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THE LINK BETWEEN ORAL HEALTH AND DIABETES COMPLICATIONS

Dr. Khaled Hassan[1], Hassan Abu-Saq[2], Hadi Al-Yami[2], Fahad Al Sawidan[2], Khalid Saud Alotaibi[3], Mishal Alruwaily[3], Zyad Alzarea[4], Adi Alturkistani[5], Mohammad Alsalloom[6], Roaa Abuhadi[7], Atheer Alenazi[8], Rahaf Aljudayi[9], Ibrahim Alqurashi[10]
[1]Consultant Family Medicine, Saudi Arabia.
[2]Najran University, Saudi Arabia.
[3]Imam Abdulrahman bin Faisal University, Saudi Arabia.
[4]Jouf University, Saudi Arabia.
[5]Taif University, Saudi Arabia.
[6]Buraydah Colleges, Saudi Arabia.
[7]Jazan University, Saudi Arabia.
[8]King Saud bin Abdulaziz University for Health Science, Saudi Arabia.
[9]Majmmah University, Saudi Arabia.
[10]King Abdulaziz University, Saudi Arabia.

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Corresponding author: Dr. Khaled Hassan
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Abstract
Background: Although oral health is linked to diabetes, the likelihood of developing acute or chronic diabetic issues as a result of this link remains unknown in Ontario, Canada's most populous province. The impact of self-reported dental health on the chance of developing acute and chronic problems in a group of previously diagnosed diabetics is investigated in this study.
Methodology: Diabetics (n = 5183) who took part in the Canadian Community Health Survey in 2003 and 2007–08 were studied retrospectively. Until March 31, 2016, self-reported oral health status was connected to health interactions in electronic medical records. After self-reporting oral health status, multinomial regression models were used to assess the likelihood of the first acute or chronic problem.
Keywords: Population health, Acute, Oral health, diabetes complications, periodontal disease, Chronic.

Introduction

Diabetes is a serious public health issue around the world. Diabetic is a metabolic illness characterized by hyperglycemia and inadequate insulin secretion or action, which enhances inflammatory immune responses and leads to diabetes complications [1,2]. Diabetes has a prevalence of 3.65 million people in Canada, and it is expected to rise by more than 30% in the next decade, resulting in rising health-care expenses, morbidity, and early mortality [3]. The present prevalence of diabetes in Ontario, Canada's most populous province exceeds national estimates, implying that public health intervention is required [4]. The association between diabetes and periodontal disease has gotten a lot of attention since the US Surgeon General's Report on oral health in 2000, which put a lot of emphasis on the interaction between dental and systemic health [5]. Periodontal disease is a chronic inflammatory disorder in which the oral tissues that support teeth are destroyed [6]. Although periodontal disease is most usually thought of as a consequence of diabetes, data suggests that there is a bidirectional link between the two disorders [7, 8]. Periodontal disease, which is caused by microbial dysbiosis, triggers a low-grade host immune response that can lead to systemic inflammation [9, 10]. The shift in symbiotic microbial communities of periodontal tissues, in particular, contributes for an increased immune defense mechanism that leads to periodontal tissue damage [9, 10]. Hyperglycemia, in turn, causes changes in cell function, faulty neutrophil apoptosis, oxidative stress, and excessive synthesis of inflammatory mediators in diabetics, all of which aggravate insulin resistance and lead to health problems [6, 11, and 12]. Diabetes health outcomes and complications are hypothesized to be influenced by a shared inflammatory mechanism between periodontal disease and diabetics [13, 14]. Acute and chronic diabetes problems are distinguished, while chronic complications are further divided into microvascular and macrovascular types [13]. Stroke, myocardial infarction, renal failure, lower limb amputations, and vision loss are among the diabetes complications with the highest prevalence and cost to the Canadian health-care system. [3, 15]. Although the molecular mechanisms underlying acute and chronic problems have long been contested, there is considerable agreement on their distinctions and the likelihood of a continuum from acute to chronic [13, 16]. Changes in metabolic regulation, notably hyperglycemia, have been associated with acute complications of diabetes [13, 17]. Chronic hyperglycemia, on the other hand, is widely thought to be the primary determinant of chronic diabetes complications. Insulin resistance and macrovascular damage, on the other hand, are reported to play a significant

