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Association between dental visits at primary care and glycated hemoglobin level in patients with type 2 diabetes: a cohort study

Associação entre visitas odontológicas na atenção primária e níveis de hemoglobina glicada em pacientes com diabetes tipo 2: estudo de coorte

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ABSTRACT: _Objective:_ To evaluate the association between dental visits and variation in the glycated hemoglobin index (A1C) of patients with type 2 diabetes (T2DM) with well or not well glycemic control over time. _Methods:_ Patients with T2DM, A1C ≥ 7% (not well-controlled) and < 7% (well-controlled), who attended a primary care service and were followed up from January 2010 to May 2018. The outcome was the variation of A1C obtained from reference laboratories. At the beginning of the study, a questionnaire with behavioral, clinical, and socioeconomic information was carried out. Multiple linear regression analyses tested interaction terms of all variables with the initial glycemic level (not well-controlled or well-controlled). _Results:_ The sample consisted of 507 people, 65% women, and 66% individuals 55 to 74 years old, followed on average for 5.4 years. There was an interaction (p = 0.01) between dental visits and initial A1C. Patients not well-controlled with at least one dental visit had an average reduction in A1C of -0.56 percentage point (95%CI -1.06 – -0.56), whereas the well-controlled group who also had at least one dental visit had an increase of 0.34 percentage point (95%CI -0.18 – 0.87). _Conclusion:_ Dental visits were associated with an improvement in A1C of approximately a half-percentage point in patients who had the initial A1C considered as not well-controlled.

Keywords: Diabetes mellitus. Primary health care. Oral health. Dental care.

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RESUMO: *Objetivo:* Avaliar a associação entre consultas odontológicas e variação no índice de hemoglobina glicada (A1C) em pacientes com diabetes *mellitus* tipo 2 (DM2) com controle glicêmico bom ou não ao longo do tempo. *Métodos:* Pacientes com DM2, A1C ≥ 7% (não controlado) e < 7% (bem controlado), que compareceram a um serviço de atenção primária e foram acompanhados de janeiro de 2010 a maio de 2018. O desfecho foi a variação de A1C, obtidos em laboratórios de referência. No início do estudo, foi aplicado um questionário com informações comportamentais, clínicas e socioeconômicas. Foram ajustados modelos de regressão linear múltipla para controle de fatores de confusão, e testou-se a interação de todas as variáveis com o nível glicêmico inicial (não controlado ou controlado). *Resultados:* A amostra foi composta de 507 pessoas, 65% mulheres e 66% indivíduos de 55 a 74 anos, acompanhados em média por 5,4 anos. Houve interação (p = 0,01) entre as consultas odontológicas e níveis iniciais de A1C. Pacientes não controlados com pelo menos uma consulta odontológica tiveram redução média de A1C de -0,56 pontos percentuais (intervalo de confiança de 95% — IC95% -1,06 – -0,56), enquanto o grupo controlado que também teve pelo menos uma consulta odontológica teve aumento de 0,34 ponto percentual (IC95% -0,18 – 0,87). *Conclusão:* As visitas ao dentista foram associadas à melhora na A1C de aproximadamente meio ponto percentual em pacientes que tiveram a A1C inicial considerada não bem controlada.

Palavras-chave: Diabetes mellitus. Atenção primária à saúde. Saúde bucal. Assistência odontológica.

INTRODUCTION

The global prevalence of Diabetes Mellitus (DM) has greatly increased over the last decades, especially in low and middle-income countries[1]. Both the disease and its complications or comorbidities are important risk factors, causing deaths worldwide[2]. According to the Global Disease Burden Study, the participation of Type 2 Diabetes Mellitus (T2DM) was the most significant among the chronic non-communicable diseases in the Brazilian epidemiological scenario in 2008, ranking among the top five disorders of the disease burden in the country[3]. Considering the current and growing load involved, actions to control and prevent DM are an urgent public health issue[4].

