ORIGINAL ARTICLE

Prevalence and correlates of inadequate glycaemic control: results from a nationwide survey in 6,671 adults with diabetes in Brazil

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Abstract Diabetes is a significant public health burden on the basis of its increased incidence, morbidity, and mortality. This study aimed to estimate the prevalence of inadequate glycaemic control and its correlates in a large multicentre survey of Brazilian patients with diabetes. A cross-sectional study was conducted in a consecutive sample of patients aged 18 years or older with either type 1 or type 2 diabetes, attending health centres located in ten large cities in Brazil (response rate = 84%). Information about diabetes, current medications, complications, diet, and satisfaction with treatment were obtained by trained interviewers, using a standardized questionnaire. Glycated haemoglobin (HbA_{1c}) was measured by high-performance liquid chromatography in a central laboratory. Patients with $HbA_{1c} \geq 7$ were considered to have inadequate glycaemic control. Overall 6,701 patients were surveyed, 979 (15%) with type 1 and 5,692 (85%) with type 2 diabetes. The prevalence of inadequate glycaemic control was 76%. Poor glycaemic control was more common in patients with type 1 diabetes (90%) than in those with type 2 (73%), $P < 0.001$. Characteristics significantly associated with improved glycaemic control included: fewer years of diabetes duration, multi professional care, participation in a diabetes health education program, and satisfaction with current diabetes treatment. Despite increased awareness of the benefits of tight glycaemic control, we found that few diabetic patients in Brazil met recommended glycaemic control targets. This may contribute to increased rates of diabetic complications, which may impact health care costs. Our data support the public health message of implementation of early, aggressive management of diabetes.

This study is conducted for the "Brazilian Diabetes Investigators' Group". The members of the "Brazilian Diabetes Investigators' Group" are listed in "Appendix" section.

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Introduction

Diabetes is one of the most prevalent non-communicable diseases globally, presenting a significant public health burden on the basis of its increasing incidence, morbidity, mortality, and economic costs [1–3]. In 2000, estimates from World Health Organization indicated that there were ~170 million people in the world with diabetes, and until 2030, it is expected that the number of cases of the disease worldwide will have more than doubled to 366 million [2]. In the Americas, the number of diabetes cases will change from 33 million to 66.8 million in the same period [2]. Diabetes is associated with serious long-term complications including microvascular and macrovascular disease,

which impose an additional socio-economic burden and account for substantial healthcare costs [1, 3–6].

Evidence from key controlled studies conducted in the past decade established the importance of tight and sustained glycaemic control among type 1 and 2 diabetic patients [7, 8]. These studies have emphasized the central role of consistently managing HbA_{1c} levels in patients with diabetes, as a result, some professional associations proposed clinical guidelines in the range of 6.5–7.0% to motivate health professionals and patients to constantly manage blood glucose levels [9, 10]. Despite the numerous advances achieved in diabetes control and evaluation, the management of such a complex disease remains challenging. Recent epidemiological data from various regions of the world show most patients with diabetes are not controlled to recommended HbA_{1c} targets [11–21]. In addition, estimates of prevalence of inadequate glycaemic control vary widely, in part due to differences in diabetes type, populations surveyed, methods used to collect data, and goals of glycated haemoglobin (HbA_{1c}).

Information about the epidemiology of diabetes in Brazil is scarce and limited. According to a Brazilian study [22], diabetes is the fifth most common reason for hospitalizations and ranks among the 10 major causes of mortality [22]. Thus, diabetes is a major problem in Brazil, with an impact on public heath comparable to that in more developed countries. Knowledge on glycaemic control is of great relevance for planning healthcare programs targeting improved diabetes control. The aim of this study was to estimate the prevalence of inadequate glycaemic control and its correlates in a large multicentre survey of adult patients with type 1 or type 2 diabetes in Brazil.

Materials and methods

Setting and participants

This was a cross-sectional and nationwide survey conducted from February 2006 to March 2007. It was designed to obtain detailed information about glycaemic control and its determinants in the largest possible sample of diabetic adults living in urban areas in Brazil. Study design and reporting format are in accordance with the recommended STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines [23]. As it was not feasible to contact patients directly, the study was based on outpatient diabetes clinics. These centres were located in 10 cities belonging to four Brazilian regions, as follows: Southeast (Belo Horizonte, Campinas, Rio de Janeiro, and São Paulo), South (Curitiba and Porto Alegre), Mid-west (Brasília), and Northeast (Salvador, Fortaleza, and Recife).

