https://doi.org/10.46389/rjd-2024-1552
www.rjdnmd.org

Rom J Diabetes Nutr Metab Dis
2024; volume 31, issue 3, pages 248–255

Original Article

Assessing the influence of home-based capillary blood glucose monitoring on healthcare utilization and glycemic management in diabetes

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Received: 26 April 2024 / Accepted: 16 July 2024

Abstract

This study aimed to examine the relationship between home capillary blood glucose self-monitoring (CBGSM) with glycemic management and the number of consultations and capillary glucose strips consumed—a random sample of 422 patients with diabetes mellitus from a CBGSM program in Ribeirão Preto, Brazil. We have collected data on the number of consultations with physicians, nurses, and the multi-professional team, the use of glucose strips and bottles of insulin and sociodemographic data. Patients with poor glycemic management showed a lower crude frequency of nurse consultations (4.9±4.8, p=0.011). A strong negative correlation was found between the consumption of glucose strips and the value of HbA1c (r=-0.758; p=0.0029). Another strong correlation observed was between the consumption of regular human insulin and the frequency of medical consultations (r=-0.815; p=0.0014). Our findings suggest that patients in CBGSM with higher use of capillary glucose strips were associated with good glycemic management.

Keywords: blood glucose self-monitoring, glycemic control, appointments, patients.

Introduction

Capillary Blood Glucose Self-Monitoring (CBGSM) constitutes an essential aspect of healthcare management and is pivotal in the regulation of glycemic levels. This practice is instrumental in the prevention of both chronic (macrovascular and microvascular) and acute (such as coma and ketoacidosis) complications arising from hypoglycemic and hyperglycemic states [1, 2].

CBGSM can be executed via a portable glucometer, a device specifically engineered to approximate the glucose concentration in peripheral blood. Alternatively, the technology involving the measurement of glucose concentration in the interstitial fluid via subcutaneous sensor insertion is available. These sensors have demonstrated a significant correlation with capillary blood glucose measurements conducted through reagent strips, offering extensive data on the glycemic profile, thereby enhancing the precision and efficacy of therapeutic adjustments undertaken by healthcare professionals and patients. This method alleviates the discomfort associated with finger pricking, albeit at an increased financial cost [3].

Irrespective of the modality employed, CBGSM augments the data procured from HbA1c measurements, facilitating informed therapeutic interventions and contributing to minimizing hypoglycemic risks through a comprehensive evaluation of glycemic fluctuations. This practice has emerged as a cornerstone in the optimization of diabetes mellitus (DM) treatment, steering it towards greater specificity and individualization [4, 5].

In the Brazilian context, Federal Law No. 11.347/06 stipulates the gratuitous provision of medications and essential supplies for insulin application and CBGSM to individuals diagnosed with DM. Ministerial Directive No. 2.583/07 articulates the inclusion and exclusion criteria for beneficiaries requiring supplies distributed by the Unified Health System (SUS), encompassing syringes with integrated needles for insulin administration, CBGSM, and lancets for finger pricking [6].

In the municipality of Ribeirão Preto, Brazil, a public health program dedicated to CBGSM is operational, supplying glucometers and the requisite monitoring apparatus for domiciliary use. The CBGSM frequency is tailored to each patient based on clinical presentation, therapeutic regimen, insulin administration pattern, and patient competence in self-care. Program participants are subject to biannual monitoring by a pharmacist and a nurse, focusing on the assessment of their clinical and metabolic conditions [7].

Notwithstanding, there exists a paucity of published research evaluating the efficacy of comprehensive CBGSM programs within the ambit of primary healthcare services. Consequently, this study endeavors to appraise the impact of CBGSM on various dimensions in individuals with diabetes mellitus, encompassing glycemic management, frequency of health consultations, and the utilization of capillary glucose test strips.

Material and methods

Design

This quantitative, observational study involved a retrospective analysis of a secondary database pertaining to a public, municipal Capillary Blood Glucose Self-Monitoring (CBGSM) program conducted in Ribeirão Preto, São Paulo, which has an estimated population of 711,825. This study is reported in accordance with STROBE.