influence [13, 17]. The “bidirectional” relationship has been thought to be driven by diabetes, insulin resistance, and increased immunological inflammatory pathways [1, 2, 18–20]. Insulin resistance and increased immunological inflammatory pathways have been proposed as the driving force in the "bidirectional" relationship between periodontal disease and diabetes [1, 2, 18–20]. Studies have looked at the effect of periodontal treatment on blood sugar levels and lipid profile markers to assess the impact of periodontal disease on diabetic health [2, 19, 21, 22]. Periodontal treatment was observed to lower blood sugar levels, cholesterol levels, and high-density lipids in diabetics, suggesting that periodontal disease may play a role as a risk factor [21]. In diabetics, periodontal care has also been linked to fewer health issues, hospital admissions, and overall medical and pharmaceutical costs. However, there has been no research on oral health and diabetes in Canadian communities, and there is a scarcity of population-level evidence confirming the epidemiological link between oral and diabetes health in general [26]. This study attempts to determine the likelihood of future acute and chronic issues among diabetics in Ontario, Canada's most populated province, who have self-reported oral health status.

Material and Methods

Participants and study design

A retrospective cohort research was conducted to determine the likelihood of acute and chronic diabetic complications in Ontario individuals who self-reported their oral health status. Participants were chosen from a pool of respondents questioned in the Canadian Community Health Survey (CCHS) in 2003 and 2007–08 [27]. The Canadian Community Health Survey (CCHS) is a national survey that uses a multi-stage, stratified, clustered-probability survey sample design that is representative of 98 percent of the Canadian population [28]. Statistics Canada administers the survey, which collects self-reported health information from Canadians over the age of 12 who are not residents of indigenous reserves, institutions, or full-time members of the Canadian armed services [28]. The CCHS approach is described in detail elsewhere [28]. Residents of Ontario over the age of 40 who had a confirmed diabetes diagnosis were excluded from the study. Health system interactions among these participants can be tracked since all citizens of the province of Ontario are insured by a single payer insurance system, the Ontario Health Insurance Plan (OHIP). Health interactions in electronic medical records kept by the Institute for Clinical Evaluative Sciences (ICES) were monitored from the initial CCHS interview date until March 31, 2016, using de-identified health card numbers. The Ontario Diabetes Database (ODD), an ICES-derived disease registry collecting physician-diagnosed diabetes cases in Ontario, was used to confirm a validated diabetes diagnosis. Individuals over the age of 40 who participated in the oral health component of the CCHS and had an ODD confirmed diagnosis of diabetes made up the final study population. Individuals were omitted if their electronic medical records could not be linked, if they were OHIP-ineligible during the follow-up period, or if they did not indicate their oral health condition during the survey administration. The total number of participants in the final analytical sample was 5183, representing a weighted sample of 1.31 million Ontario people. The University of Toronto Research Ethics Board granted ethical approval for this study, which was followed by ICES approval for data. Kaura Parbhakar and colleagues Page 2 of 9 BMC Oral Health (2020) 20:66 Page 2 of 9 Sunnybrook Hospital in Toronto, Ontario.

Oral Health Status

For the province of Ontario, the CCHS cycles 2003 and 2007–08 were chosen due to the availability of oral health data [28]. The question "would you say the health of your teeth and mouth is excellent, very good, good, fair, or poor?" was used to measure self-reported oral health status. The exposure variable was re-categorized into two values representing “good to excellent” and “poor to fair” oral health categories based on the distribution of self-reported oral health status among study participants and to determine the differences between positively and negatively inclined oral health responses. The content of the CCHS on oral health is explained in further detail elsewhere [28].

Diabetes Complications

The first diabetes problem experienced by individuals following the CCHS interview date was the primary outcome of this study. Hospitalization and emergency department records were used to extract complications.

Diabetes-specific complications were extracted from these data using International Classification of Disease (ICD-9) codes [30]. Myocardial infarction, stroke, skin infections, amputation, dialysis, and retinopathy were among the acute problems; chronic complications included myocardial infarction, stroke, skin infections, amputation, dialysis, and retinopathy. Following the CCHS interview, individuals were divided into three groups: those who had no complications, those who had an acute issue, and those who had a chronic complication.