The cities included were the largest in their respective regions and nine of them are ranked among the most populous municipalities in Brazil. For the recruitment of diabetes centres, we asked the Brazilian Diabetes Association to identify in each of the participating cities a list of candidate centres, to be chosen from those with longer experience in epidemiological research and where at least 300 adult patients with diabetes were followed per month. According to these criteria, each city contributed with two centres for the sampling of the study participants. All 20 centres invited joined the study; they were classified as a university-affiliated hospital (5), a general public hospital (11), or not-for-profit private hospital (4).

Study population

We selected a sample of all consecutive patients with diabetes mellitus attending each participating clinic during a 30-day period. Eligible cases were adults aged 18 years or older, who had been previously diagnosed by a physician with either type 1 or type 2 diabetes before the survey. Patients who had participated in an intervention trial in the previous 3 months and women who reported a history of diabetes only during pregnancy were not included. Each centre was asked to recruit at least 150 patients. Overall, the response rate was 84% (ranging from 78 to 95%). All participants provided written informed consent, and the study protocol was approved by Ethical Review Boards in each respective city.

Data and specimens collection

A structured questionnaire was administered in person by trained and certified interviewers, not part of the study centre staff. A team of study interviewers was hired and trained by one of the investigators (EDM) in each participating centre. They were given an orientation on the protocol and specific details concerning participation in the study. Prior to study commencement, they all carried out practice sessions with authentic respondents. These preliminary interviews were observed and critiqued by the investigators.

The study questionnaire sought information about diabetes history and main characteristics of each patient. This included self-reported data on socio-demographic and disease factors (age, sex, educational level, marital status, duration of diabetes, number of diabetes-related disorders, etc.); clinical parameters (fasting blood glucose, HbA_{1c}, body mass index [BMI], and blood pressure); and factors related to treatment processes such as actual treatment for diabetes, adherence to treatment, and access to multi professional care (defined as health care delivered by a team comprised by at least, an Endocrinologist or diabetes

specialist, a Nurse, and a Dietitian or Nutritionist). In addition, we also gathered information on self-perception of glycaemic control (using a scale with four levels: poor, fair, good, and very good), and satisfaction with current diabetes treatment (using a single global question: "If you were to spend the rest of your life with your diabetes treatment the way it is today, how would you feel about this? Very satisfied, somewhat satisfied, neither dissatisfied nor satisfied, somewhat dissatisfied, or very dissatisfied"). The questionnaire was piloted on a sample of volunteer patients to refine the wording of items and ensure clarity of the text. All items were assessed for face validity by health survey experts. The individual interviews lasted an average 20–25 min, and the sessions occurred in a private room.

A peripheral blood sample was collected for the measurement of HbA_{1c} in every patient. All measurements of HbA_{1c} were made with an automated high-performance liquid chromatography (Variant Turbo—BioRad) in a central laboratory. The normal value range is 4.0–6.0%.

Statistical analysis

All collected data were double-entered into a computerized database using a word processing, database, and statistics program (EPI INFO version 3.04d, centres for Disease Control & Prevention, USA; World Health Organization, Geneva, Switzerland) with custom-designed algorithms and cross-checks to verify for correctness and internal consistency. The number and percent of diabetic patients who achieved glycaemic control were calculated using a cutpoint $HbA_{1c} < 7.0\%$, as defined in the American Diabetes Association standards of medical care for persons with diabetes [24]. The values of HbA_{1c} were also classified into three arbitrary categories: $<7.0\%$, 7.0–8.9% and $\geq 9.0\%$. The data presented were stratified by diabetes type (1 or 2) and by diabetes duration (<5 years and ≥ 5 years). In some analysis, the data on type 2 diabetes were further stratified by therapeutic regimen in two categories: insulin-treated and non-insulin-treated. Basic descriptive statistics and frequency calculations were performed on all variables; a chi-square test was used to assess differences in answers by categories of stratifying variables, with statistical significance at 5%. All statistics analyses were performed using the "R" statistical software (Version 2.5.0; The R Foundation for Statistical Computing, Vienna, Austria).

