Technology and Inequity in Health: The Geographical Distribution of Glucometers for the Control of Diabetes

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Abstract: Technological innovation plays an important role in the dynamics of economic growth and in promoting the welfare of the general population. In support of this hypothesis, an empirical study was carried out to assess the spatial distribution of insulin and supplies (glucometers) for the control of diabetes in patients registered in the Public Healthcare System in Salvador, Bahia, from 1998 to 2012. In order to achieve this objective, we applied a combination of data collection strategies, including spatial analysis and discrete choice model estimation. The study proposed to answer the following question: What factors affect access to the supplies required to control diabetes in insulin-dependent patients? To this end, we assessed the spatial distribution of diabetic patients in Salvador who had received glucometers. The hypothesis asserted that social, economic and geographical factors determine access to the supplies (glucometers) used to control diabetes. Exploratory Spatial Data Analysis (ESDA) was therefore performed using the Global Spatial Autocorrelation Index in order to analyze the spatial distribution of glucometers. We then performed econometric estimations and analyzed the results. The final results initially demonstrated that there were major inconsistencies in the distribution of glucometers; i.e. purely random factors largely determined the probability of obtaining this device. Individual characteristics were not decisive factors in the probability of obtaining a glucometer, which were instead related to type of diabetes and recommended treatment.

Keywords: Diabetes. Glucometer. Innovation. SUS.

1. Introduction

The Brazilian Unified Public Health System (SUS) is formed a set of interconnected elements which express, determine and influence the state of individual and population health. It contains a complex network of service providers and purchasers in competition with each other. It is divided into three sub-sectors: public, private and supplementary health. The system's public and private components are interconnected but distinct. People may use services from the three sub-sectors, although this depends on

ease of access and/or ability to pay.

Progress has been made in the implementation of SUS over the last 20 years and access to healthcare services in Brazil has improved. According to the 1981 National Household Sample Survey (PNAD), 8% of the population (9.2 million people) confirmed that they had used the Public Healthcare System in the previous 30 days, while in 2008, 14.2% of the population (26,866,869 people) declared they had used it over the previous 15 days.

Despite an increase in the number of people who sought basic care, this level remains low in comparison with more developed countries. Additionally, new technologies have been incorporated into healthcare services in recent years, which have had an impact on

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its organization and have increased complexity and cost. Both a new financial structure and a substantial review of public-private relationships are required (PAIM et al., 2011) in order to overcome the challenges faced by SUS.

According to the Constitutional Rights advocated by the Brazilian Sanitary Reform Movement, health is an inalienable right and the Brazilian State must guarantee universal and equitable access to activities and services, including the prevention of diseases, health promotion and recovery. This study aims to analyze the conditions of access to a glucometer in the Public Healthcare System in Salvador. A glucometer is an essential device required to control diabetes, and its distribution is centralized in a Health Center close to Salvador's historic center.

The glucometer was selected because it is a vital piece of technology for observing glucose levels in order to avoid their fluctuation, and contributes to greater autonomy, since the subject participates in their own health-illness process. This is fundamental for diabetes care, since the patients themselves can adjust medication, food and exercise.

The technological accuracy of these devices is considered satisfactory and has been evidenced in glycemic results close to the findings of blood glucose laboratory tests. However, monitoring depends on the patient's use of the device and their interpretation of capillary blood glucose results at home. Diabetic patients or their relatives should be able to carry out this control. The procedure must be performed correctly, in order to ensure the creation of blood glucose maps that identify the daily profile of patient glycemic levels.

The study proposes to answer the following investigation question: what are the main variables that affect insulin-dependent patient access to a glucometer? As a hypothesis, we assumed that better informed members of the population, who have a higher income, have greater access to a glucometer. There are, thus, social, economic and geographical

factors which determine access to glucometers.

The methodology utilized Exploratory Spatial Data Analysis (ESDA) and Moran's Global Spatial Autocorrelation Index (Moran's I) to evaluate the spatial pattern for glucometer distribution. In order to analyze the importance of several factors that affect the probability of an individual obtaining a glucometer, an equation was specified for a discrete choice model in order to capture the factors that determine the probability of an individual receiving a glucometer. This was estimated econometrically using the Maximum Likelihood method.