Covariates

The demographic features, health behaviors, and medical histories of CCHS participants were used as covariates in the study because of their link to dental health and diabetes outcomes. Age, sex, income, education, rural/urban index, race, physical activity, smoking status, alcohol consumption, dental visits, BMI, prior co-morbidity, diabetes duration prior to interview date, stress, community sense of belonging, health care visits prior to the complication, and self-reported overall health were among the covariates. All other factors were categorical, with the exception of age, BMI, and diabetes duration. To examine the influence of a dated or early diabetes diagnosis, the duration of diabetes prior to the interview date was employed. Participants were divided into two groups based on their co-morbidity at the time of the interview: those with no co-morbidity and those with any of the following conditions: arthritis, chronic obstructive pulmonary disease (COPD), heart disease, or stroke. Extraction of OHIP codes for visits to a general practitioner or specialist was used to

assess health care visits. Participants who saw their general practitioner, specialist, or both general and specialist practitioners for diabetes care were divided into three categories.

Statistical analysis

All variables were evaluated for their relationship with self-reported oral health, beginning with baseline characteristics. The means and standard deviations of continuous variables were expressed using T-tests, while the cross tabulation frequencies of categorical variables were expressed using Chisquared tests. The multi-categorical outcome performed bivariate analysis. Following the baseline and bivariate analyses, variables with a p-value 0.25 were included, and the most parsimonious model was created [32]. Variables that did not achieve a p-value of 0.25 but were linked to the exposure or outcome in the literature were also incorporated into the model. The probabilities of developing an acute or chronic result following the interview date were determined using multinomial logistic regression models among participants reporting "poor to fair" oral health. For diabetes complications related with dental health, multinomial odds ratios with confidence intervals were calculated, with those reporting "good to excellent" oral health status and no diabetes issues following the interview date serving as the reference group. The explanatory variable was oral health, and variables were included in the model if they were relevant. Bootstrapping sample weights provided by Statistics Canada were applied to the analysis to adjust for the complex nature of the CCHS survey design. This generated inferable estimates for the Ontario population. All statistical analyses were performed using SAS version 9.4 and data was accessed at Sunnybrook Hospital ICES Central in Toronto, Canada. PROC SURVEY MEANS, PROC SURVEYFREQ and PROC SURVEYLOGISTIC were used in the analysis [33].

Results

At ICES, computerized medical records were used to track 5183 diabetics over the age of 40. As seen in Table 1, 38 percent of those with "poor to fair" oral health had a diabetes problem. Kaura Parbhakar et al. BMC Oral Health (2020) 20:66 Page 3 of 9.

Table 1 Type of diabetes complications experienced by participants self-reporting their oral health status ($n = 5183$; $N = 1,308,911$)

Oral Health Status	Complication Type			Total
	No complication	Acute complication	Chronic complication	
Good to Excellent	2693 (66%)	199 (5%)	1198 (29%)	4090
Poor to Fair	674 (62%)	55 (5%)	364 (33%)	1093
Total	3367	254	1562	5183

Chronic problems were found to be prevalent in 33% of this subgroup. In comparison, 34% of individuals who said their oral health was "good to excellent" had a problem. Chronic problems were found to be prevalent in roughly 29% of this population. Acute problems occurred at a comparable rate in both groups, around 5% in both. Table 2 shows the baseline characteristics of individuals based on the kind of diabetes result. Participants who did not have a complication had an average age of about 62 years, while those who had an acute or chronic issue had an average age of around 65 years. The majority of individuals who did not have a complication were also men with higher self-reported income. Individuals who self-identified as white, lived in metropolitan regions, and had a post-secondary education made up the majority of the study sample. They were also current smokers, regularly drank alcohol, led sedentary lifestyles, and had not seen a dentist in the previous 12 months. Table 3 shows the difference in the chance of an acute or chronic diabetic complication among study participants using odds ratios. The risks of an acute complication against no complication were 10% higher in the fully adjusted multinomial model among patients reporting "poor to fair" versus "good to excellent" oral health [OR = 1.10, 95 percent CI 0.81, 1.51]. The odds of those experiencing a chronic complication in the final model, versus no complication among participants reporting "poor to fair" versus "good to excellent" oral health was 34% greater [OR = 1.34, 95% CI 1.11, 1.61]. Age and income differences among participants were not significantly linked with the likelihood of acute and chronic complications among the factors included in the multinomial model. Because sex was not found to be linked with the study outcome in the bivariate analysis, it was included as an interaction variable in the fully adjusted model. However, every unit increase in age had no effect on the chance of acute or chronic complications versus no complications in both males and females. Education levels, self-reported overall health, smoking, and dental visits all show trends. When it came to education levels, those with a secondary school certificate or less had a higher risk of acute and chronic problems than those with a post-secondary degree. Similarly, the further a study participant's self-reported overall health was from "good to outstanding," the higher their risk of problems. In comparison to individuals who had visited the dentist more than twice in the previous year and those who had never smoked, those who had fewer dental visits and current smoking exhibited similar tendencies. There was a tendency among individuals who drank alcohol regularly and rarely that was linked to a higher risk of acute complications alone. People who identified as members of an ethnic minority had a higher risk of acute complications and a decreased risk of chronic problems. Surprisingly, those who lived in rural areas had a higher risk of chronic rather than acute complications than

