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Direct costs of severe hypoglycemia events in individuals with diabetes mellitus: a perspective from the Colombian health system - a single-center study

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ABSTRACT

Background and aims: Diabetes mellitus is one of the more prevalent chronic diseases globally, and healthcare expenditures for diabetes care are on the rise. Intensive diabetes treatment has been associated with reducing the risk of chronic complications. However, hypoglycemia, the most common adverse effect, poses a significant risk to individuals' lives and is linked to high costs for healthcare systems.
Methods: We conducted a retrospective cross-sectional study to determine direct costs by identifying emergency room visits due to hypoglycemia events using diagnostic codes during January 2017 to June 2019. Direct costs were calculated using billed data from the payer and information on outpatient treatment regimens. Differences in median costs were estimated based on length of stay and type of outpatient treatment.
Results: Data from 101 patients and the same number of events were included. Women represented (62.4%) of the patients, the median age was 70 (IQR 59.5–80). Blood glucose levels at admission ranged from 12 mg/dL to 67 mg/dL. Most patients were on insulin for outpatient treatment. The median cost of care per hypoglycemia episode was US $345.35 (IQR US $202–727.8), and the cost per episode was higher in patients treated with regimens that included sulfonylureas.
Conclusions: The management of patients admitted to the emergency department with a diagnosis of hypoglycemia places a significant burden on the Colombian healthcare system, primarily due to the associated hospitalization costs. Patients treated with regimens that included sulfonylureas incurred higher costs per episode. Prevention, patient education, and individualized treatment approaches could help alleviate the burden of hypoglycemia on both patients and the healthcare system.

Introduction

Diabetes mellitus (DM) is a non-communicable chronic disease and one of the most prevalent public health challenges worldwide. Epidemiological data suggests that unless measures are taken to prevent or treat associated risk factors, the global prevalence of diabetes will continue to rise. It is projected that the disease will affect 366 million individuals by 2030, with the most significant demographic shift being the increase in the population aged 65 and older during this period [1].

Medical care for diabetes and its complications imposes a significant financial burden on countries and healthcare institutions, leading to substantial out-of-pocket expenses [2]. The escalation in global healthcare expenditures related to diabetes care has been considerable, rising from US $232 billion in 2007 to US $966 billion in 2021 for adults aged 20 to 79, representing a 316% increase over 15 years [3].

Hypoglycemia in a patient diagnosed with diabetes can result from factors such as an excessive dose of insulin, insufficient food intake, or vigorous physical activity without caloric replacement.

According to the American Diabetes Association (ADA), blood glucose levels below 70 mg/dL are classified as hypoglycemia and can be clinically characterized as severe or non-severe. Severe hypoglycemia is characterized by the need for medical intervention and an inability to resolve it through oral carbohydrate intake due to the patient's altered consciousness [4]. Hypoglycemia is considered the most common complication of intensive diabetes treatment, posing risks to the patient's life and incurring substantial costs for healthcare systems [5].

Hypoglycemia in individuals with diabetes is a significant concern, particularly when striving for stricter goals for diabetes control. This issue is relevant because short-term complications may include cardiovascular events, neurological damage, physical injuries, and even fatalities [6]. It is, therefore, imperative to establish individualized goals for glycemic control, considering factors such as diabetes duration, life expectancy, and comorbidities. According to ADA recommendations, younger patients without complications should aim for more stringent therapeutic goals (HbA1c < 6.5%), while

those with a shorter life expectancy, chronic complications, limited socioeconomic support, and associated comorbidities should have more relaxed glycemic goals (HbA1c 7.5–8%) [7].

In Colombia, the costs associated with diabetes mellitus constitute a substantial portion of healthcare expenditures [8]. Severe hypoglycemia (potentially preventable events) generates one of the highest costs [9]. Hence, it is crucial to quantify and understand the costs involved in these events.

From a societal perspective, the annual cost of DM in Colombia is US $2.708 billion. According to the Ministry of Health and the Colombian Healthcare System's viewpoint, the annual direct healthcare costs are $911 million. This translates to an annual direct cost of US $288 per patient, with an additional indirect cost of US $559 (total = US $847). The expenses related to diabetes treatment and macrovascular complications account for 86% of direct costs and 95% of indirect costs [10].

Estimating the economic impact of hypoglycemia is crucial as it aids in the development of effective interventions that improve diabetes control and the overall patient care process.

This study estimates the direct costs of hypoglycemia resulting from the care of patients admitted through emergency services, focusing on a payer's perspective.

Methods

Study design and patients

This was a retrospective cross-sectional direct costs study. Data were extracted from the digital medical records (DMR) of patients admitted to the emergency room (ER) and diagnosed with hypoglycemia between January 2017 and June 2019. To identify the DMR, diagnostic codes from the ICD-10-CM: E160 (drug-induced hypoglycemia without coma), E161 (other types of hypoglycemia), and E162 (unspecified hypoglycemia) were used. Hypoglycemia events were defined as instances where the admission blood glucose level was below 70 mg/dL.