The database contains 6,249 diabetic (insulin-dependent) patients, resident in Salvador, who receive treatment from the public healthcare service free of charge. In addition, social and economic variables were obtained from the 2010 Demographic Census of the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística* - IBGE). Using the geographic location coordinates for the material and equipment (glucometers) in the distribution center in Salvador's historic center, we also calculated the distances (geographic variables) between these locations and patient neighborhoods. These variables were used both for a spatial analysis of the results and to estimate the discrete choice models.

2. Experimental Section

We combined two methodological strategies to achieve the study objectives. The first refers to an Exploratory Spatial Data Analysis (ESDA) which spatialized the social and economic information regarding glucometer distribution based on the demarcation of neighborhoods in Salvador. We also applied two indicators of spatial correlation: Moran's Index of Global Spatial Autocorrelation (Moran's I), and Local Indicators of Spatial Association (LISA). The aim of these indicators is to support the verification, concentration and spatial dependence between diabetes cases and glucometers in Salvador,

Bahia. Logit and Probit estimated discrete choice econometric models were then used to assess the social and economic factors that interfere with the probability of obtaining a glucometer, taking into consideration the centralization of the glucometer distribution process within a single location in Salvador.

3. Results and Discussion

To present the results, we will first analyze the spatial distribution of the main variables contained in the Salvador database and the strategy for obtaining variables. These variables include the distribution of patients across the neighborhoods, as well as the social, economic and geographic variables. We will then present the results of the Exploratory Spatial Data Analysis and estimations originating from the discrete choice models.

3.1 Spatial Analysis: Insulin-Dependent Patients, Location of Glucometers and the Social and Economic Structure of the Neighborhoods

The database contains 6,249 diabetic (insulin-dependent) patients who reside in Salvador and receive treatment free of charge from the public healthcare service. Out of this total, 2,273 (36.4%) are male and 3,976 (63.6%) are female. The data shows that only 1,941 of the 6,249 patients received a glucometer, representing 31.1% of patients.

By locating diabetic patient records registered on the Clinical Management System for Hypertension and Diabetes Mellitus (Hiperdia) and on the Supply Distribution Control System for the Care of Diabetes at the Carlos Gomes Health Center, it was possible to determine the spatial location of the distributed glucometers. This is in line with Directive GM/MS Nº 3237/2007 of December 24, 2007, which approved the implementation and financial regulation of pharmaceutical assistance in basic healthcare. The neighborhood location of patients was carried out using the geographical demarcation for the city of Salvador, and the current neighborhood names used

by the scientific community¹.

As we can see in Figure 1, there is no well-defined spatial distribution pattern for these patients. However, before examining the income data, we predicted that the majority of these patients live in lower-income neighborhoods in Salvador, at a considerable distance from the Distribution Center on Avenida Carlos Gomes, in the city's historic center.

Figure 2 presents the spatial distribution of glucometers in Salvador. In addition to the number of patients, we can also observe that there is no well-defined pattern for the spatial distribution of the

Fig. 1 Diabetes Mellitus cases recorded in the neighborhoods.

Source: Salvador's Municipal Health Department.

¹Veiga, et al. (2012) describes the process of updating the current demarcation of neighborhoods for the municipality of Salvador. This demarcation resulted in the definition of 160 neighborhoods and, aside from work related to the islands, was carried out between October 2007 and October 2009 by a multidisciplinary team including professionals from the Federal University of Bahia (UFBA), the State Government, the Urban Development Company of the State of Bahia (Conder) and the Municipality of Salvador (PMS). The concept of a neighborhood considered within this project took account of resident identity and sense of belonging, in addition to aspects related to urban structures. This joint effort aimed to construct a reference unit for citizens, researchers and the city authorities, since several institutions active within the urban space had produced their own territorial snapshots. This had resulted in a potpourri of layouts, with citizens not being effectively recognized within them, due to the lack of official neighborhood demarcation.

Technology and Inequity in Health: The Geographical Distribution of Glucometers for the Control of Diabetes

Fig. 2 Glucometers distributed according to neighborhood: 2006 to 2012

Source: Salvador's Municipal Health Department.

number of devices. However, there is a slight trend for neighborhoods with a higher number of devices to be more centrally located in the city. We can also see that neighborhoods considered to be more affluent have fewer records for the distribution of free of

charged devices.