Results

Overall 6,701 patients were included in this survey, 979 (15%) with type 1 and 5,692 (85%) with type 2 diabetes.

The characteristics of the study participants are shown in Table 1. The age ranged from 18 to 98 years, approximately 40% of the patients with type 1 diabetes were younger than 35 years, whereas almost all patients with type 2 diabetes were 35 years or older. Most of the study participants were females, married or living with a partner, white, and had attained primary school education or less, regardless of diabetes type. The distribution of BMI categories among the patients with type 1 diabetes revealed that

Table 1 Selected characteristics (%) of 6,671 patients, according to diabetes type, Brazil, 2006

	Diabetes	
	Type 1 (n = 979)	Type 2 (n = 5,692)
Age in years		
<25	18.6	0.2
25–34	21.0	0.8
35–44	21.9	5.6
45–54	19.6	21.5
55–64	13.8	34.7
≥65	5.1	37.2
Female	63.8	66.5
Current marital status		
Married/living with partner	46.4	58.5
Single, never married	39.9	14.2
Divorced/separated	7.5	8.9
Widowed	6.2	18.4
Racial/ethnic background		
White	49.9	45.2
Mixed	35.3	41.1
Black	12.7	12.3
Other	2.1	1.4
Education		
Primary school or less	40.8	72.7
Secondary/high school	43.4	18.7
At least some college	15.8	8.6
Body Mass Index (Kg/m^2)		
Underweight (≤18.5)	4.4	1.6
Normal weight (18.6–24.9)	47.6	28.2
Overweight (25.0–29.9)	32.6	39.8
Obese (30.0–39.9)	13.6	27.9
Morbidly obese (≥ 40.0)	1.8	2.5
Multi professional care[a]	83.4	50.5
Number of diabetes-related complications		
None	34.1	24.0
1	25.7	30.9
2	20.6	25.1
≥3	19.6	20.0

[a] Comprised at least: an Endocrinologist (or diabetes specialist), a Nurse, and a Dietitian (or Nutritionist)

47.6% were classified as normal weight and 15.4% as obese compared to 28.2 and 30.4% among the patients with type 2 diabetes, respectively. Health care delivered by a multi professional team was reported more often by patients with type 1 diabetes (83.4%) than by patients with type 2 diabetes (50.5%).

The prevalence of diabetic patients with inadequate glycaemic control (HbA$_{1c}$ ≥ 7.0%) was 76% (5,044/6,671). Table 2 shows the frequency distribution of HbA$_{1c}$ values in the population studied according to diabetes type and duration. Poor glycaemic control was more common in patients with type 1 diabetes (90%) than in those with type 2 (73%), $P < 10^{-3}$. However, the distribution of HbA$_{1c}$ values in patients with type 2 diabetes (insulin-treated) resembled that found in type 1 patients; whereas patients with type 2 diabetes (non-insulin-treated) were more likely to have a higher prevalence of adequate glycaemic control (35.7%) when compared to patients with type 1 (10.4%) or type 2 (insulin-treated) (9.7%), $P < 10^{-3}$. After stratifying the data by diabetes duration, patients with either diabetes type 1 or 2 lasting 5 years or more were more likely to have worse control than those whose diabetes started <5 years (Table 2).

The frequency distribution for categories of HbA$_{1c}$ values by selected characteristics and diabetes type is summarized in Table 3. There was no significant difference in glycaemic control according to gender, except for type 2 patients (insulin-treated), where females were nearly twice more likely to have adequate glycaemic control (13.1%) than males (7.8%) ($P < 0.001$). Patients with type 1 diabetes or with type 2 diabetes (insulin-treated) cared by a multi professional team were less likely to present HbA$_{1c}$ values in the highest categories than those receiving non-specialist care (Table 3). The self-perception of glycaemic control was associated with HbA$_{1c}$ levels, regardless of diabetes type. Hence, patients who perceived their glycaemic control to be "poor" or "fair" were more likely to fall in the top category of HbA$_{1c}$ values, conversely, patients perceiving their glycaemic control to be "good" or "very good" were more likely to have adequate glycaemic control and to be classified in the lower category of HbA$_{1c}$ values (<7.0%). Ever participating in a group or programme that promotes diabetes health education was associated with lower rates of elevated HbA$_{1c}$ values in patients with type 1 diabetes, but there was no significant difference among patients with type 2 diabetes (Table 3).