The treatment of a patient with T2DM aims to maintain adequate blood glucose levels since chronic hyperglycemia is associated with micro and macrovascular complications[5]. Several oral diseases have also been reported in these patients, as greater severity and prevalence of periodontitis[6-8], more tooth loss[6,9], higher caries index[10,11], increased prevalence of candidiasis[12], xerostomia[12], and oral cancer[6].

In particular, the association between periodontal disease and DM has been extensively explored over the years, and it is the only one among these conditions considered with a bidirectional effect in the control of glycemia[13]. On the one hand, there is increased prevalence and severity of periodontal disease among patients with diabetes[14] and, on the other, there is the possibility of the periodontal disease to raise systemic inflammatory burden and contribute to increased risk of complications[15]. However, few studies in the literature about the influence of access to dental care in a primary health care scenario have been found.

Controlling the common risk factors for many chronic non-communicable diseases can be a shared role for oral health professionals[16]. Oral health is also determined by diet, hygiene, smoking, alcohol use, stress, and trauma, and a collaborative approach related to these factors can promote better health status with reduced cost, increased effectiveness, and efficiency than adopting isolated approaches[17]. Considering Primary Health Care as an essential setting to promote the health of patients with T2DM, in which oral care is included, the present study aims to evaluate the association between dental visits and variation in the glycated hemoglobin index (A1C) of patients with type 2 diabetes (T2DM) with well or not-well glycemic control over time.

METHODS

STUDY POPULATION AND DATA COLLECTION

A fixed cohort study was performed in adult patients with T2DM residents in the area covered by the Community Health Service of the Conceição Hospital Group (CHS/CHG). The CHS/CHG is a public service integrated with the Brazilian Unified Health System (SUS) and based on Primary Health Care principles in Porto Alegre, a city in Brazil's southern region. From the population enrolled in the CHS/CHG system (~108 thousand people), it was estimated that 8% had T2DM. The Research Ethics Committee approved the study protocol of Nossa Senhora da Conceição Hospital (Protocol No. 10261). The written Informed Consent Form was obtained from all participants included in the study.

The cohort's time frame started in 2011; when structured interviews were conducted at the participants' houses, the study was called "Evaluation of Health Care in Hypertension and Diabetes in Primary Care". The baseline sample was randomly selected from those enrolled in the CHS/CHG health information system. To participate in research cited, individuals had to meet the following inclusion criteria:

- having a confirmed diagnosis of hypertension or diabetes (using clinical and laboratory standard tests) in the CHS/CHG Service Information System that included clinical and laboratory exams in 2009-2011 (before the interviews);
- having consulted in the health system at least once in the three years before the study recruitment;
- being 18 or older by March 1st, 2009.

Out of 9,059 eligible patients (baseline), a randomized selection of 3,784 individuals was performed, of which 2,482 were effectively enrolled (65.6% response rate)[18]. The exclusions occurred due to individuals not being found after four attempts, refusal to participate, change of address, or death. The selection process is illustrated in Figure 1.

Socioeconomic, demographic, behavioral, and lifestyle data were obtained retrospectively in 2011 from structured interviews conducted at the participants' houses by a company

