Factors associated with glycemic control in people with diabetes mellitus

Mariana Angela Rossaneis [1]
Selma Maffei de Andrade [2]
Raquel Gvozd [1]
Paloma de Souza Cavalcante Pissinati [1]
Maria do Carmo Lourenço Haddad [1]

[1] Departamento de Enfermagem, Centro de Ciências da Saúde,Universidade Estadual de Londrina. Av. Robert Kock 60, Vila Operária. 86039-440 Londrina PR Brasil. marianarossaneis @gmail.com
[2] Departamento de Saúde Coletiva, Centro de Ciências da Saúde, Universidade Estadual de Londrina. Londrina PR Brasil.

Abstract *Investigate the factors associated with the glycemic control in people with diabetes mellitus (DM). Cross-sectional study with 746 people with type-2 DM of age 40 or older. The following variables were selected: socioeconomic, clinical data, lifestyle and the risk of developing foot ulcers. Data collection occurred through interviews, medical record analysis and clinical examination of the lower limbs. We used the Poisson multiple regression model to determine the crude and adjusted prevalence ratios (PR) of the glycemic alteration. The alteration in the glycated hemoglobin (HbA1c) test was considered as a dependent variable in this study, which has been classified as high when the result was higher than 7%. The alteration in HbA1c was present in 68.9% of the participants and was more prevalent in individuals aged between 50 and 69 (PR = 1.38/$IC_{95\%}$ = 1.09-1.75), who were taking insulin (PR = 1.35/$IC_{95\%}$ = 1.24-1.47), obese (PR = 1.14/$IC_{95\%}$ = 1.03-1.25) and who had foot ulceration risk (PR = 1.14/$IC_{95\%}$ = 1.09-1.28). Individuals aged between 50 and 69; the ones who used insulin; the obese ones; and those who had a risk of foot ulceration, presented higher prevalence rates of alteration in the glycated hemoglobin.*

Key words *Diabetes mellitus, Hemoglobin A, Glycosylated, Primary Health Care, Nursing*

Introduction

The increase in the life expectancy of the population contributed to a transition in the morbimortality profile, in which chronic noncommunicable diseases (CNCD) have become the leading cause of death in the world. Among the CNCD, diabetes mellitus (DM) is considered to be a serious public health problem due to its high prevalence, which has already reached epidemic proportions, being one of the main risk factors for cardiovascular diseases and cerebrovascular accident[1,2].

The DM consists of a group of metabolic disorders characterized by defects in the synthesis and/or action of the insulin, which generates a state of constant hyperglycemia. The DM type 2 (DM2) is the form present in 90% to 95% of cases[1]. In 2014, 387 million people aged between 20 and 79 had DM worldwide, with a prevalence of 8.3%, of which 77% lived in underdeveloped countries[2]. In Brazil, 11.6 million people live with DM, a prevalence of 8.6% in the adult population, with a prognosis of being 16.3 million individuals in 2030[2] A study conducted with data from the National Survey of Health (PNS), a household survey conducted in Brazil in 2013 by the Brazilian Institute of Geography and Statistics (IBGE), found that the prevalence of diabetes increased with the advancement of age, reaching approximately 20% of the population of the age groups 65-74 years and 75 years and over, a contingent of more than 3.5 million people[3].

The development of DM2 is associated with hereditary, behavioral and socioeconomic factors. The control of this disease involves individual actions for self-care, associated with a constant support from a patient care team health team which provides guidance on the follow-up of an alimentary plan, on the monitoring of capillary glycemia, on the practice of physical activities and on the correct usage of medication[4].

One of the strategies to evaluate the effectiveness of the DM treatment is the periodic laboratorial measurement of the glycated hemoglobin (HbA1c), which represents the percentage of hemoglobin that is bound to glucose and is considered to be the basic reference for the glycemic control. This is an important tool for health professionals in the monitoring of diabetics and in the analysis of the effectiveness of the therapeutic plan[1,5].

Although the literature demonstrates the importance of the HbA1c test as an indicator of the glycemic control of DM2[1,4], we did not identify any national study covering the evaluation of this test in people over 40 years old, age at which most people with DM2 are diagnosed[1,6], and the factors associated with its alterations. In addition, this research aimed to identify the situation of people with DM2 monitored by the Primary Health Care, based on this indicator of the therapeutic plan outcome.

This study aimed to investigate the factors associated with the glycemic control in people with diabetes mellitus.