The reported satisfaction with current diabetes treatment was directly associated with glycaemic control (Fig. 1). Diabetic patients satisfied with their treatment were more likely to have adequate glycaemic control. This was more evident in patients with type 2 diabetes (non-insulin-treated), but was also seen among patients with type 1 diabetes and type 2 diabetes (insulin-treated).

Table 2 Distribution (%) of HbA$_{1c}$ in 6,671 patients by type, treatment, and duration of diabetes, Brazil, 2006

HbA$_{1c}$ (%)	Type 1			Type 2						All		
	<5 years (n = 110)	≥5 years (n = 869)	All[a] (n = 979)	Insulin-treated			Non-insulin-treated			<5 years (n = 1,574)	≥5 years (n = 4,118)	All[b] (n = 5,692)
				<5 years (n = 208)	≥5 years (n = 1,729)	All[b] (n = 1,937)	<5 years (n = 1,366)	≥5 years (n = 2,389)	All[b] (n = 3,755)			
<7.0	22	9	10	17	9	10	48	29	36	42	19	27
7.0–7.9	11	18	17	21	15	16	21	23	22	20	19	20
8.0–8.9	19	21	21	11	22	21	12	15	14	12	19	16
9.0–9.9	14	18	18	11	19	18	7	11	9	8	15	12
10.0–10.9	9	12	12	12	13	13	4	9	7	5	11	9
11.0–11.9	9	9	9	12	10	10	4	5	5	5	7	6
≥12.0	16	13	14	16	13	13	5	8	7	7	11	9

[a] $P = 0.002$; [b] $P < 10^{-3}$

Table 3 Characteristics of patients with diabetes, according to HbA$_{1c}$ value and diabetes type, Brazil, 2006

	Type 1					Type 2 (insulin-treated)					Type 2 (non-insulin-treated)				
	n	HbA$_{1c}$ <7.0	HbA$_{1c}$ 7.0–8.9	HbA$_{1c}$ ≥9.0	P-value[a]	n	HbA$_{1c}$ <7.0	HbA$_{1c}$ 7.0–8.9	HbA$_{1c}$ ≥9.0	P-value[a]	n	HbA$_{1c}$ <7.0	HbA$_{1c}$ 7.0–8.9	HbA$_{1c}$ ≥9.0	P-value[a]
Gender															
Male	626	67 (10.7)[b]	227 (36.3)	332 (53.0)	0.62	1,266	99 (7.8)	444 (35.1)	723 (57.1)	10^{-3}	2,525	893 (35.4)	943 (37.3)	689 (27.3)	0.18
Female	353	35 (9.9)	139 (39.4)	179 (50.7)		671	88 (13.1)	270 (40.2)	313 (46.7)		1,230	450 (36.6)	422 (34.3)	358 (29.1)	
Multi professional care[c]															
Yes	816	81 (9.9)	331 (40.6)	404 (49.5)	10^{-3}	1,320	128 (9.7)	510 (38.6)	682 (51.7)	0.05	1,557	564 (36.2)	580 (37.3)	413 (26.5)	0.29
No	163	21 (12.9)	35 (21.5)	107 (65.6)		617	59 (9.6)	204 (33.1)	354 (57.3)		2,198	779 (35.4)	785 (35.7)	634 (28.8)	
Self-perception of glycaemic control in past 12 months															
Poor control	175	8 (4.6)	41 (23.4)	126 (72.0)	10^{-3}	287	9 (3.1)	46 (16.0)	232 (80.9)	10^{-3}	455	83 (18.2)	128 (28.1)	244 (53.7)	10^{-3}
Fair control	417	33 (7.9)	150 (36.0)	234 (56.1)		864	60 (6.9)	331 (38.3)	473 (54.8)		1,528	437 (28.6)	623 (40.8)	468 (30.6)	
Good control	320	42 (13.1)	146 (45.6)	132 (41.3)		649	89 (13.7)	281 (43.3)	279 (43.0)		1,429	640 (44.8)	509 (35.6)	280 (19.6)	
Very good control	60	16 (26.7)	26 (43.3)	18 (30.0)		123	29 (23.6)	48 (39.0)	46 (37.4)		322	170 (52.8)	101 (31.4)	51 (15.8)	
Ever participated in diabetes health education group or program															
Yes	466	52 (11.2)	191 (41.0)	223 (47.8)	10^{-3}	857	78 (9.1)	316 (36.9)	463 (54.0)	0.80	1,071	369 (34.5)	390 (36.4)	312 (29.1)	0.45
No	426	38 (8.9)	136 (31.9)	252 (59.2)		979	98 (10.0)	356 (36.4)	525 (53.6)		2,531	921 (36.4)	916 (36.2)	694 (27.4)	