An analysis of georeferenced data enabled us to obtain a general spatial distribution for the Salvador variables.

Ordering these variables by neighborhood also provided some relevant information. Table 1, below, reveals the 10 neighborhoods with the highest number of patient records. The Fazenda Grande do Retiro neighborhood has the highest number of patients, at 189. We can also see that 1,401 patients are concentrated within these 10 neighborhoods, representing 22.4% of the total. This shows the concentration of patients within certain Salvador neighborhoods, which is also found for the number of glucometers and health units. However, the spatial concentration for the number of patients is heterogeneous. Among these 10 neighborhoods, some are much closer to the distribution center, such as the neighborhood of Federação (2,069.9 meters), while others are further away, such as Itapuã (17,530 meters).

The 10 neighborhoods with the highest number of patients contain 445 glucometers. This represents

Table 1 The 10 neighborhoods with the highest number of patient records

Neighborhood	Patient Records	Devices Distributed	Health Units	Number of Hospitals	Distance from Distribution Center (in meters)	Average Age of Patients
Fazenda Grande do Retiro	189	57	11	0	5659.2	57.7
Pernambúes	182	52	19	0	5347.9	51.7
Brotas	169	42	217	8	3393.8	53.6
Beiru/T Neves	151	54	6	0	8068.4	51.8
São Caetano	145	60	18	0	6430.4	54.6
Liberdade	121	40	45	0	4415.1	55.6
Federação	121	41	147	9	2070	56.6
Paripe	112	28	10	0	16613.7	53.6
Itapuã	106	29	47	1	17530.2	55.2
Cosme de Farias	105	42	3	0	2848.4	58.7
Subtotal	1401	445	523	18	-	54.91

Source: Salvador's Municipal Health Department.

Table 2 The 10 neighborhoods with the greatest distribution of devices

Neighborhood	Patient Records	Devices Distributed	Health Units	Number of Hospitals	Distance from Distribution Center (in meters)	Average Age of Patients
São Caetano	145	60	18	0	6430.4	54.6
Fazenda Grande do Retiro	189	57	11	0	5659.2	57.7
Beiru/Tancredo	151	54	6	0	8068.5	51.8
Neves	182	52	19	0	5348	51.7
Pernambúes	169	42	217	8	3394	53.6
Brotas	105	42	3	0	2848.4	58.7
Cosme de Farias	121	41	147	9	2070	56.6
Federação	121	40	45	0	4415.1	55.6
Liberdade	78	37	15	2	10308.6	49.3
São Marcos	93	31	14	3	13360.3	50.7

Source: Salvador's Municipal Health Department.

Fig. 3 Distribution of patients and glucometers.

Source: Compiled by the author.

22.9% of the total number of devices distributed to all patients. As we can see in Table 2 below, of the neighborhoods with the highest number of devices, only the neighborhoods of Paripe and Itapuã are not among the 10 neighborhoods with the highest number of patients; this demonstrates the existence of a considerable concentration in the distribution of

devices within these 10 neighborhoods.

The direct relationship between the number of patient records and the number of devices is confirmed in Figure 3 below. We also observe that a linear trend exists between the two variables. It is therefore assumed that there is no relationship between location characteristics and/or income and

distribution of devices, but rather, a relationship with individual patient characteristics, such as age, level of education and access to information.

Table 3, below, shows the 10 neighborhoods closest to the Supply Distribution Center for diabetic patients who reside in Salvador. We observe that the city center is the closest neighborhood and that Engenho Velho de Brotas has the highest number of patients: 80. We confirm that the 10 closest neighborhoods contain 268 patients, representing only 4.3% of the total.

Using the patient record variable, we conducted a preliminary analysis of the determining factors for number of devices by neighborhood. A simple regression between the other variables demonstrated that the coefficient of determination (R^2) was 0.91; in other words, 91% of the variation in the number of devices by neighborhood is explained by divergence in the number of patients.

Age is an important variable for diabetes patients, due to conditions worsening over time and/or the need for priority care. The distribution of patients by age is shown in Figure 4. The average age of patients in this sample is 53.6 years old.

Unlike the variables that refer to the number of patients and glucometers, we can see that the majority of elderly patients are located in the neighborhoods closest to Salvador's central region, which, to some extent, facilitates the patient's journey to the distribution center.