those who lived in cities. In comparison to acute complications, there was only a minor but insignificant increase in the risks for chronic complications for every unit increase in BMI. Those who had comorbidities before the interview date showed a similar pattern, with a higher risk of chronic problems. Those who had diabetes for a longer period of time prior to the interview date, on the other hand, were shown to have a higher risk of acute complications than those who had diabetes for a shorter period of time. Those who had only had interaction with a general physician prior to any difficulty had a lower chance of suffering acute or chronic difficulties. Those who only had interaction with an expert, on the other hand, were at a higher risk. The reference group consisted of those who had contact with both a general physician and a specialist.

Table 2 Baseline weighted characteristics of study participants according to type of complication outcome (n = 5183; N = 1,308,911)

Baseline Characteristics	Diabetes Complications		
	No Complication (n = 3367)	Acute Complication (n = 254)	Chronic Complication (n = 1562)
Age (Mean, ±SD)	61.6 ± 0.4	64.8 ± 1.4	65.6 ± 0.7
Sex (% Male)	51.8	42.2	44.1
Race (%White)	72.7	80.9	82.4
Income (%)			
Quintile 1	14.7	19.0	18.1
Quintile 2	13.2	9.8	15.1
Quintile 3	20.4	16.2	17.8
Quintile 4	19.2	17.7	22.0
Quintile 5	17.9	21.1	14.7
Education (%)			
< Diploma	21.0	33.8	31.9
Diploma	12.3	13.1	16.3
Post-Secondary	61.6	48.4	49.2
RIO (%)			
Urban	92.3	91.0	87.7
Rural	7.7	9.0	12.4
Chronic disease (%)	49.6	65.8	64.4
BMI (Mean, SD)	27.8 ± 0.2	28.4 ± 0.8	28.6 ± 0.3
DM duration (years) (Mean, SD)	6.4 ± 0.2	10.4 ± 0.5	7.4 ± 0.2
Stress (%)	43.2	38.7	39.9
Health status (%)			
Health status (%)			
Excellent	6.5	3.9	4.7
Very good	21.9	8.1	16.1
Good	38.2	33.1	31.0
Fair	23.4	32.6	30.8
Poor	10.0	22.3	17.9
Community belonging (%)	66.7	65.5	64.4
Smoking (%)			
Current	13.5	21.3	17.6
Former	46.8	46.8	48.2
Never smoked	39.7	33.3	34.2
Alcohol use (%)			
Regular	46.2	31.9	41.2
Occasionally	18.3	23.8	21.7
Former	30.8	39.8	31.4
Never drank	4.7	4.5	5.9
Activity index (%)			
Active	17.9	14.4	17.7
Mod. active	21.9	13.7	19.1

Table 2 Baseline weighted characteristics of study participants according to type of complication outcome (n = 5183; N = 1,308,911) *(Continued)*

Baseline Characteristics	Diabetes Complications		
	No Complication (n = 3367)	Acute Complication (n = 254)	Chronic Complication (n = 1562)
Inactive	60.2	71.8	63.1
Dental visits (%)			
0/year	37.6	46.2	45.8
1–2 Visits/year	45.5	42.2	40.1
> 2 Visits/year	16.9	11.7	14.1
Health care visits (%)			
General Physician	11.1	2.3	3.1
Specialist	8.7	15.6	12.2
GP + SP	80.2	82.1	84.7