Sample and population

The study population comprised 8,046 individuals who obtained capillary blood glucose test strips (CBGTS) from pharmacies in primary care units in Ribeirão Preto, Brazil. Of these, 3,830 (47.6%) had at least one recorded HbA1c test result in the digital system known as *Hygiaweb* and were distributed by the health district for sample size calculation.

In our sampling, the sample size was determined using stratified random sampling with proportional allocation by strata in the R programming environment, where each stratum was formed by the five Health Districts.

Adopting parameters of a 10% relative error, a 5% level of significance, the prevalence of HbA1c results in the municipality by district according to the study by Calixto *et al*. (2023), and the sample from each stratum, the required sample size was determined to be 422 participants, who were randomly selected [8, 9].

Variables

In this research report, the studied variables included: sex; age (in years); age group (adults aged 21 to 59, and seniors aged ≥60 years); health district (West, North, East, South, and Central); type of insulin [NPH (Neutral Protamine Hagedorn) or regular]; number of vials of human NPH insulin 100 UI/ml and human regular insulin 100 UI/ml withdrawn per year.

NPH insulin consumption was categorized as 1 to 12 vials per year and ≥13 vials per year. Regular insulin consumption was categorized as 1 to 6 vials per year and ≥7 vials per year. The CBGTS variable was classified as 250 or fewer and ≥251 strips per year.

Regarding glycemic management, we considered the result of HbA1c: good management was defined as HbA1c <7% for adults and <7.5% for healthy seniors. For individuals with more than one test result, the most recent value within the year was considered. The number of HbA1c tests and consultations with the healthcare team in the last 12 months (grouped as 1 to 6 and ≥7 consultations) were also quantified. Consultations included those with healthcare professionals such as physicians, nurses, and the multi-professional team (pharmacists, psychologists, occupational therapists, physiotherapists, nutritionists, speech therapists, and physical education professionals).

Data collection

Data collection was manually conducted by three researchers using computers at the municipal health department (*Hygiaweb* digital system) and entered into an Excel® spreadsheet.

Statistical analysis

In the data analysis plan, data were described using absolute frequencies and percentages (qualitative variables), mean, standard deviation (SD), minimum, median, and maximum (quantitative variables). Subsequently, researchers performed a cross-tabulation of the aforementioned variables according to the patients' glycemic management control (good or poor) using Fisher's exact test.

For correlation analysis, Spearman's correlation coefficient was used. The strength of the correlation between variables was classified as weak $0 < r < 0.4$; moderate $0.4 < r < 0.7$; and strong $0.7 < r < 1.0$. Correlations were considered statistically significant if they presented $p \leq 0.05$ and a moderate or strong degree of correlation. Data processing and analysis were performed using the Statistical Package for the Social Sciences (SPSS), version 21.0. A significance level of 5% was adopted for all analyses.

Ethical Issue

This research was approved by the Research Ethics Committee of the Ribeirão Preto College of Nursing at the University of São Paulo, under number CAAE: 141955421.0.0000.5393. Data collection was authorized by the municipal health department, which waived the requirement for an Informed Consent Form due to the use of secondary data.

Results

The majority of the sample comprised females (n=273; 64.7%), with ages ranging from 22 to 89 years, and an average age of 62.3 years (SD=13.8). Notably, the age group over 60 years exhibited poor glycemic management (p=0.000) (Table 1).

There were no statistically significant differences between the study groups regarding sex (p=0.795), nor in the use of blood glucose test strips (p=0.488) and regular (p=0.839) or NPH insulin vials (p=0.536) (Table 1). Patients with good glycemic management had lower levels of glycated hemoglobin (p=0.000) and were older (62.3±16.7 *versus* 62.2±12.1 years; p=0.000) compared to those with poor management (Table 2).

Patients with poor glycemic management demonstrated a lower mean frequency of consultations with nurses (4.9±4.8; p=0.011), although frequency category analysis indicated the opposite (predominance of 1–6 and >7 consultations; p=0.025). This aspect is linked to an uneven distribution of patients across the groups (Table 3).

No significant statistical differences were identified in the number of consultations with pharmacists (p=0.313), physiotherapists (p=0.681), dietitians

Table 1: Sociodemographic data and supplies were withdrawn by people who collected blood glucose test strips according to glycemic management. Ribeirão Preto, Brazil, 2024.