Figure 1 Flowchart of sample selection at baseline (2009–2011) and last follow-up (2018)
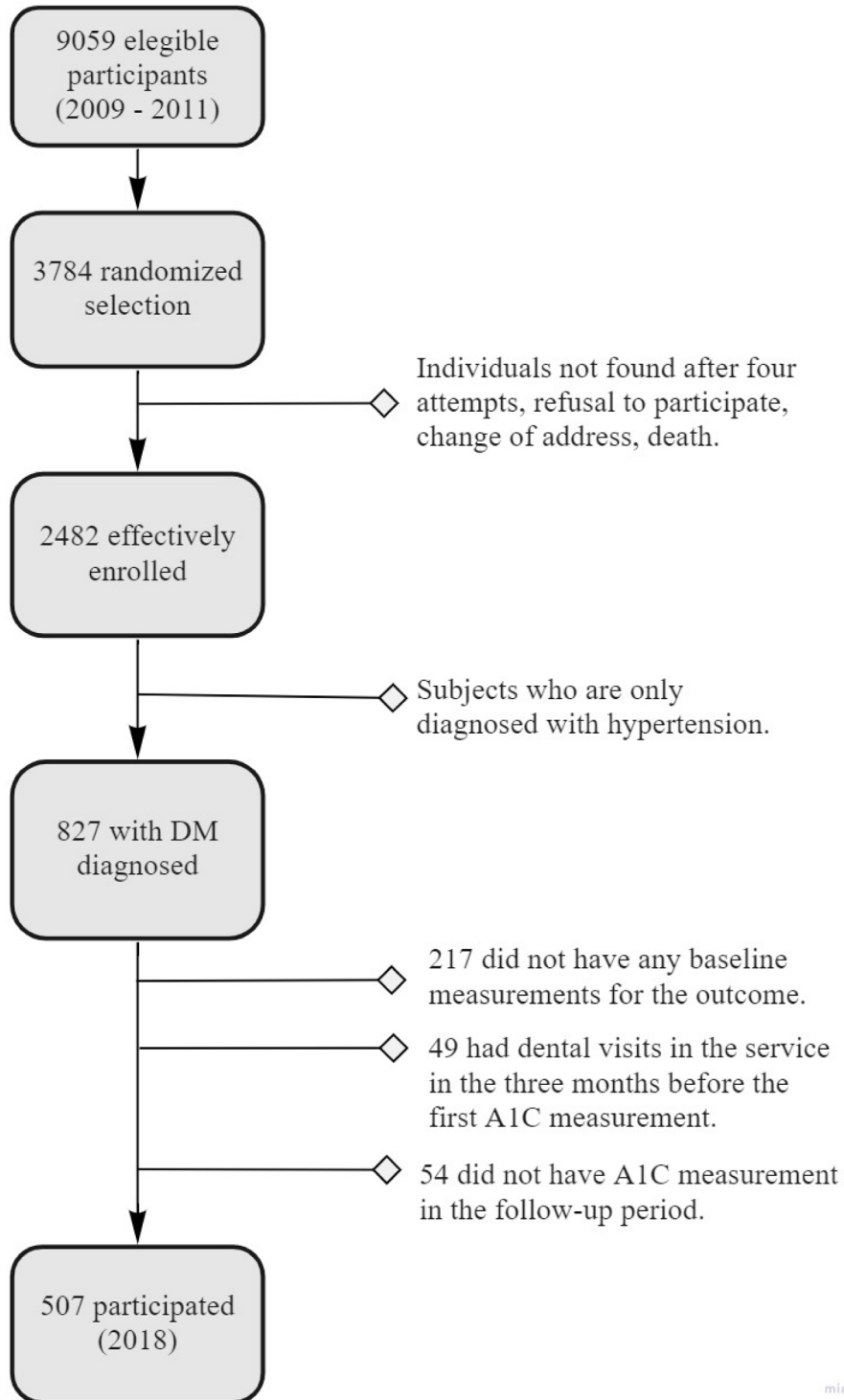
specialized in population studies. Trained interviewers conducted data collection using questionnaires only; they were not health professionals[18]. Baseline clinical data were obtained from existing information in the CHS/CHG health information system between 2010–2012. Therefore, the first measurement of A1C dates from 2010–2012. The final A1C measurement dates from 2012–2018.

For present research, 1,655 subjects who were only diagnosed with hypertension without diabetes were excluded. Besides them, other 217 were excluded because they did not have any baseline measurements for the outcome. Since dental visits were the primary variable of interest, 49 additional people were also excluded because they had dental visits in the service in the three months before the first A1C measurement, and this visit could affect the patient's average blood glucose levels and the first A1C measurement. From the 561 patients that started, 54 were lost because they did not have A1C measurement in the follow-up period between 2013 and 2018 (9.6% attrition rate).

The sample was divided into two groups, according to the initial glycemic control. Participants with the initial A1C lower than 7% were considered the well-controlled group, and those equal to or greater than 7% were the not well-controlled group. Glycemic control goal for most patients with T2DM is known for maintaining the A1C measurement below 7%; a more or less rigid target may be indicated depending on individual characteristics, such as the presence of comorbidities and type of treatment adopted.