[a] Chi-square test; [b] n (%); [c] Comprised at least: an Endocrinologist (or diabetes specialist), a Nurse, and a Dietitian (or Nutritionist)
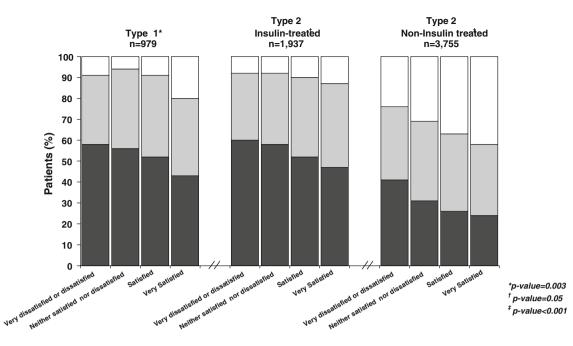
Fig. 1 Relationship between self-reported global satisfaction with diabetes treatment and distribution of HbA$_{1c}$ values, according to diabetes type, Brazil, 2006

Discussion

To our knowledge, this is the largest multicentre, nation-wide survey to estimate prevalence rates of inadequate glycaemic control in Brazil, and the first to evaluate these rates in patients with type 1 or type 2 diabetes. The overall prevalence of inadequate glycaemic control in our study (76%) was high, and greater than previous estimates from studies in Germany (40%) [18], Denmark (51%) [14], and Kenya (61%) [17], which also included type 1 and 2 diabetic patients.

The rates of inadequate glycaemic control were higher in patients with type 1 diabetes (90%) than in patients with type 2 diabetes (73%). Among the latter group, patients without insulin in their therapeutic regimen had lower rates of poor glycaemic control (64%). While patients using insulin presented a prevalence of inadequate glycaemic control (90%) similar to that found in patients with type 1 diabetes. These differences changed after we stratify the data by diabetes duration, but even among patients at earlier stage of diabetes (<5 years duration) insulin treatment is associated with worse control when compared to diet alone or combined with oral treatment, possibly due to more severe and more difficult to control diabetes in the former patients. Furthermore, patients using oral treatment (the major option in the group "non-insulin-treated") have a more simple to administer treatment option, which tends to be more effective under the conditions of daily life.

Our rates of inadequate glycaemic control in patients with type 2 diabetes are higher than those reported in the

same type of diabetic patients in the United States, where estimates derived from the National Health and Nutrition Examination Survey [NHANES] were 63% (1999–2000), 51% (2001–2002), and 43% (2003–2004) [25]. Similarly, reports from Canada (49%) [13], and the Netherlands (42%) [26] also revealed rates of poor glycaemic control in type 2 diabetes lower than ours. However, recent surveys in patients with type 2 diabetes in the United Kingdom [UK] ($N = 10,663$) [12] and Canada ($N = 5,569$) [20] provided estimates of inadequate glycaemic control closer to ours, 76 and 73%, respectively. Although these variations across studies may be true, they may also be due to differences in populations surveyed, methods of data collection, measurements of HbA$_{1c}$, and definitions of HbA$_{1c}$ cutpoint for adequate glycaemic control.