The study included DMR from patients over 18 years of age, diagnosed with type 1 or 2 DM receiving outpatient treatment with insulin or oral antidiabetic medication, and admitted to ER due to a hypoglycemia event requiring medical attention. The collected data included patients' demographic and clinical characteristics, type of diabetes, medications, disease duration, and hospitalization-related information, including length of stay and associated causes.

Cost calculation

Direct costs were identified as expenses related to medical and non-medical clinical consultations, prescribed treatments (medications and medical devices), clinical laboratory tests, procedures, diagnostic aids, and length of stay. The direct costs per hospitalized patient with a hypoglycemia event were determined using billed data from the payer and information on outpatient treatment regimens. All the costs are presented in US Dollars, with an exchange rate of 1 US $ = 3.753 Colombian pesos used for conversion.

Statistics methods

Data analysis involved the use of descriptive statistics. The Mann-Whitney U test was employed to assess differences in median costs, length of stay, and types of treatments between groups, as the data did not adhere to a normal distribution and exhibited unequal variances. SPSS 21 software was used for all statistical analysis.

Ethics

The study was approved by the Pablo Tobon Uribe Hospital Ethics Committee (code 2019.086). Only one of the researchers had access to patient identification. The rest of the authors only had access to a de-identified database. Informed consent was not required by the committee due to the study design. All authors had access to the study data and reviewed and approved the final manuscript.

Results

Data from 112 patients' digital medical records (DMR) were retrieved, and 101 patients were included in the final analysis. Excluded records belonged to patients with hypoglycemia but without diabetes. The median age was 70 (IQR 59.5–80), and most patients were women (62.4%). The median length of stay (LOS) was 1.3 days (IQR: 0.6–2.3). The median duration of diabetes was 14 years (IQR: 10–21.5). A substantial proportion of the patients, 90.1%, were literate, and the subsidized insurance system covered 43.6%. Cardiovascular disease was the most frequent macrovascular complication observed in 78.2% of cases. At least one microvascular complication was present in 46% of patients.

At admission, the most common outpatient treatment regimen was the exclusive use of insulin, followed by a combination of basal insulin with one or more non-sulfonylurea oral antidiabetic medications. Detailed demographic and clinical characteristics are presented in Table 1.

Table 1. Patients demographic and clinical characteristics.

	Total $N = 101$
Sex, female, n (%)	63 (62)
Age in years, median (IQR)	70 (59.5–80)
Length of stay in days, median (IQR)	1.3 (0.6–2.23)
HbA1c%, median (IQR)	6.5 (5.6–7.3)
Insurance category	
Contributory plan	50 (49.5)
Subsidized	44 (43.6)
Education, n (%)	
No education	10 (9.9)
Primary	60 (59.4)
Secondary	27 (26.7)
Tertiary	4 [4]
Type 2 diabetes, n (%)	94 (93.1)
Duration of diabetes in years, median (IQR)	14 (10–21.5)
Microvascular complications, n (%)	
Diabetic kidney disease (DKD)	35 (34.7)
Retinopathy	21 (20.8)
Neuropathy	15 (14.9)
Macrovascular complications, n (%)	
Cardiovascular Disease	79 (78.2)
Arterial Disease	13 (12.9)
Cerebrovascular disease	11 (10.9)
Outpatient insulin treatment, n (%)	85 (84.1)

IQR: Interquartile range.

Table 2. Possible causes of hypoglycemia.

	Total $N = 101$
Insufficient carbohydrate intake	44 (43.6%)
Overinsulinization	20 (19.8%)
Medication error	
Incorrect insulin dose	15 (14.8%)
Incorrect insulin type	2 (2%)
Unprescribed medication	3 (3%)
Unknown	13 (12.9%)
Delayed mealtime	4 (4%)

Hypoglycemia events and related causes

Overall, 64% of patients had a blood glucose level at admission equal to or below 40 mg/dL, and 7% had a glucometer reading indicating 'LOW.' The recorded blood glucose levels ranged from a minimum of 12 mg/dL to a maximum of 67 mg/dL. Furthermore, 84.2% of the patients were on outpatient treatment with insulin.

The leading cause of hypoglycemia was insufficient carbohydrate intake, accounting for 43.6% of cases, followed by excessive insulin doses and medication errors. The reasons leading to hypoglycemia are presented in Table 2.

Among all the treatment regimens, those that included a sulfonylurea were associated with a median hospital length of stay of 1.45 days (IQR: 0.92–2.85), compared to regimens without a sulfonylurea, where the median length of stay was 1.2 days (IQR: 0.60–2.25).

Costs

The total cost of the hypoglycemia episodes amounted to US $59.75. The median price of care per hypoglycemia episode was US $345.35 (IQR US $202–727.80). Medications accounted for 32.2% of the total expenses, diagnostic aids for 30%, LOS for 24.3%, medical team care for 13.6%, and non medical clinical consultations for 0.26%.