OUTCOME VARIABLE AND MAIN EXPOSURE

The primary exposure was dental visits for any reason (dental check-up, oral diagnosis, urgent care, prevention, treatment) in the CHS/CHG during the period established as a follow-up. This variable was obtained from the CHS/CHG health information system and categorized into "no dental visit" during follow-up or "some/several" because the distribution was skewed, and few individuals had more than one visit.

The outcome was the change in glycemic control from baseline to the final measurement (incidence measure) in the system regarding the hemoglobin A1C test measured in percentage points (pp). Such data were obtained in the CHS/CHG health information system, an electronic medical record maintained by health professionals during the follow-up of these patients in the service. A1C change was used as a continuous scale.

COVARIATES

The group of demographic factors included three variables. Gender was defined as male or female. Participants were divided into three age groups: up to 54 years old, between 55 and 74 years old, and equal to or over 75 years old. Marital status was defined as "living with a partner" for individuals who responded that they were married or lived

with a partner, and "living alone" for the respondents who were single, widowed, separated, or divorced.

Socioeconomic factors comprised two variables. The classification criteria of the Brazilian Association of Market Research Companies (Associação Brasileira de Empresas de Pesquisas — ABEP) was used to define the economic situation of participants using the purchasing power and level of education of the head of the household, ranging from the highest to the lowest level, in the A/B, C, and D/E classes. Schooling was measured at educational attainment and dichotomized as < elementary or ≥ elementary school, representing four years of study.

Behavioral and lifestyle factors included six variables. To define adequate or inadequate diet, interviewers asked questions proposed by the Brazilian Food Guide for the Brazilian population about the consumption of fruits, vegetables, fish, fried foods, sausages, sweets, soft drinks, besides the habit of removing visible fat from meats. Diet's adequacy was classified into three levels, according to the points obtained in the questionnaire. These data came from a previous study[19], and for analysis purposes in this work, the category "partially adequate diet" was grouped into the "appropriate diet category". Tow measure of a sedentary lifestyle (yes or no) was obtained, one at baseline and the other closest measure to A1C, according to information filled out by doctors or nurses. According to data in the Information System database, patients were not considered sedentary when performing at least 150 minutes of light or moderate physical activity per week. Smoking was collected in three categories: former smoker, current smoker, or never smoker. DM medication use and attendance at diabetic/hypertensive groups were self-reported and categorized as yes or no. Finally, the number of specific doctor visits for this condition was defined as medical appointments for diabetes and collected from the CHS/CHG health information system.

Two variables on health status were used. Body mass index (BMI) was calculated through the answers obtained on weight and height and interpreted according to the World Health Organization in underweight, normal weight, overweight, and obesity[20]. The number of teeth was obtained from the self-report and dichotomized in the median (< 10 teeth or ≥ 10 teeth).

STATISTICAL ANALYSIS

First, bivariate analyses were performed with the non-parametric Mann-Whitney or Kruskal-Wallis test. Multiple linear regression analysis was carried out by testing interaction terms of all variables with the initial glycemic level (well-controlled *versus* not well-controlled). The final model was adjusted using a backward stepwise technique with $p < 0.10$ if there was a significant interaction at a 5% level. The residuals of the final model were evaluated concerning normality, heteroskedasticity, variance inflation factor, and the presence of outliers with leverage power. For presentation, a stratified table was made with mutually adjusted coefficients. All analysis was performed using the Stata software, version 13.1.

RESULTS

In total, 507 people participated. They were followed for a mean of 5.4 years (maximum of 8.33 and a minimum of 0.45 years). At baseline, 269 patients had initial A1C equal to or greater than 7% and were allocated in the not well-controlled group. They were followed for 5.4 years on average. The remaining 238 individuals had an initial A1C measurement lower than 7%, were part of the well-controlled group, and were followed for 5.3 years on average. The follow-up period length was not statistically significant related to A1C variation (p = 0.81). Table 1 shows the means and the medians of the follow-up time between the first and last A1C measurements.