Using patient glucometer records, we also analyzed the spatial distribution of health units located in Salvador, as seen in Figure 5. These units comprise public and private hospitals and health centers, with a well-defined location pattern in Salvador's central neighborhoods. Although information regarding the population of each neighborhood needs to be analyzed, we can assume that a number of the neighborhoods further from the central region do not provide facilities for preventive or emergency services for patients suffering from any type of disease, incident or complication.

Prior analysis based on the spatialization of information enables a preliminary inference that there is a direct relationship between the number of patients and devices by neighborhood. The average age of patients is 53.6 years old, with the majority located in

Table 3 Patients from the 10 neighborhoods closest to the Distribution Center in Salvador.

Neighborhood	Patient Records	Devices Distributed	Health Units	Number of Hospitals	Distance from Distribution Center (in meters)	Average Age of Patients
Centro	58	19	134	0	460.7	58.8
Barris	21	5	17	1	683.1	54
Tororó	12	4	7	1	860.3	49.7
Centro Histórico	9	1	4	0	908.2	62
Nazaré	24	5	63	8	1130.1	58.3
Saúde	7	3	1	0	1355.8	52.9
Garcia	34	11	23	1	1377	54.9
Canela	14	3	147	3	1593.8	63.5
Boa Vista de Brotas	9	1	2	0	1682.7	60.7
Engenho Velho de Brotas	80	26	7	0	1734.5	59.5
Subtotal	268	78	405	14	-	57.43

Source: Salvador's Municipal Health Department.

Fig. 4 Patient age by neighborhood, according to the database

Source: Salvador's Municipal Health Department.

Fig. 5 Records of health units by neighborhood, March 2012

Source: SUS IT Department (DATASUS).

neighborhoods closest to Salvador's central region, thereby facilitating the patient's journey to the distribution center. There is also a trend for those neighborhoods with the highest number of devices to be located closer to the city's central region, while neighborhoods considered to be more affluent have fewer records of devices distributed free of charge. Finally, as mentioned above, a number of

neighborhoods at a distance from both the central region and the distribution center do not provide facilities for preventive or emergency services.

3.2 Exploratory Statistical Spatial Data Analysis

In order to calculate the spatial association indicators, we analyzed the data for the number of records of patients with diabetes and glucometers, according to the population of their respective neighborhoods. Thus, we constructed an indicator for the number of records of patients with diabetes and glucometers for every 1,000 inhabitants.

The results of this indicator are presented in Figure 6, in which we can observe that the spatial distribution of the number of records and devices for every 1,000 inhabitants is very similar. The two variables have a slightly higher concentration in the two central regions in Salvador (the historic center and the new center known as the Iguatemi region). This means that a large concentration of patients, close to the city's second central region, are at a locational disadvantage compared to the historic center. This observation is of particular concern when we consider that this is a low-income population. On the other hand, we expect the global spatial autocorrelation indicator to be positive.

Figure 7 below presents a graph showing the distribution and Moran's Spatial Autocorrelation Index. We observe that there is a positive spatial autocorrelation for both diabetes records (0.1945) and number of glucometers (0.1349). Although this autocorrelation is quite low, we can confirm that a spatial autocorrelation pattern exists in Salvador, composed of neighborhoods with a high number of records for diabetic patients and glucometers per 1,000 inhabitants, surrounded by neighborhoods with the same attributes.

From the public policy point of view, this shows that it is possible to optimize the structure for patient care, in other words, to decentralize distribution and thereby guarantee wider access to medical supplies and glucometers.

Fig. 6 Records of diabetes and glucometers per 1,000 inhabitants.

Source: Compiled by the author, 2013.

Fig. 7 Global Spatial Autocorrelation

Source: Compiled by the author, 2013.

Although the global autocorrelation index shows that a spatial autocorrelation pattern exists, it does not enable an analysis of the different pattern locations. Figure 8 therefore shows that the most significant statistical neighborhood clusters with a higher number of patient records and glucometers are concentrated in the areas surrounding the central regions (center and Iguatemi). This concentration of devices and patients

shows that the social and economic conditions in the neighborhoods did not define device location. Additionally, it is possible that device location follows the pattern related to type or severity of diabetes. However, there is a pronounced inequality, since there are two statistical clusters of patients with devices but only one distribution center, located close to the cluster for the city's historic region.