Variable	Good glycemic management n (%)	Poor glycemic management n (%)	Total (n=422) n (%)	P-value*
Sex				0.795
Male	46 (30.9%)	103 (69.1%)	149 (35.3%)	
Female	96 (35.2%)	177 (64.8%)	273 (64.7%)	
Total	142 (33.6%)	280 (66.4%)	422 (100%)	
Age group				**0.000**
21–59 years	41 (28.9%)	104 (71.7%)	145 (34.4%)	
≥60 years	101 (36.5%)	176 (63.5%)	277 (65.6%)	
Total	142 (33.6%)	280 (66.4%)	422 (100%)	
Consumption of blood glucose test strips (units per year)				0.488
Up to 250	101 (34.7%)	190 (65.3%)	291 (69.0%)	
≥251	41 (31.3%)	90 (68.7%)	131 (31.0%)	
Total	142 (33.6%)	280 (66.4%)	422 (100%)	

https://doi.org/10.46389/rjd-2024-1552

Table 1: Continued.

Variable	Good glycemic management n (%)	Poor glycemic management n (%)	Total (n=422) n (%)	P-value*
Consumption of NPH human insulin ** (vials per year)				0.536
1 to12	77 (36.2%)	131 (63.8%)	213 (55.3%)	
≥13	57 (33.1%)	115 (66.9%)	172 (44.7%)	
Total	134 (34.8%)	251 (65.2%)	385 (100%)*	
Consumption of regular human insulin (vials per year)				0.839
1 to 6	41 (36.0%)	73 (64.0%)	114 (65.1%)	
≥7	21 (34.4%)	40 (65.6%)	61 (34.9%)	
Total	49 (27.8%)	113 (64.6%)	180 (100%)*	

Note: * – Fisher test; ** – The total number of people who did not collect any vials of NPH human insulin was 36, and for Regular insulin, it was 242.

(p=0.324), psychologists (p=0.814), and occupational therapists (p=0.147) in relation to the glycemic management profile.

Table 4 data reveals statistically significant correlations in several associations. A strong negative correlation was observed between the use of blood glucose test strips and HbA1c levels (r=-0.758; p=0.029), indicating that higher strip usage is associated with better glycemic control. For instance, a strong correlation was noted between the use of regular human insulin and the frequency of medical consultations, with a significant p-value (r=-0.815; p=0.014). This suggests that more frequent insulin use may be associated with fewer medical consultations in this group (Table 4).

Discussion

Participants with effective glycemic management were predominantly elderly (65.6%) compared to adult counterparts (28.9%). Previous investigations conducted in Brazil and China have observed similar findings: positive glycemic management progressively increases from the ages of 66 and 75, respectively [9, 10].

Table 2: Glycemic management of people who collected blood glucose test strips according to glycated hemoglobin, age, and supplies were withdrawn during 12 months. Ribeirão Preto, Brazil, 2024.

	Min–Max	Average	Standard Deviation	Median	Sum	P-value*
Glycated hemoglobin						
Good metabolic management (n=142)	4.3–7.4	6.31	0.76	6.5		
Poor metabolic management (n=280)	7.0–17.7	9.42	1.66	9.10		
Total (n=422)	4.3–17.7	8.37	2.04	8.2		**0.000**
Age						
Good metabolic management (n=142)	23–88	62.35	16.75	65		
Poor metabolic management (n=280)	22–89	62.28	12.11	64		
Total (n=422)	22–89	62.30	13.82	65		**0.000**
Consumption of blood glucose test strips						
Good metabolic management (n=142)	50–1850	256.73	257.65	150	36.455	
Poor metabolic management (n=280)	20–1700	237.54	237.77	150	66.511	
Total (n=422)	20–1850	244	244.50	150	102966	0.447

Table 2: Continued.

	Min–Max	Average	Standard Deviation	Median	Sum	P-value*
Consumption of NPH human insulin vials **						
Good metabolic management (n=134)	1–47	13.25	10.615	11	1776	
Poor metabolic management (n=251)	1–48	12.83	9.718	11	3220	
Total (n=385)	1–48	12.98	10.028	11	4996	0.693
Consumption of regular human insulin vials						
Good metabolic management (n=62)	1–27	5.98	4.857	5	371	
Poor metabolic management (n=113)	1–43	6.11	5.799	5	690	
Total (n=175)	1–43	6.06	5.470	5	1061	0.888

Note: * – Fisher test; ** – NPH: Neutral Protamine Hagedorn; Min–Max – Minimum–Maximum.