In our data, there was no significant difference in glycaemic control by gender, except among patients with type 2 diabetes (insulin-treated), where women achieved a better glycaemic control. In contrast, a study in a Pakistani moslem diabetic population in Manchester, UK, women were worse than men in performing regular glucose measurements, in managing persistent hyperglycaemia, and had poorer glycaemic control overall [27]. Results from a survey in Mexico have suggested that women have several social disadvantages, deterioration of healthy life, poor self-care, and lack of solidarity that increases their vulnerability to reach glycaemic control successfully [28]. However, several studies have failed to show significant gender differences related to self-care and control of type 2 diabetes [12, 20, 25, 26].

We found that health care delivered by a multi professional team was associated with improved glycaemic control in patients with type 1 diabetes or with type 2 diabetes (insulin-treated). Our results are consistent with previous studies comparing primary with specialist diabetes care [16, 20, 26, 29]. In the Pittsburgh Epidemiology of Diabetes Complications Study, specialist care was associated with higher levels of participation in diabetes self-care practices and a lower HbA1 level, but in the multivariate analyses the lower HbA1 levels observed in patients receiving specialist care were restricted to patients with an annual income >$20,000 [30]. Possible explanations for the better HbA$_{1c}$ seen with prior multi professional care include greater access to other health care providers such as nurse educators or dietitians, greater focus on glycaemia management, or more aggressive use of glucose-lowering medications by specialists.

There is evidence that poor numeracy skills are common in patients with diabetes, and that low diabetes-related numeracy skills are associated with fewer self-management behaviours, and possibly poorer glycaemic control [31]. Diabetes self-management education programs are considered an essential strategy for improving health behaviors of adults with diabetes. In a study to estimate the impact of participation in a diabetes health education program on glycaemic levels, Roblin et al. [32] reported that participation significantly improved glycaemic levels between baseline and follow-up periods. Our findings suggest that participation in a diabetes health education programme is associated with lower HbA$_{1c}$ values in patients with type 1 diabetes, but we failed to show that among patients with type 2 diabetes. However, our assessment was limited to whether the patient had ever participated in a diabetes health education program, and did not differentiate subjects according to the amount of time and/or effort dedicated to such programs.

Among the participants in our survey, self-perception of glycaemic control was associated with HbA$_{1c}$ levels. That is, patients who perceived their glycaemic control to be "poor" or "fair" were more likely to present higher HbA$_{1c}$ values. This awareness may result from several reasons including: the patients experiencing adverse symptoms associated with hyperglycaemia, the patients' knowledge about their actual adherence to diet and antidiabetic medication, and/or the patients' information of their recent HbA$_{1c}$ results. Unsurprisingly, we also found that global satisfaction with current diabetes treatment was associated with improved glycaemic control. It has been shown that improvement in patient convenience provides better compliance with therapeutic regimen and greater patient satisfaction, and this in turn leads to better glycaemic control [33–36].

Strengths and limitations

The distinctive strengths of this study are the large multi-centre sample, the collection of data by trained and certified interviewers (not part of the staff at each study centre), the measurement of HbA$_{1c}$ by a reliable method in a central laboratory, and the high response rate (84%). This high response was accomplished by rigorous training of interviewers, who were selected based on interpersonal skills displayed in previous surveys. Despite that, one limitation is that the study was centre based, and while our sample might be representative of patients with diabetes attending health care facilities in Brazil, it may not be representative of the whole population of Brazilian patients with diabetes.

Conclusion

Despite clinical evidence supporting tight control of diabetes and increased awareness of the benefits of improved metabolic control, we found that few diabetic patients in Brazil met recommended glycaemic control targets. A large proportion of patients with either type 1 or type 2 diabetes were inadequately controlled. This may contribute to increased rates of diabetic complications, which will impact health care costs. Our data support the public health message of implementation of early, aggressive management of diabetes. The reasons for a worse metabolic control in patients treated with insulin are not evident in our data. One may argue that poor adherence to insulin and/or some degree of inertia to apply the best currently available treatment regime in patients who need insulin might account for this finding.

Appendix

The following is a list of co-authors, the members of the Brazilian Diabetes Investigators' Group: Adriana C. Forti, MD; Célio C. Borges, MD; Débora V. Soares, MD; Edson

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