Fig. 8 Local Spatial Autocorrelation (Cluster Map)

Source: Compiled by the author, 2013.

Following a breakdown of the data and a social, economic and exploratory analysis of the spatial data, the aim of the next section is to econometrically estimate the parameters which refer to the conditional probability of insulin-dependent patients receiving glucometers free of charge, on account of the observable attributes of these patients, and the geographical, social and economic characteristics of their respective neighborhoods.

3.3 The Probability of Obtaining a Glucometer: a Clear Overview

Descriptive statistics related to the database used for estimations are presented in Table 4. Following data processing, the final database contained the neighborhoods' individual, social and economic characteristics and records for the 6,245 patients served by Salvador's Municipal Health Department.

The average age of these patients is 53.6 years old, varying between one and one hundred years.

In accordance with the 2010 Census of the Brazilian Geography and Statistics Institute (*Instituto Brasileiro de Geografia e Estatística* – IBGE), an average of 96.02% of the population in the Salvador neighborhoods are literate. In the neighborhood with

the highest level of education, 99.4% of the inhabitants are literate, while this falls to 83.6% in neighborhoods with the lowest level of education.

Average income in the neighborhoods was BRL 1,214.30 in 2010, while the average in the district with the highest income was BRL 7,255.06. This was BRL 387.42 in the neighborhood with the lowest income, revealing the high income inequality in the Salvador population. We can infer that the same is true of diabetic patients.

With regard to journeys, patients had to travel an average of 8.12 km to arrive at the glucometer distribution center. The patient with the longest journey travelled 23.3 km, while the shortest journey was 0.4 km, demonstrating high standard deviation.

In accordance with the correlation matrix presented in Table 5 below, we confirm that the majority of the correlation values were relatively low. We note that age, level of education, neighborhood, income and order of patient inclusion in the Public Healthcare System presented a negative correlation for obtaining a glucometer.

On the other hand, in relation to the distribution center, the distance for male patients with type 1

Table 4 Descriptive statistics

Variable	Observations	Average	Standard Deviation	Minimum Value	Maximum Value
Glucose	6245	-	-	0	
Age	6245	53.64836	18.65731	1	10
Gender	6245	-	-	0	
Level of education	6245	96.0203%	1.88456%	83.61%	99.46%
Income	6245	1214.296	1049.729	387.42	7255.0
Distance to center	6245	8124.327	4623.147	398.4384	23376.6
Type 1	6245	-	-	0	
Insulin	6245	-	-	0	
Order	6245	-	-	1	624

Source: Compiled by the author, 2013.

Table 5 Correlation matrix

	Glucose	Age	Gender	Level of education	Log (income)	Log (distance C Gomes)	Type 1	Insulin
Glucose	1							
Age	-0.028	1						
Gender	0.0015	-0.089	1					
Level of education	-0.009	0	0.0096	1				
Log (income)	-0.013	0.0138	0.0112	0.7713	1			
Log (distance C Gomes)	0.0141	0.0038	-0.019	-0.402	-0.403	1		
Type 1	0.0334	-0.488	0.0423	-0.003	0	-0.006	1	
Insulin	0.0669	0.0484	-0.007	0.0147	0.0048	-0.017	-0.042	1
Order	-0.145	0.1885	-0.013	0.0294	0.0466	-0.021	-0.102	0.0155

Source: Compiled by the author, 2013.

diabetes mellitus who received insulin demonstrated a positive correlation for obtaining a glucometer.

Further important correlations show that patients with the highest education levels also have a higher income. In terms of distance from the distribution center, we note the high negative correlation between distance from the distribution center, age and income. This shows that younger patients on lower incomes reside at some distance from the Supply Distribution Center for the control of diabetes.

With regards to type of diabetes, we note the high negative correlation between type 1 diabetes mellitus

and age, in line with the medical literature. Patients who received insulin present a positive correlation with receipt of a glucometer and a positive correlation with age, education level and income. On the other hand, there is a negative correlation with male patient, distance from distribution center and type 1 diabetes mellitus.