The descriptive characteristics of participants and bivariate associations between the A1C variation with sociodemographic and behavioral characteristics were shown in Tables 2 and 3. The sample consisted mainly of women (65% of participants) and individuals between 55 and 74 years old (66%). Of the total sample, 55% of the individuals reported living with their partners, and 57% of participants belonged to Economic Class C. At baseline, 72% completed elementary education or more, 41% of the individuals were overweight, and 34% were obese. Only 12% were current smokers, whereas nearly half had never smoked. The diet was considered adequate for 67% of individuals. A sedentary lifestyle was measured with longitudinal data, and 69% of participants started the study and remained sedentary until the last measurement of their last glycemia result. During follow-up, 35% of the total sample did not visit the dentist in the CHS/CHG service. Of those with A1C values of not well-control at baseline, 36% did not visit the Dentist, whereas 34% in the well-controlled group did not visit the dentist.

The overall mean change in A1C was -0.02 pp (± SD 1.95, min = -8.2, median = 0, max = 8.5) in all groups. Among those who initially did not have well-controlled A1C values, the mean reduction was -0.59 pp (± SD 2.16). Among those in the well-controlled A1C group, it increased by 0.63 pp (± SD 1.43) on average in the period.

Table 1 Follow-up time in years between the first and last A1C measurement

	Total sample	Initial A1C ≥ 7%	Initial A1C < 7%
Mean (years)	5.4	5.4	5.3
95%CI	(5.2 – 5.5)	(5 – 5.5)	(5.2 – 5.7)
Minimum/Maximum (years)	0.45 / 8.33	0.45 / 8.33	0.53 / 7.99
25th percentile	4.1	3.9	4.2
Median	6.2	6.1	6.2
75th percentile	6.8	6.9	6.8

A1C: glycated hemoglobin index; 95%CI: 95% confidence interval.

Table 2 Mean change of the glycated hemoglobin (A1C) in percentage points (pp) and standard deviation (± SD) in patients of a Primary Health Care Service, according to the initial values and the association with covariables

	N	Percentage	Change in A1C pp	(± SD)	*p*-value
Total	507	100.0%	-0.02	(1.95)	
Initial A1C					
≥ 7%	269	53.1%	-0.59	(2.16)	< 0.01
< 7%	238	46.9%	0.63	(1.43)	
Gender					
Male	178	35.1%	0.03	(1.88)	0.32
Female	329	64.9%	-0.05	(1.98)	
Age at baseline					
< 55	82	16.2%	0.38	(2.49)	0.04
55–74	332	65.5%	-0.06	(1.92)	
≥ 75	93	18.3%	-0.23	(1.37)	
Diet					
Adequate	340	67.1%	-0.06	(1.96)	0.27
Inadequate	106	20.9%	0.28	(1.94)	
Dental visits					
None	177	34.9%	0.07	(1.63)	0.94
Some/several	330	65.1%	-0.07	(2.10)	
Medical appointments for diabetes melitus					
None	185	36.5%	-0.01	(1.75)	0.11
1 to 2 times	200	39.4%	-0.19	(2.06)	
> 3 times	121	23.9%	0.21	(2.01)	

A1C: glycated hemoglobin index.

Four variables were included in the final multiple linear regression model: dental visits, age, diet, and baseline glycemic control (Table 4), but due to missing in at least one variable, the final analytical sample was 446 individuals. Multiple regression showed that, at baseline, older people reduced the A1C annually on average -0.02 pp (95%CI -0.04 – -0.01) by controlling their diet, glycemic control, and dental visits. Participants with an initial inadequate diet had an increase of 0.34 pp (-0.06 – 0.74) after controlling for age, glycemic control, and

Table 3 Mean change of the glycated hemoglobin (A1C) in percentage points (pp) by intial level of A1C and standard deviation (± SD) in patients of a Primary Health Care Service, according to the initial values and the association with covariables

