Evaluation in the first level of care of patients with type 2 diabetes and their risk of hospitalization in Mexico

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Abstract

**Background:** A significant body of international evidence suggests that effective primary care systems are associated with better health, lower total health costs, and more equitable access to health care services, which has led the World Health Organization (WHO) to call for strengthening primary care systems globally. Patients with diabetes often seek treatment and have follow-up as outpatients, be it at private or government health facilities. Thus, the objective of this study was to assess the effect of glucose control during outpatient care on first hospitalization risk in type 2 diabetes mellitus (T2DM) patients.

**Methods:** The data used in this retrospective cohort study were obtained from the Non-Communicable Diseases Analysis System (SANENT)® of the Instituto Mexicano del Seguro Social (IMSS). Thus, this work was performed on 3,716,031 DM2 patients, with data regarding a first hospitalization risk estimated using a Cox regression model.

**Results:** The first hospitalization crude risk for diabetes mellitus decreased by 32% in T2DM patients under control through outpatient care (HR: 0.68, 95% CI [0.68,0.69]). Adjusted risk decreased by 23% (HR: 0.77, 95% CI [0.76, 0.77]).

**Conclusion:** The obtained results are consistent with what has been stated in the literature. Outpatient care of diabetic patients at the IMSS should be further strengthened by means of preventive and educational strategies and supported by technology.

**Background**

Type 2 diabetes (T2DM) is a global health problem, and Mexico ranks sixth in the prevalence of this disease [1]. Mexico has experienced several decades of rapid epidemiological and demographic changes, making a combined national and subnational analysis of the burden of diseases, injuries, and their risk factors timely. The Instituto Mexicano del Seguro Social (IMSS) in Mexico is the health institute that assists a large portion of the population (76%). In addition, diabetes is the leading cause of death and is a major cause of hospital care being responsible for approximately 1 in 5 discharges. In the hospital setting, it has been observed that hyperglycemia in diabetic patients is associated with an increased risk of complications, disability and death and that adequate control of blood glucose
levels produces a reduction in these complications [2]. The World Health Organization (WHO) in 2000 calculated the disability-adjusted life years (DALYs) by region and country, which allowed a comparison of the magnitude of diseases, injuries and risk factors. Diabetes entered the table of the main causes and became of leading cause of death in the world. [3]

Diabetes hospitalization costs at the IMSS from 2008 to 2013 were estimated at 1.563 million dollars [4]; a third of this amount was assigned to peripheral circulatory complications. On the other hand, the costs of preventable hospitalizations or those sensitive to primary care at the IMSS over a similar period of time (2007-2014) have been estimated at 2.186 million pesos [5]. Evidence regarding the effects of primary care on various health outcomes, corresponding hospitalizations or death has been documented in different studies, some of which evaluated the impact of specific programs [6-10]; other studies have analyzed hospitalization trends for potentially preventable chronic conditions, which at the same time, helped to indirectly measure outpatient care effectiveness and quality [11-17]. Thus, several studies have provided evidence regarding different interventions to avoid hospitalization and the use of emergency services in diabetic patients [18-21].

In 2018, at the IMSS, 15.3 million family medicine consultations on T2DM were provided [22], which was equivalent to 18% of the total medical consultations given and placed diabetes as the second leading cause for medical attention. Diabetes stands in the 9th position on the list of reasons for specialty consultations with 0.62 million consultations (3%). It also stands in the 9th position on the list of reasons for urgent care visits, with almost 0.4 million patients attended to (2%) and in the 8th position on the list of hospital discharge diagnoses, with 57,406 hospital admissions (3%). These numbers would be higher if the burden on medical services due to diabetes comorbid with other causes was taken into consideration.

The IMSS has implemented programs to prevent diabetes and to attend to diabetic patients. These programs, such as the Health Integrated Program (PREVENIMSS, by its acronym in Spanish) and theUnits for Diabetes Control and the Detection of its Complications (DIABETIMSS, by its acronym in Spanish), integrate a number of actions to prevent and control diabetes and their comorbidities. The impact that such integrated programs have on death rates, and the frequency of the diseases
that have been focused on, have been documented by PREVENIMSS [23]. This program has also allowed the Institute to estimate the diabetes preventable hospitalization burden at the IMSS; however, the effects of diabetes controlled though outpatient care services on hospitalization has not been studied in Mexico [12, 24]. In Australia, from 2006 to 2014, a cohort study was performed among a group of government veterans to estimate the impact that the General Practitioner Management Plan (GPMP) had over diabetes hospitalization risk [25]. Similarly, the main aim of this work is to assess the effects of control through outpatient care at the IMSS Family Medicine Division on the first hospitalization risk for diabetes.