The variable for the order of patient registration reveals some important information about whether or not the standard of care in the Public Healthcare System changed between 2006 and 2012. In the last line of Table 5, we can observe that patients who were

the last to enter the system (in ascending order of time) are not only negatively correlated with receipt of a glucometer (less possibility), but also present a positive correlation for age (more advanced); a negative correlation for male patients (a trend for females); a positive correlation with level of education (higher); a negative correlation with distance (closest to the distribution center); a negative correlation with type 1 diabetes mellitus; and a positive correlation with receiving insulin, corroborating the fact that they are of more advanced age.

It is probable that the patients who received the most insulin were those who had most recently entered the system and that the majority do not have an essential glucometer requirement.

Although the correlation analysis presents important information, there are a number of intersections between the variables. We can therefore apply the econometric estimation procedure described above, in order to exclude these intersections and present only specific information about the contribution of each variable to patient receipt of a glucometer. These estimations are presented in Table 6.

Ordinary Least Square (OLS) estimations for the Linear Probability Model (LPM) were performed prior to the appropriate estimation; this is an estimation using the Probit and/or Logit non-linear model for comparison purposes.

From the R^2 coefficient of determination in the OLS estimation, the results of the econometric estimations initially demonstrate that the explanatory variables only explain 2.6% of variation for the probability of the patient receiving a glucometer. This demonstrates that factors which are considered random explain almost the entire variation for the probability of obtaining a device.

These results also show that estimations, such as the OLS method (which is not methodologically indicated), were considerably different from those found in the Probit and Logit models, which were very close to each other.

Table 6 Econometric Estimations

Dependent variable			
$y = 1$, if the patient received a glucometer			
$y = 0$, if they did not			
Variable	OLS (LPM)	Probit	Logit
<i>Constant</i>	0.2511 (0.4238)	-0.7346 (1.2293)	-1.1448 (2.0261)
<i>Age</i>	0.0002 (0.0004)	0.0007 (0.0011)	0.0012 (0.0017)
<i>Gender</i>	0.0000 (0.0120)	0.0013 (0.0348)	-0.0004 (0.0576)
<i>Level of education</i>	0.0004 (0.0049)	0.0014 (0.0142)	0.0019 (0.0234)
<i>Income</i>	-0.0024 (0.0164)	-0.0052 (0.0476)	-0.0095 (0.0788)
<i>Distance</i>	0.0080 (0.0093)	0.0248 (0.0269)	0.0391 (0.0446)
<i>Type 1</i>	0.0264 (0.0146)**	0.0822 (0.0415)**	0.1311 (0.0690)**
<i>Insulin</i>	0.0797 (0.0143)***	0.2378 (0.0427)***	0.4002 (0.0721)***
<i>Order</i>	0.0001 (0.0000)***	-0.0001 (0.0000)***	-0.0002 (0.0000)***
<i>N</i>	6190	6190	6190
<i>R²</i>	0.0264		

Source: Compiled by the author, 2013.

Note: Level of significance established at: *** 1%; ** 5%.

None of the constant term and parameter estimates for the variables age, gender, level of education, income and distance were statistically significant, and we confirm that these variables do not individually explain the probability of an individual obtaining a glucometer.

On the other hand, the variables for type 1 (whether the patient has type 1 diabetes mellitus), insulin (whether insulin was among the medication received) and order (the order in which the patient entered the system between 2006 and 2012) were statistically significant. However, the results of the Logit model are most frequently methodologically indicated.

In the Logit model, the results show that the

variables referring to type of diabetes and stage of insulin treatment explain a variation of 0.311 and 0.400, respectively, for the probability of obtaining a glucometer. This demonstrates that, independent of the other variables and patient characteristics, type of diabetes and disease severity determined device acquisition. On the other hand, another important result is that patient order of entrance to the system was a determining factor for obtaining a glucometer. This variable was statistically significant at 1%.

All these patients should have received a device, however, we can confirm that those patients who entered the system most recently had a reduced probability of receiving a device. It is worth remembering that this variable would not present statistical significance in a healthcare system that provided standardized care.

4. Conclusions

This article presented an analysis of the spatial distribution of patient records and glucometers in the Public Healthcare System in Salvador. We also conducted an econometric estimation of the probability of a patient receiving this device in terms of observable patient characteristics, social and economic structure, location of neighborhood in which the patient resides and period in which the patient used the healthcare system to obtain this device.