*Note: percentages may not add up to 100% because of missing categories or rounding

Discussion

After controlling for a wide variety of confounders, the findings show that "poor to fair" self-reported oral health is linked to a higher risk of chronic problems than acute difficulties. This is consistent with studies that show diabetics with periodontal disease or who do not undergo periodontal therapy have higher medical costs and more hospitalizations, indicating a link between periodontal disease and chronic diabetes problems [24, 25, 34–37]. In Ontario, Canada, this study sheds light on the possibility of problems among diabetes. Many hypotheses based on the microbial dysbiosis of periodontal disease have been established during the last century to explain the oral-systemic relationship [38]. . Systemic health is assumed to be impacted by oral infections by direct invasion or indirect stimulation of immune-inflammatory responses [38, 39]. Scientists found stronger support for the idea of indirect invasion, which may explain the bidirectional influence of periodontal disease, due to the discrepancy of evidence on direct invasion [36, 38, 39]. . Although our findings does not claim causation or favor one explanation over the other, the increased risk of chronic problems in our study could be explained by the concept that periodontal disease and diabetes are linked through indirect enhanced immune inflammatory responses [40–42]. However, in order to understand why diabetics with "poor to fair" dental health have a higher risk of chronic complications than those with "good" oral health, it is necessary to understand the differences in the mechanisms of acute and chronic diabetes complications. The evidence implies that metabolic abnormalities and hyperglycemia are at the root of acute diabetic problems [13, 17]. Insulin resistance, which can cause micro- and macrovascular damage, is another feature of chronic complications [13, 16, 17, 43]. Although many clinical trials have looked at the effect of periodontal treatment on blood sugar levels, few have looked at lipid markers like cholesterol, triglycerides, and high-density lipids, which are important contributors to insulin resistance and are linked to more chronic complications [44–48]. However, in this study [49], BMI was not found to have a significant effect on either acute or chronic problems, despite its use as a predictive indicator for insulin resistance. Further research into this component of the proposed bidirectional link could provide insight into preventive treatments, as insulin resistance may be the connecting factor for periodontal disease and chronic diabetic problems. This may give support for parallel demands for enhanced access to dental treatment in Canada and better diabetes control at the public health level, for example, where health outcomes, health expenditures, and improved quality of life are of concern. Improvements in the quality of life of diabetics [52] and decreases in inefficient healthcare costs, such as physician and emergency department utilization for oral health-related problems [50, 51]. This research has a number of advantages. It has primarily been done at the population level, allowing for population-based inferences for diabetics over 40. Second, in contrast to most of the present literature [24, 25], we used a validated diabetes diagnosis. In contrast to observational research, our retrospective participant selection and longitudinal follow-up allows us to make claims that go beyond a simple link between self-reported dental health and diabetes problems. In this study, the utilization of self-reported oral health is also a strength. Self-reported oral health is a practical measure for examining the diabetes health experience because it is multi-faceted in nature, representing the social, psychological, economic, and cultural components of oral health [53–55]. Self-reported oral health state is congruent with the clinical requirement for oral care, according to research [56]. This measure might potentially be used to estimate the risk of diabetes problems among diabetics, as well as a way to promote health literacy and increase the referral network for diabetics in need of dental treatment [57]. Despite these advantages, there are some significant drawbacks to consider. Self-reported oral health status can

be a useful tool for predicting oral health requirements, but it may not be a reliable indicator of clinical periodontitis [54]. Self-reported oral health can be extremely specific but not sensitive, according to the data [56]. As a result, participants in the current study may be able to indicate that they do not have periodontal disease with more accuracy than those who do [56]. Diabetics, on the other hand, appear to be more conscious of their periodontal disease state [58, 59]. Despite the fact that clinical measurements of periodontal disease and diabetes control would give our study more strength, such measures have not yet been connected to electronic medical records in Canada. Using the ODD has the drawback of not being able to differentiate between type 1 and type 2 diabetes [29]. This limitation may overestimate results because the periodontal disease-diabetes link is based on the pathological mechanism of adult onset diabetes; however, because more than 95 percent of the ODD is made up of type 2 diabetics and the sample was restricted to participants over the age of 40, the impact of type 1 diabetics is minimal and does not arguably impact the study results.