The cost per episode was higher in patients treated with regimens that included sulfonylureas *(p 0.015)*, with a median price of US $492.20 (IQR: 359.20–991.80), compared to patients treated with other regimens, US $287.70 (IQR: 187.3–703), with no significant differences *(p 0.19)* in the median LOS between the groups. Table 3 presents the median costs associated with different treatment regimens.

Discussion

The study underscores that the management of patients admitted to the emergency department with a diagnosis of hypoglycemia imposes a significant burden on the Colombian healthcare system, primarily due to the associated hospitalization costs. Interestingly,

Table 3. Hypoglycemia costs per treatment.

Treatment	Costs median (IQR) US $
Insulin + SU	2023.3 (1187.64 to 2858.97)
SU + other antidiabetic	572.3 (381.6 to 767)
Non insulin antidiabetic	412.3 (271.26 to 543.42)
SU	408 (393.13 to 1061.41)
Insulin only	379.5 (220.29 to 790.57)
Insulin + other antidiabetic	240.9 (154.98 to 345.55)

SU: sulfonylurea; IQR: interquartile range.

the median cost per hypoglycemia episode in this study was approximately US $350 considerably lower than the average price of $1387 per visit reported in a study conducted in the United States [11].

The finding that insufficient carbohydrate intake is the primary cause of hypoglycemia (43.6%), aligns with findings from a study conducted in Korea, which investigated clinical characteristics, causal factors, and medical costs of patients with severe hypoglycemia in an emergency department. In the Korean study, the leading causes of hypoglycemia were poor nutrition (73.4%), changes in medication or dosage (12.5%), alcohol consumption (11.6%), hemodialysis (4.4%), and exercise (9%) [12]. Both studies emphasize the significant role of poor nutrition or skipped meals in hypoglycemic events. This commonality underscores the importance of timely paramedic interventions to educate patients about safe treatment management and promote healthy lifestyle habits to minimize complications.

Hypoglycemia care costs vary according to the severity of hypoglycemia, the length of hospital stay, patient complications, and the level of care. A study conducted in Thailand reports a cost of 831.1 US per event, where the main charges related to inpatient services, laboratory tests, and medications [13]. Our study's median length of stay was 1.97 days, aligns with findings from other studies. A study conducted in two private hospitals in Amman, Jordan, reported a median stay of two days for patients admitted for hypoglycemia (IQR = 2 days). Similarly, a study conducted in Denmark analyzing hypoglycemia-related emergency department admissions between 2008 and 2011 reported a mean length of stay of 2.7 days [14]. These findings highlight the need for efficient management and prompt interventions to reduce the duration of hospitalization for patients with hypoglycemia, and specific strategies could include implementing personalized nutrition education programs to address the frequent issue of insufficient carbohydrate intake, optimizing treatment regimens to minimize the use of sulfonylureas, and introducing continuous glucose monitoring systems for high-risk patients to prevent severe episodes.

Our study has several limitations. As a single-center report from a hospital that provides complex care, these findings can't be generalized to other settings such as primary care. Additionally, indirect costs associated with hospitalization and non-medical expenses were not analyzed due to a lack of available data. This limitation hinders a comprehensive understanding of the full economic impact of hypoglycemia episodes. According to recent reports, these contribute 37% to 40% of the total costs of diabetes management [13]. On the other hand, the population in our study may not accurately reflect the diabetes population in our country, particularly those with severe hypoglycemia. Unfortunately, the lack of epidemiological data hinders our ability to make comparisons with other local studies. Finally, recent technological developments, such as nasal glucagon, could reduce the need for hospitalization due to hypoglycemia; however, these advances often take longer to reach developing countries.

Conclusions

The study findings underscore the substantial economic impact of hypoglycemia, with hospitalization and medical care expenses including medication and diagnostic aids,

being the primary cost drivers. Patients treated with regimens that included sulfonylureas incurred higher costs per episode compared to those on other regimens.

These findings emphasize the importance of prevention, patient education, and individualized treatment approaches to alleviate the burden of hypoglycemia on patients and the healthcare system. Future interventions should address modifiable factors such as nutrition education and medication management to improve outcomes and reduce healthcare costs associated with hypoglycemia.

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Declaration of financial/other relationships

The authors certify that they have no affiliation nor are they involved with any organization or entity with any financial interest (such as fees, financial aid for education, shares, employment contracts, work as consultants, or any other type of interest) or non-financial interest (such as personal, professional relationships, affiliations, or beliefs) in the topic of interest or any material discussed in this manuscript. CEBM has received consulting or speaker fees from Sanofi, Novo Nordisk, Novartis, Recordati, and Boehringer Ingelheim.

Author contributions

CEBM and NRH participated in the concept and design of the study. MAGR, ACHH, JDG were responsible for data acquisition. NRH reviewed and analyzed the data. All the authors were involved in writing and editing the final version of the manuscript.

Data availability statement

The datasets generated or analyzed for the current study are available from the sponsor institution on reasonable request.

Previous presentations

This work was previously presented as a poster under the title 'Costos directos de la hipoglucemia como causa de ingreso al servicio de urgencias desde la perspectiva del pagador.'

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