A potential explanation for the higher adherence to home-based glycemic self-management care (AMGC) among the elderly may be attributed to life experience and emotional maturity. As individuals age, they may develop greater responsibility and seriousness regarding the management of their chronic health conditions.

Moreover, elderly individuals with diabetes tend to have more established routines and fewer daily demands compared to younger adults, potentially facilitating regular adherence to blood glucose monitoring. Conversely, the presence of comorbidities and more frequent medical consultations might also contribute to better follow-up and awareness of the importance of glycemic control [11].

Our findings indicate that individuals in AMGC with well-managed diabetes were associated with increased

Table 3: Profile of consultations with health professionals of patients who collected blood glucose test strips in 12 months according to glycemic management. Ribeirão Preto, Brazil, 2024.

Heath worker	Number of consultations	Glycemic management Good n (%)	Glycemic management Poor n (%)	Total n (%)	P-value
Doctor	1 to 6	100 (31.3%)	219 (68.7%)	319 (86.4%)	0.158
	≥7	21 (42.0%)	29 (58.0%)	50 (13.6%)	
	Total	121 (32.8%)	248 (67.2%)	369 (100%)	
	Average (SD)	4.23 (2.952)	3.91 (2.616)	4.02 (2.731)	0.291
	Median (Min–Max)	3 (1–15)	3 (1–18)	3 (1–18)	
Nurse	1 to 6	67 (29.0%)	164 (71.0%)	231 (74.0%)	**0.025**
	≥7	35 (43.2%)	46 (56.8%)	81 (26.0%)	
	Total	102 (32.7%)	210 (67.3%)	312 (100%)	
	Average (SD)	7.23 (11.056)	4.90 (4.889)	5.66 (7.547)	**0.011**
	Median (Min–Max)	4 (1–93)	3 (1–51)	3 (1–93)	
Healthcare team	1 to 6	35 (92.1%)	67 (89.3%)	102 (90.30%)	0.623
	≥7	3 (7.9%)	8 (10.7%)	11 (9.7%)	
	Total	38 (33.6%)	75 (66.4%)	113 (100%)	
	Average (SD)	2.26 (2.627)	3.36 (5.535)	2.99 (4.774)	0.250
	Median (Min–Max)	1 (1–13)	1 (1–30)	1 (1–30)	

Note: SD – Standard Deviation; Min–Max – Minimum–Maximum.

https://doi.org/10.46389/rjd-2024-1552

Table 4: Correlation between variables of age, HbA1c, consumption of blood glucose test strips, consumption of NPH and regular human insulin, consultation with nurse, doctor, and multi-professional team according to glycemic management. Ribeirão Preto, Brazil, 2024.

Variables	r	Classification	P-value *
Good and poor glycemic management			
Age – Consumption of blood glucose test strips	-0.419	Moderate	**0.019**
Age – Consultation with a doctor	-0.360	Weak	**0.047**
Age – Consultation with nurse	-0.425	Moderate	**0.017**
Consumption of NPH human insulin – Regular human insulin	0.388	Weak	**0.031**
Consumption of NPH human insulin – HbA1c	0.414	Moderate	**0.021**
Consumption of regular human insulin – Consultation with a doctor	-0.466	Moderate	**0.008**
Consumption of regular human insulin – HbA1c	0.532	Moderate	**0.002**
Consultation with nurse – HbA1c	-0.565	Moderate	**0.001**
Good glycemic management			
Age – HbA1c	0.778	Strong	**0.012**
Consumption of blood glucose test strips – HbA1c	-0.758	Strong	**0.029**
Consumption of regular human insulin – Consultation with a doctor	-0.815	Strong	**0.014**
Poor glycemic management			
Consumption of NPH human insulin – Regular human insulin	0.470	Moderate	**0.024**
Consumption of NPH human insulin – Consultation with a multi-professional team	0.467	Moderate	**0.025**
Consumption of NPH human insulin – HbA1c	0.463	Moderate	**0.026**
Consumption of regular human insulin – HbA1c	0.459	Moderate	**0.027**

Note: * – Fisher test; NPH – Neutral Protamine Hagedorn.

use of blood glucose test strips (TGC). A population-based observational study in Ontario showed that introducing reimbursement limits for TGC did not impact emergency care rates for hypo- or hyperglycemia, nor average HbA1c levels [12]. In Song *et al.*'s (2018) study, HbA1c levels significantly decreased from an initial value of 8.5% to 8.2% ($p<0.001$) following six months of TGC cost reimbursement [13].