Table 3 Odds ratios and 95% confidence intervals from a fully adjusted multinomial logistic regression for the relation between self-reported oral health and diabetes complications

	Diabetes Complications			
	Acute vs. No complication		Chronic vs. No complication	
	Odds Ratio	95% CI	Odds Ratio	95% CI
Self-reported oral health				
Good to excellent	1.00	—	1.00	—
Poor to fair	1.10	0.81, 1.51	1.34	1.11, 1.61
Age	1.00	0.99, 1.02	1.02	1.01, 1.03
Age*Sex				
Male	1.00	—	1.00	—
Female	1.00	1.00, 1.01	0.99	0.99, 0.99
Race				
White	1.00	—	1.00	—
Ethnic minority	1.12	0.73, 1.70	0.76	0.58, 0.99
Income				
Quintile 1	0.34	0.21, 0.55	0.94	0.71, 1.25
Quintile 2	0.30	0.19, 0.49	1.08	0.80, 1.46
Quintile 3	0.35	0.22, 0.54	0.69	0.54, 0.89
Quintile 4	0.46	0.30, 0.71	1.04	0.81, 1.33
Quintile 5	1.00	—	1.00	—
Education				
< Diploma	2.39	1.85, 3.10	1.61	1.28, 2.03
Diploma	1.53	1.04, 2.24	1.69	1.37, 2.10
Post-secondary	1.00	—	1.00	—
Rurality index of Ontario				
Urban	1.00	—	1.00	—
Rural	1.18	0.84, 1.65	1.48	1.26, 1.74
Chronic disease	1.05	0.81, 1.36	1.35	1.15, 1.59
< Diploma	2.39	1.85, 3.10	1.61	1.28, 2.03
Diploma	1.53	1.04, 2.24	1.69	1.37, 2.10
Post-secondary	1.00	—	1.00	—
Rurality index of Ontario				
Urban	1.00	—	1.00	—
Rural	1.18	0.84, 1.65	1.48	1.26, 1.74
Chronic disease	1.05	0.81, 1.36	1.35	1.15, 1.59
BMI	1.00	0.98, 1.02	1.01	1.00, 1.02
DM duration	1.22	1.18, 1.25	1.03	1.01, 1.04
Self-reported general health				
Excellent	1.00	—	1.00	—
Very good	0.44	0.04, 5.19	0.83	0.57, 1.20
Good	1.06	0.09, 12.64	0.87	0.60, 1.26
Fair	1.32	0.11, 15.78	1.11	0.78, 1.59
Poor	1.76	0.14, 22.56	1.53	1.01, 2.33
Smoking				
Current	1.77	1.08, 2.88	1.17	0.90, 1.51
Former	1.06	0.77, 1.46	0.90	0.76, 1.07
Never smoked	1.00	—	1.00	—
Dental Visits				
0/year	1.68	1.19, 2.39	1.27	1.04, 1.55
1–2 Visits/year	1.68	1.62, 2.44	1.05	0.84, 1.31
> 2 Visits/year	1.00	—	1.00	—

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Table 3 Odds ratios and 95% confidence intervals from a fully adjusted multinomial logistic regression for the relation between self-reported oral health and diabetes complications *(Continued)*

	Diabetes Complications			
	Acute vs. No complication		Chronic vs. No complication	
	Odds Ratio	95% CI	Odds Ratio	95% CI
Alcohol use				
Regular	1.05	0.40, 2.75	0.63	0.40, 1.00
Occasionally	1.82	0.69, 4.75	0.86	0.53, 1.41
Former	1.43	0.57, 3.59	0.64	0.41, 1.01
Never drank	1.00	–	1.00	–
Health care visit				
General Physician	0.73	0.18, 2.94	0.38	0.20, 0.70
Specialist	1.52	0.67, 3.45	1.36	0.99, 1.87
GP + SP	1.00	–	1.00	–

Conclusion

Overall, the findings of this study indicate the need to better understand the link between oral health and diabetes problems. Within its limitations, "poor to fair" oral health was linked to a higher risk of chronic complications than acute difficulties, offering useful information for diabetes patients in the province of Ontario, Canada.

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