Method

This study meets one of the objectives of a funded research project that evaluated factors associated with the risk of ulceration in feet of people with DM, conducted in a large municipality in southern Brazil. This is a cross-sectional study carried out with individuals with DM2 registered in all 38 Basic Health Units (BHU) in the urban area of this municipality in 2012. For the calculation of the sample, we requested the total population of the municipality with DM2 from the Municipal Secretary of Health. However, according to the secretary, the data referring to the registry of people with DM were outdated, making it impossible to identify the total population of diabetics. Thus, the calculation of the total population with DM2 was performed based on the estimate of the Ministry of Health, which determines a prevalence of DM2 of 11% for the population over 40 years old[6], that is, 20,634 individuals. In this sense, the sample of this project was stratified by region of the municipality and calculated in the program *Epi Info*, considering a sample error of 5% and confidence level of 95%, totaling 1,679 individuals. However, approximately 10% of losses were obtained and the final sample consisted of 1,515 individuals.

Despite this, in view of the objective of this study, 769 people out of the 1,515 participants of the "umbrella project" were excluded from the analysis, since they presented results for the laboratory tests that were either incomplete or old (over 12 months). Therefore, the final sample was established in 746 people.

Each BHU in the municipality provided a list with the identification of diabetics registered in the Registration and Monitoring System for Hypertensive and Diabetics Patients. From this list, the participants of the study were drawn to compose the sample. These individuals should meet the following criteria for inclusion in the study:

preserved cognitive ability; absence of active ulcers in the lower limbs; and not undergoing dialysis treatment. During data collection, when one of these criteria were not identified, the participant was replaced by another in a new draw. The data were collected in the BHU in 2012 by students of the master's and undergraduate nursing courses previously trained by the coordinator of the research project.

An instrument was used that covers the steps of interview, analysis of health records and clinical evaluation of the feet of the patients[5]. The alteration of the glycated hemoglobin (HbA1c) test was considered as the dependent variable in this study, which was classified as high when the result were higher than 7%. It is recommended that the HbA1c test be performed at least twice a year for patients with reasonable control, and every 3 months for the most unstable ones[1]. However, in this study, the results of tests performed within 12 months were considered, since these results were collected from the patients' medical records and only 20% of the sample presented the data of this exam performed within 6 months.

The independent variables correspond to socioeconomic and lifestyle data, clinical conditions and the risk for the development of foot ulcers. Socioeconomic variables included gender, age, marital status, level of education, skin color and socioeconomic classification. The socioeconomic classification was determined according to the Brazilian Market Research Association (ABEP)[7]. Lifestyle variables were also self-reported and refer to the practice of regular physical activity, following of a diet plan, smoking and excessive alcohol consumption. The practice of physical activity was considered to be regular when the individual reported performing at least 30 minutes of physical exercises, three times per week or over. Alcohol intake was considered to be in excess when greater than one dose/day, for women, or two doses / day, for men[1].

Data regarding the clinical conditions were: time of diagnosis, insulin usage, obesity, arterial hypertension (AHT) and dyslipidemia. Also, in this item, we verified histories of the following cardiovascular events or chronic complications: stroke, myocardial infarction, retinopathy and diabetic nephropathy. These data were collected from the medical records and completed during the interview. Obesity was identified by calculating the body mass index (BMI), and diagnosed when BMI $\geq$ 30 kg/m^2. Dyslipidemia was determined according to the results of the laboratory tests of the lipid profile for the past year and was

characterized by high-density lipoprotein (HDL) < 45 mg/dl, triglycerides > 150 mg/dl, low-density lipoprotein (LDL) $\geq$ 100 mg/dl and total cholesterol > 200 mg/dl[1].

A clinical evaluation of the lower limbs was also carried out by the researchers. The individual was considered to be at risk of developing foot ulcers when presenting signs of peripheral neuropathy, vascular alterations, foot deformities and/or in case of amputation or previous ulcers[1].

Statistical analyzes were performed with the aid of the software Statistical Package for the Social Sciences (SPSS) 21.0. The measure of association used for both the bivariate analysis and the Poisson regression was the prevalence ratio (PR). For both analyzes, we adopted the significance level of 5% in the Wald chi-square test and we presented the p-value and the 95% confidence interval (95% CI). Variables with p-value < 0.20 in the bivariate analysis were selected to compose the model adjusted by Poisson regression.

The research was approved by the Research Ethics Committee of the State University of Londrina.

Results

The differences between the socioeconomic characteristics of participants included and excluded from the study are presented in Table 1.

After analysis of losses for all variables, a statistically significant difference between the individuals included and excluded from the study was observed only for the variable gender: 48.7% of the women and 54.2% of the men were not included in the sample for not presenting the results of the laboratory tests for the past year.