	Initial A1C ≥ 7%				Initial A1C < 7%			
	Change in pp	(SD)	N	*p*-value	Change in pp	(SD)	N	*p*-value
Total	-0.59	(2.16)	269		0.63	(1.43)	238	
Gender								
Male	-0.66	(2.21)	86	0.63	0.67	(1.20)	92	0.15
Female	-0.56	(2.13)	183		0.60	(1.55)	146	
Age at baseline								
< 55	-0.49	(2.46)	49	< 0.01	1.66	(1.94)	33	0.71
55–74	-0.59	(2.24)	173		0.51	(1.29)	159	
≥ 75	-0.73	(1.44)	47		0.29	(1.09)	46	
Diet								
Adequate	-0.68	(2.12)	181	0.16	0.65	(1.46)	159	0.86
Inadequate	-0.14	(2.17)	56		0.74	(1.54	50	
Dental visits								
None	-0.22	(1.73)	96	0.04	0.41	(1.44)	81	0.02
Some/several	-0.80	(2.34)	173		0.74	(1.41)	157	
Medical appointments for diabetes melitus								
None	-0.56	(2.18)	81	0.27	0.41	(1.16)	104	0.10
1 to 2 times	-0.80	(2.08)	119		0.71	(1.65)	81	
> 3 times	-0.33	(2.20)	68		0.91	(1.49)	53	

dental visits. As to dental visits, in an adjusted model, the well-controlled group presented a non-significant increase of 0.34 pp (-0.18 – 0.87). Simultaneously, participants in the initial well-controlled group showed a reduction of -0.56 pp (95%CI -1.06 – -0.07). When comparing the results of the two groups of patients (well-controlled *versus* not well-controlled), a statistically significant interaction was observed (coefficient for the interaction term 0.90 pp of A1C 95%CI 1.63 – 0.18; p = 0.01). The final model had an R^2 = 13.1%, and the studentized residuals were normally distributed with some right-tail outliers that accounted for heteroskedasticity (Cook-Weisberg test for heteroskedasticity p < 0.01). Almost 10% of

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Table 4 Adjusted variation over the follow-up in glycated hemoglobin in percentage points (pp) and 95% confidence intervals (95%CI), obtained by multiple linear regression stratified by initial values

		Initial A1C ≥ 7%		Initial A1C < 7%		Interaction* (p-value)
		change** in pp	95%CI	change** in pp	95%CI	
Age	(every extra year)	-0.02	(-0.04 – -0.01)	-0.02	(-0.04 – -0.01)	--
Diet	Adequate	ref		ref		
	Inadequate	0.34	(-0.06 – 0.74)	0.34	(-0.06 – 0.74)	--
Dental visits	None	ref		ref		
	Some/ several	-0.56	(-1.06 – -0.07)	0.34	(-0.18 – 0.87)	0.01

*This p-value refers to the interaction term (coefficient estimate = 0.90 A1C p.p. 95%CI 1.63 – 0.18) between the initial A1C and dental visits; **non-interaction terms are fixed coefficients (age and diet); they do not vary by the initial A1C categories.

the sample may be considered outliers. Concerning sensitivity analysis, analysis for outlier removal was reperformed, and the magnitude of interaction was only slightly stronger.

DISCUSSION

The present study showed that patients with initial A1C considered not well-controlled and who visited the dentist had an average reduction of approximately half percentage point in A1C. For example, from 7.56 to 7%, that was statistically significant, whereas the group that already had a good glycemic control had a non-significant increase of 0.34 pp. Clinically, any improvement in glycemic control is likely to reduce the risks of diabetes complications and brings long-term benefits to patients. A previous study showed that each 1pp reduction in A1C reduced the risk of any endpoint related to diabetes by 21%[5].

Different from our findings, a previous study did not find an association between dental visits (defined by the authors as having received prophylactic treatments or periodontal treatments) and glycemic control, choosing as an outcome the dichotomous measure A1C < 7% *versus* A1C < 7%, not the continuous variation of A1C as we did[21]. Another observational study[22] found an association between dental visits related to periodontal treatment and glycemic level, and the reduction found for patients with an initial not well-controlled A1C was -0.035 pp lower than in the present study. The same authors did not find any association when the dental visits were not related to periodontal treatment. Nevertheless, only 8.2% of the sample with a diagnosis of T2DM had consulted the dentist for a non-periodontal reason, whereas 48.7% had received periodontal treatment.