An analysis based on the spatialization of information led to the observation of a direct relationship between the number of patients and devices per neighborhood. The average age of patients is 53.6 years old and the majority resided in neighborhoods where the journey to the distribution center is relatively easy. There is a direct relationship between patient and receipt of device, in that the neighborhoods with the highest number of devices are also closest to the city center. Neighborhoods considered more affluent have fewer records of devices distributed free of charge. Neighborhoods

further from the central region, and thus from the distribution center, do not contain facilities for preventive or emergency patient care.

The exploratory analysis of spatial data provided by the global spatial autocorrelation index and Moran's distribution graph revealed evidence of a spatial pattern in which neighborhoods with a high patient concentration are surrounded by others also with a high patient concentration. This was also observed in neighborhoods with a low patient concentration, which were, in turn, surrounded by those with a low patient concentration. In addition, we noted a statistical cluster of patients close to the new central region of Salvador, who had relatively less access to health facilities that treat diabetes (hospitals and health centers) and were further away from the distribution center. This evidence is particularly important, since the second cluster is located in a region with a low-income population. We noted that the average patient journey to the glucometer distribution center ranged from 8.12 km to 23.3 km. Patients with a shorter journey travelled 0.4 km, also demonstrating high standard deviation.

Decree N° 2583/2007, which established the incorporation of glucometers into the list of medical supplies, encountered certain obstacles in relation to the medication and supplies made available to users with diabetes mellitus through the Unified Public Health System under the terms of Law N° 11347 of 2006, which prevented access to the home monitoring of glucose levels. The acquisition of this device necessitates a journey to the health center closest to the patient's home, with transport costs borne by the patient. Centralized distribution at the Carlos Gomes Health Center therefore hinders access, since we found that patients are heterogeneously distributed across a number of neighborhoods in Salvador, and have to pay the transport costs to this location.

The econometric estimation results initially demonstrated that the probability of a patient receiving a glucometer is extremely random; that is,

purely arbitrary factors determine a high percentage of the probability of obtaining a device. Individual characteristics alone were not determining factors, instead these included type of diabetes and recommended treatment. In parallel, patients who were the last to enter the system had less probability of receiving a device, suggesting recent alterations to the form of distribution and/or availability.

Equality is a SUS principle, established through the 1990 Organic Health Law (Nº 8080), and could have been implemented in this case, given that it is already applied in public healthcare and used by the municipality in its distributive analysis of public resources. Given this, why has this principle not been applied to the distribution of glucometers?

Decree GM/MS Nº 3237/2007 approved the implementation and financial regulation of pharmaceutical assistance in basic healthcare. It determined that supplies for the care of patients with diabetes mellitus would be financed by the States and Municipalities. If this law envisaged resources for the acquisition of supplies, why were a sufficient number of glucometers not acquired in order to provide them to all registered patients? In this case, why were only 1,941 glucometers distributed to diabetic patients?

It is necessary to guarantee access to vital supplies for the care of this disease. The use and distribution of glucometers needs to be monitored and public resources must be used in line with the SUS principles of universality and comprehensiveness.

Management needs to monitor the implementation of planned activities, to evaluate policies to prevent the widening of existing inequalities and ensure that such activities do not lead to unequal access to technologies. We therefore recommend the decentralization of the distribution of supplies to control diabetes in Salvador and the acquisition of sufficient supplies for SUS user needs, in order to ensure access to a glucometer and to control the disease.

Managing and inputting more data to information systems, in order to guarantee data reliability, will

enable the formulation of specific policies and local activities related to the care of diabetes involving health centers and basic healthcare teams.

We did not confirm the hypothesis that the better-informed section of the population, which generally has a higher income, has greater access to the glucometers made available through the network. While acknowledging the existence of certain constraints, social, economic and geographical factors do determine access to the supplies used to control diabetes. Although the research hypothesis was rejected, the study remains important and demonstrates the need for further research in order to identify the factors that determine access to supplies for diabetes care in Salvador. We recommend extending the study to the entire State of Bahia.

Human life should be valued within the context of health, and information is a pathway utilized as a form of empowerment, through the appropriation of knowledge. Investing in strengthening communication and health is therefore a strategy which can enable SUS users to guarantee their rights to health promotion and prevention and their access to diabetes care.

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