Among the 746 participants included in the study, 521 (69.8%) presented result for the glycated hemoglobin test as high. Regarding the socioeconomic data, this alteration was more prevalent in women, people with partners, non-white, with over eight years of schooling and from the economic class A/B. A statistically significant association was identified only for the variable age, with individuals between 50 and 69 years old presenting a higher prevalence (76.9%) of above-normal glycated hemoglobin values when compared to those between 40 and 49 years old (p-value = 0.019) (Table 2).

No significant differences were found between categories of the variables related to smoking, diet, regular physical activity and excessive alcohol consumption.

Table 1. Differences between socioeconomic characteristics of participants included and excluded from the study, Brazil, 2012.

Variables	Participants included in the study (n=746)		Participants excluded from the study (n=769)		p-value
	n	%	n	%	
Gender					
Female	489	65.5	465	60.5	0.043
Male	257	34.5	304	39.5	
Age (years)					
40-49	49	6.6	38	4.9	0.375
50-69	424	56.8	451	58.6	
≥70	273	36.6	280	34.4	
Skin color					
White	382	51.2	430	55.9	0.071
Non-white	364	48.8	339	44.1	
Marital status					
with partner	489	65.5	515	67.0	0.298
without partner	257	34.5	254	33.0	
Years of schooling					
Eight years or over	162	21.1	231	30.0	0.051
Up to eight years	589	78.9	538	70.0	
Socioeconomic classification					
A/B	176	23.6	255	29.3	0.052
C	462	61.9	468	60.9	
D/E	108	14.5	76	9.9	

However, in the analysis of the clinical conditions, higher prevalence of elevation in the glycated hemoglobin result were associated with time of diagnosis of DM greater than 10 years (p = 0.003), insulin usage (p < 0.001), and dyslipidemia (p = 0.036). Also, it was found that individuals with obesity presented a higher prevalence of alteration in the HbAc1 when compared to those with normal weight (p < 0,001). In turn, the participants who had any chronic complication due to DM had prevalence of uncontrolled HbAc1similar to those not identified with any of these complications. Also, a high prevalence (80.6%) of elevation in the glycated hemoglobin was observed in people who had foot ulceration risk (p = 0.004) (Table 3).

In the adjusted analysis, the variables age, between 50 and 69 years; obesity; insulin usage; and risk of foot ulceration remained statistically associated with the glycemic alteration (Table 4).

Discussion

The results of this study are of clinical relevance for making it possible to analyze the cardiometabolic profile of patients with DM2 who have a registry in BHUs of the city under study. It was verified in this research that the treatment of most diabetics registered in the BHUs may not have been being effective in controlling the disease and in preventing chronic complications. This difficulty in the health care of this population was already mentioned at the beginning of the study, since it was not possible to evaluate the health conditions of 50.7% of the individuals for not having up to date laboratory exams, who were then excluded from the research. This fact compromised the results of the research because it interfered in the stratification of the sample, since it was not possible to guarantee the representativeness of the characteristics of the total population, as it was necessary to exclude all the individuals that did not present the result of the glycated hemoglobin test. Considering the socioeconomic profile of the studied population, it is

Table 2. Prevalence of elevation in the glycated hemoglobin result, according to socioeconomic and demographic variables, in people with diabetes mellitus type 2.

Variables	n	%	p-value	Raw PR	95% CI
Gender					
Female	352	72.0		1	-
Male	169	65.8	0.089	0.91	0.82-1.01
Age (years)					
40-49	28	57.1	-	1	-
50-69	326	76.9	0.019	1.34	1.05-1.72
≥ 70	167	61.2	0.608	1.07	0.82-1.38
Skin color					
White	266	69.6	-	1	-
Non-white	255	70.1	0.900	1.00	0.91-1.10
Marital status					
With partner	349	71.4	-	1	-
Without partner	172	66.9	0.220	0.93	0.84-1.03
Years of schooling					
Eigth years or over	119	73.5	-	1	-
Up to eigth years	402	68.3	0.236	0.93	0.84-1.04
Socioeconomic classification					
A/B	132	75.0	-	1	
C	314	68.0	0.068	0.90	0.81-1.00
D/E	75	69.4	0.319	0.92	0.79-1.07

assumed that the BHU are the main health care service sought by these individuals.

It was identified the high prevalence of glycemic alterations, since seven in ten people presented altered test results. In addition, after adjustments by possible confounding variables, this alteration was associated with age, obesity, insulin therapy and risk of foot ulceration, which indicates subgroups of this population that were more vulnerable to present hyperglycemia.