This study also showed that dental visits were associated (statistically non-significant) with an increase in A1C in the controlled group. However, this may be a spurious finding, as there is no previous report to support it, and it does not seem plausible that dental visits would causally increase A1C levels. In support of this argument, CHS/CHG introduced several management measures to improve the health indicators of patients with diabetes to increase both diagnosis and control. Examples include enhancement of access to dental care, an increase in the percentage of diagnosis, and the professionals' qualification involved[18]. Importantly, those measures were generic to all patients with DM and not specific to those well-controlled or not well-controlled. The analyses of present research sought to complement the understanding of the association of only one factor involved: expanding access to dental visits. However, other studies are necessary to measure the effectiveness of the other actions of this qualification.

Based on these managerial measures, there was an increase in the supply of dental visits in the public health service for patients with DM. In 2011, 16% of all DM patients enrolled in the service had at least one dental visit, and it increased to 37% in 2016[23]. A study that qualitatively evaluated dental care in this health service found practices of a new health care model, characterized by clinical performance, beyond the traditional approaches, with more listening and dialogue with patients[24]. Nonetheless, dental care in CHS/CHG is integrated into general health, and dental teams are committed to working with effective prevention and health promotion, as shown elsewhere[25]. Therefore, all these efforts may help diabetic patients in controlling the disease.

The benefits of periodontal treatment for patients with T2DM are now widely known[26,27]. Although data on the dental condition were not available, people with not well-controlled T2DM had an increased prevalence of periodontitis and tooth loss[9,14]. Seen that, these patients could still have benefited more from dental treatment. The Study of Health in Pomerania (SHIP) — a trend that examined the periodontal status of 3,086 patients with T2DM and pre-diabetes found an association between periodontitis and edentulism with poorly controlled diabetes, but not in well-controlled and pre-diabetes patients. Besides that, Workers' Oral Health Study, which examined 5,154 participants in Spain, demonstrated that severe periodontitis was associated with diabetes[8]. Furthermore, the patients in the present study belonging to the not well-controlled group may have received increased attention from health teams concerning the need for blood glucose reduction, besides the benefit of greater control of a more severe periodontal condition.

Among the potentialities of present research, its longitudinal design, long follow-up period, large sample size, and insertion in a health service's practical scenario are highlighted. Besides that, few studies have been found separately evaluating patients with well and not well-controlled status.

Regarding study's limitations, residual confounding may exist, despite controlling for some important confounding measures available in the database, such as medication adherence, diet, BMI, socioeconomic conditions, schooling, marital status, attendance at diabetic and hypertensive groups, and perhaps changes may have occurred in this period. Additionally, no information was available about the type of dental treatment performed, whether it was

completed or not, how it was performed, and for how long. It is also unknown if patients had sought dental treatment outside the CHS/CHG services during the period and how it affected the results. Although some variables are self-reported, measurement bias and validity have been considered acceptable. For example, self-reported weight and height have a remarkably high intra-class correlation (> 0.94), and BMI has high sensitivity and specificity[28]. Finally, the absence of data on dental conditions other than the number of teeth is a limitation that future studies should overcome.

With the increasing burden of morbidity and mortality, coping with T2DM has become a growing challenge in public health, and these patients may benefit from a common risk factor approach. An integrated approach to the main oral problems, such as diet, hygiene, smoking, alcohol use, stress, and trauma is more rational, increases effectiveness and efficiency, and reduces isolation[17]. This work is innovative, as it shows that the dental consultation for any reason and performed in Primary Health Care represent a positive impact on the A1C reduction in a population with T2DM.

It also contributes to understanding the effects of a protocol aimed at increasing the number of dental visits among patients with T2DM. Encouraging visits to the dentist and promoting better oral health conditions may play a relevant role for patients with T2DM in PHC. Further studies are required to better understand all these factors and the relation between receiving dental visits and the A1C of patients with T2DM in PHC.

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