: professional education/intervention, establishment of provider champions, self-support and self-management patient education facilitated by nurse practitioners, adherence to CPGs, implementing process measures, and performance feedback.⁵⁵ These parameters underline the critical need for inclusion of dental providers as primary care providers and increased visibility of oral health in CPGs.

Public Health Perspectives

Access to dental care for low income and disparity populations persists as an issue with major impact on quality of life. Dental service cost in the United States in 2014 was \$113.5 billion, with an estimated 40% constituting out-of-pocket

cost,⁵⁶ disproportionately impacting disparity populations. To address persistence of access disparity, just under half of US states have dental coverage allowances for high-risk Medicaid patients with high prevalence of periodontitis and complex diseases including diabetes. Integration of public health with dentistry and medicine was recently advanced as the healthcare service delivery model for underserved populations, but efficacy research in this area is sparse.⁵⁷ Due to successful interventional models created by Family Health Centers, Centers for Medicare/Medicaid Service continues to partner with Family Health Centers to solve access disparities and reduce cost of care to underserved populations. Guidelines for incorporating improved dental benefits have recently been released to assist the insurance marketplace.^{58,59} While recent studies report cost savings in association with oral health maintenance as a strategic approach to establishing/facilitating glycemic control in diabetic patients,⁶⁰ methodological approaches to analyses have been challenged,⁶¹ and further well-designed studies are needed to validate predictions.

Conclusion and Future Directions

A role for dental providers in risk factor management to delay/prevent diabetes onset/progression has been advanced.⁶² Notably, odds for periodontitis increases proportionally with every unit increase in HbA1c,⁶³ and periodontal treatment was projected to reduce HbA1c with efficacy equivalent to supplementary pharmacological intervention.³⁵ Updates on 'dental recall' clinical guidelines updated in 2011 by the National Institute for Health and Clinical Excellence (scheduled review: 2014) remain pending and periodicity, particularly during treatment, remains to be defined especially for the diabetic population.⁶⁴ Quality tracking implementation in the dental setting would support analyses of dental health outcomes relative to frequency of dental visits in dental patients relative to their oral health status. To date, lifestyle intervention including pharmacological management (Table 5) and bariatric surgery in morbidly obese patients have demonstrated greatest efficacy in delaying/preventing diabetes onset in pre-diabetic individuals, achievement of glycemic control and improvement in oral indices.⁶⁵ In the absence of screening, maintenance of oral health, healthy lifestyles promotion, emphasis on increasing health literacy and emphasis on implementing integrated medical-dental care delivery provide current best practices for mitigating disease onset or progression. Emerging non-invasive technologies surrounding glycemic assessment may mitigate screening barriers in the dental setting and may be incorporated as components of effective ICMs. Resolution of key persistent pivotal barriers to translation of ICMs into clinical care will benefit from more 'A'-level evidence. For example, well designed studies are needed to assess cost effectiveness of addressing periodontitis as a modifiable risk factor in the context of maintaining glycemic control in order to define downstream capacity to leverage health benefits associated with reduction in the levels of oral and systemic inflammatory processes.

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Author Affiliations

*Ingrid Glurich, PhD**; *Gregory Nycz†*; and *Amit Acharya, BDS, PhD**

**Center for Oral and Systemic Health, Marshfield Clinic Research Institute, Marshfield, Wisconsin, USA*

†Family Health Center of Marshfield, Marshfield Clinic, Marshfield, Wisconsin, USA