Performing the HbA1c test regularly allows the assessment of glycemic control and verification of the efficacy of medication treatment and of education for self-care. It is estimated that 33% to 49% of people with DM2 cannot achieve adequate goals for glucose, blood pressure, or lipid profile control and only 14% reach normal parameters in these measurements[1,8].

The increase in the incidence of DM2 is closely related to the age groups. In this study, the age group 50-69 years was associated with a higher prevalence of elevated glycated hemoglobin. In most people, the symptoms of DM2 emerge after 40 years of age, but they might have already presented the state of decreased glucose tolerance up to ten years before[1,5,9].

In addition, studies show that most individuals seek health care only when the first symptoms of complications due to CNCD arise. Thus, it is often no longer possible to adopt strategies for behavioral lifestyle changes, so it is necessary to initiate medication treatment due to the cardiovascular alterations and to the advancement of age[10,11].

It is also assumed that people at that age are too engaged in their work occupations and have little time to devote to actions related to health promotion and prevention of problems, like physical activities and periodic consultations with professionals in the area. However, sickness within this age group has serious social repercussions since these individuals might face different problems that affect participation in the labor market, such as time requirements for medical consultations, hospitalizations, licenses, physical limitations, early retirement and mortality[10,12].

These are some of the hypotheses that may explain the higher relative frequency of men who did not undergo DM control tests within a past year, according to the losses analysis of this study. Health care for men has been a challenge for public policies. Because of sociocultural factors,

Table 3. Prevalence of elevation in the glycated hemoglobin result regarding the variables of clinical conditions, in people with diabetes mellitus type 2.

Variables	Total (n=746)		Glycemic alteration		p-value	Raw PR	CI95%
	n	%	n	%			
Time of diagnosis							
Up to 10 years	390	52.3	254	65.1	-	1	1
Over 10 years	356	47.7	267	75.0	0.003	1.15	1.04-1.26
Insulin usage							
No	572	76.7	369	64.5	-	1	1
Yes	174	23.3	152	87.4	< 0.001	1.35	1.24-1.47
Dyslipidemia							
No	161	21.6	88	61.5	-	1	-
Yes	585	78.4	418	71.5	0.036	1.16	1.01-1.33
Obesity							
No	389	52.1	250	64.3	-	1	
Yes	357	47.9	271	75.9	< 0.001	1.18	1.09-1.29
Arterial hypertension							
No	139	18.6	99	71.2	-	1	
Yes	607	81.4	422	69.5	0.688	0.97	0.86-1.09
Chronic complications							
No	559	74.9	300	53.7	-	1	
Yes	187	25.1	102	54.5	0.834	1.01	0.87-1.18
Risk of foot ulceration							
No	653	87.5	446	68.3	-	1	-
Yes	93	12.5	75	80.6	0.004	1.18	1.05-1.32

most of them neglect signs of chronic diseases, seek professional care only in cases of worsening symptoms and have greater difficulty in adapting to changes in lifestyle and to self-care[10,11].

Obesity was also associated with altered glycemic levels, independently of other variables. Overweight is one of the determining factors for the maintenance of hyperglycemia due to several mechanisms, such as the increase of circulating free fatty acids, the reduction of adiponectin and the secretion of cytokines by adipose tissue, which ultimately exacerbate the resistance to insulin[1,9].

Although the regular practice of physical activity was not statistically associated to the glycemic alteration in this sample, it is essential in order to improve conditions of weight and of alterations in the lipid profile. Dyslipidemia has toxic effects on pancreatic cells (lipotoxicity) and, in the presence of hyperglycemia, potentially increases the risk of cardiovascular diseases, the leading cause of death in the population with diabetes[1]. In a research developed with obese adults, with and without DM2, who underwent a 20 to 30 minute aerobic training program four to five times a week, it was identified at the end

of the tenth week that both groups had increased the mitochondrial respiration, the maximal oxygen consumption and the sensitivity to insulin, with no significant differences between the groups[13]. Thus, normalization of BMI is one of the most important goals for DM2 control. A weight loss of two to eight kilograms can provide a reduction in glycemic levels from 0.5% to 2%, which would result in benefits to the quality of life of people with diabetes, especially at the onset of the disease[8,14].

Another important result was the association between insulin usage and the higher prevalence of elevated HbA1c. Insulin therapy may be initiated in early stages of the DM treatment when only lifestyle modifications associated with oral hypoglycemic agents are insufficient to achieve adequate glycemic control. Adjustments in the insulin dose may be done until this goal is achieved, with no recommendation for dosage limit[1,15]. Therefore, the identified result demonstrates that insulin therapy has not been effective in the glycemic control of the majority of people with DM in this study.