Individuals with good glycemic management might use more TGC due to various factors. Effective glycemic control often involves regular monitoring of glucose levels, enabling precise adjustments in diet, physical activity, and medication. Frequent use of TGC may reflect this proactive and careful approach. Additionally, improvements in the accuracy and ease of use of glucose meters over the years have made self-monitoring more accessible and reliable for patients. These advancements encourage more frequent use of test strips, as results are more accurate and easier to obtain, contributing to more effective glycemic control [14, 15].

We have observed in patients in AMGC that more frequent insulin use could be associated with fewer medical consultations and good glycemic control. Regular AMGC allows patients to more effectively adjust food intake, physical activity, and pharmacological therapy based on their glucose readings. This can lead to better glycemic control, reducing the need for frequent doctor visits for treatment adjustments. Furthermore, advancements in monitoring technology have made self-monitoring more convenient, which might have contributed to greater adherence and, consequently, better diabetes control. Improved disease management may reduce long-term complications, lessening the need for frequent medical interventions [16, 17].

The Brazilian Diabetes Society recommends an HbA1c target of <7% for all individuals with diabetes mellitus (DM) to prevent microvascular complications, provided it does not result in severe and frequent hypoglycemia [18]. In our study, the average HbA1c value was 8.37%, aligning with international studies of people in

AMGC, where most average HbA1c levels were above 8.0% [13, 19–22].

An average of 1.72 (SD=0.85) HbA1c tests were conducted annually. However, 52.4% of participants received TGC and did not undergo any HbA1c tests in the last 12 months. Since TGC is provided for prescriptions from both public and private sectors, we could not access the test results for all these patients.

We have identified an association between poor glycemic management and a lower frequency of consultations with nurses. The AMGC program in Ribeirão Preto, Brazil, advocates for individual consultations with nurses and doctors, preferably alternated every two to six months, depending on the risk level [7]. In our study, 73.9% of individuals had nurse consultations. Nursing consultations involve actions for cardiovascular risk stratification, guidance on lifestyle changes, non-pharmacological treatment, identification of at-risk feet, adherence verification, and possible treatment complications [23]. Scain *et al.*'s (2007) study showed that education by nurses was associated with a higher proportion of patients with HbA1c <7.0% [24].

Some limitations of this study involve data collection through secondary databases and the need for access to information from the private or supplementary sector and from medical consultations conducted in specialized care. Additionally, it was not possible to determine the type of diabetes mellitus (DM) of the sample participants. Caution is advised when interpreting the data, as it is not possible to extrapolate the analyses to other populations since the data was not produced for this purpose.

From our perspective, we strongly recommend that future research focus on reassessing the necessity of patient involvement in consultations with multidisciplinary health teams, as well as in educational programs related to glycemic management care (TGC). Such a reconsideration could be instrumental in facilitating new studies and in conducting more comprehensive cost-effectiveness analyses, ultimately contributing to more effective strategies for glycemic management.

Conclusion

This study highlights the positive link between older age and effective glycemic management in patients practicing home blood glucose self-monitoring (AMGC). We have also observed that these patients, showing good glycemic control, required fewer medical consultations. Conversely, patients with poor glycemic management needed fewer nurse consultations. Researchers have also found significant statistical correlations between the use of blood glucose test strips, HbA1c values, and the frequency of medical consultations. These findings underscore the complex relationship among self-monitoring practices, age, and active healthcare engagement in managing glycemic levels.

Acknowledgments

We want to extend our sincere gratitude to the Municipal Health Department of Ribeirão Preto, Brazil, for their invaluable support in providing the necessary infrastructure for the collection, integration, and analysis of data related to the blood glucose self-monitoring program. Their collaboration and facilitation were instrumental in the successful execution of this study.

Conflict of interest

The authors declare no conflict of interest.

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