The prevalence of chronic complications was also found in more than half of the sample

Table 4. Poisson multiple regression model with variables associated with a result high for the glycated hemoglobin test in people with diabetes mellitus type 2.

Variables	p-value	PR*	95% CI
Age (years)			
40 - 49		1	-
50 - 69	0.008	1.38	1.09-1.75
70 or over	0.355	1.12	0.87-1.46
Obesity			
No		1	-
Yes	0.006	1.14	1.03-1.25
Insulin usage			
No		1	
Yes	0.001	1.28	1.16-1.40
Risk of foot ulceration			
No		1	-
Yes	0.029	1.14	1.09-1.28

* Model adjusted by: gender, socioeconomic status, practice of regular physical activity, time of diagnosis and dyslipidemia.

and the risk of foot ulceration remained associated with the elevated HbA1c. The development of macroangiopathies is common, which affect the coronary, lower limb and cerebral arteries. Other complications are also known in DM and encompass the microangiopathies, specifically affecting the retina, renal glomerulus and peripheral nerves[11,15]. The persistence of the hyperglycemic state is the primary triggering factor of microvascular complications[8,11,15]. In this sense, the difficulty in controlling glycemia must be a criterion for the systematic and periodic evaluation of feet of people with DM, in order to avoid the appearance of lesions that predispose amputations. Maintaining the value of glycated hemoglobin lower than 7% is associated with a reduction in the risk of vascular complications[1,16].

Glycemic control and prevention of chronic complications in people with DM depend on several factors, including the knowledge and attitude of the individual diagnosed with this disease in changing behavior and lifestyle. The *American Diabetes Association* recommends that individuals with DM receive education and support for self-management of the disease, since it has been identified as the most effective measure for the control and improvement of quality of life[1]. Studies have found that diabetes education programs, which included nutritional therapy and individualized care plans, were associated with a decrease in HbA1c in people with DM[14,17,18].

In most of the basic health care services, nurses have assumed the responsibility of managing the cases of users with DM and other CNCDs. The nursing consultation has been an effective strategy in the follow-up of the diabetic and in the teaching for the self-care necessary to prevent chronic complications[19]. In this context, HbAc1 is an important indicator for the evaluation of the effectiveness of the therapeutic plan and can also be used in the prioritization of cases requiring intervention and support. There is also a need to implement an active search for diabetics to perform the glycated hemoglobin test at least every six months, or in a shorter period for those taking insulin therapies.

People with DM have to learn to cope with the various behavioral changes required for the disease control, and these changes take time to be accepted and incorporated by individuals and their families. It is common for individuals who initiate pharmacological treatment to have side effects such as diarrhea, nausea, dizziness, and crisis of hypoglycemia, as well as discomfort due to the glycemic self-monitoring and insulin administration, which in some cases require daily skin perforation[1]. This routine induces a large proportion of diabetics not to follow the treatment properly and even to abandon it. Therefore, without the support of the basic care services providing self-care education and subsidies for the DM control, the clinical condition of these individuals worsens rapidly, and the comorbidities and chronic complications that negatively impact their quality of life arise.

The limitations of the study refer to the need to exclude individuals from the studied sample due to the non-existence of either the laboratory tests within the past year period or either annotations in the medical records. This fact made it impossible to evaluate the therapy, based on the analysis of glycated hemoglobin, of more than half of the sample, which is one of the main objectives of the original project. This mainly compromises the analysis of association with socioeconomic factors and with the clinical situation of diabetics.

In addition, we chose to evaluate the HbA1c test performed within the period of one year, since the number of individuals who had the results of the test within the timeframe stipulated by the protocol was very low, which would make it impossible to perform the analyzes.

Also, lifestyle data were self-reported and therefore may be underestimated or overestimated. Finally, it was impossible to establish the

cause and effect relationship between the dependent and the independent variables, due to the cross-sectional design of the research.

Conclusion

It was possible to verify that individuals in the age range between 50 and 69 years; those who used insulin; the obese ones; and those who had risk of foot ulceration had a higher proportion of high results for the glycated hemoglobin test, independently of other risk factors. This indicates subgroups of people with DM who must receive more attention from basic care services.

Collaborations

MA Rossaneis and MCL Haddad on the conceiving, delineation, data analysis and interpretation, writing and critical review of the article. SM Andrade, R Gvozd e PSC Pissinati worked on data analysis and interpretation, writing and critical review of the article.

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