 Methods

 Study Population

This was a retrospective cohort study (2006-2017). The patients were clinically diagnosed by doctors at the IMSS. We included primary care patients and those hospitalized who had a history of diabetes. All analyses were performed at the state level by sex and age. For presentation, we grouped the 32 Mexican states into four geographic regions, which were determined and classified by the IMSS. The North-West region and the North-East region are the most socially and economically developed and have relatively close cultural and economic links to the United States. The Central Northern and Central Southern regions are the least developed and have significantly higher poverty and indigenous populations than the other regions. Mexico City is a highly urbanized, wealthy region with excellent infrastructure but with immigration from poor areas in the Central, Gulf, and Southern regions. Regional and national results were obtained by aggregating state-level results. This protocol was evaluated and approved by the National Research and Health Ethics Committee of IMSS, with the registry number R-2014-785-024.

 Data Sources

The data used in this study were obtained from the Non-Communicable Diseases Analysis System (SANENT)® of the Instituto Mexicano del Seguro Social (IMSS). This work was performed on 3,716,031 T2DM patients, with data regarding the first hospitalization risk estimated using a Cox regression model; by 2017, the database had a total of 4,223,430 people with access to healthcare. Based on
this database, a search was conducted on the records from 2006 to 2017 to determine how many diabetic patients had received attention at the Family Medicine Division and how many admissions had been registered. Data regarding outpatient and hospital care were found for 3,882,581 subjects (Figure 1), of which 3,716,031 were selected according to the following criteria: 20 years of age or older; date of first hospital admission subsequent to their last Family Medicine consultation; diagnosis coding compatible with the 10th revision of the International Classification of Diseases (ICD-10); and complete records with sex, anthropometric data, glucose, blood pressure, and consultation and hospitalization dates.

**Baseline Variables and Follow-up**

Outpatient care data were used to obtain information about blood glucose measurements in mg/dl, blood pressure in mmHg, weight in kilograms, size in centimeters and date of consultations, which was also used to estimate how long they had been receiving outpatient care. This was determined as the difference in years between the first medical consultation and last medical consultation dates. The difference in years between the hospital admission date and first medical consultation date at the Family Medicine Services was used to establish the elapsed time until the first hospitalization event. Hospital discharge data were used to define the kind of admission (urgent or scheduled), the average length of stay (days), the necessity for any kind of surgical intervention and death as the reason for discharge.

The time patients spent with the disease was estimated as the difference in years between the first medical consultation and last medical consultation dates, according to the information available on the diabetic patient census. From this source, information about age, sex, district of residence and last diabetes diagnosis, as well as the presence of any disease complications, was also obtained.

**Defining complications**

The following conditions were selected for inclusion: coma, ketoacidosis, renal, ophthalmic, neurological, and peripheral circulatory complications, multiple complications and other specific complications.

**Metabolic measurements**
Blood glucose measurements, blood pressure and body mass index data available for each patient during the period of time assessed were averaged. The average measurement of blood glucose was transformed to glycation hemoglobin (HbA1c) [26]. The subjects were classified as controlled diabetic patients when their HbA1c measurements fell under 6.5 % [27]; when their average measurements were higher, the patients were classified as uncontrolled. Individuals with an average systolic blood pressure lower than 140 mmHg and an average diastolic blood pressure lower than 90 mmHg were considered controlled, whereas those with values equivalent to or higher than the ones referred to above were classified as uncontrolled. On the basis of the fourth ICD-10 digit of the patients’ latest registered diagnosis, digit 9 patients were classified as uncomplicated, and digit 0 to 8 patients were classified as complicated; all patients whose fourth digit “X” was not specified were excluded from the study.

**Statistical analysis**

To assess the differences between the group of controlled diabetic patients and the group of uncontrolled diabetic patients, the Kruskal-Wallis test was used for the numerical variables, and the chi-square test was used for the categorical variables. The Kolmogorov-Smirnov normality test was also applied to the numerical variables. The hospitalization crude risk for both groups was estimated, and the existence of an interaction was evaluated.

The effect that outpatient care control of the diabetic patient has over hospitalization risk was estimated by means of a Cox regression model, using days as the time measure between first consultation and first hospitalization dates; the estimations were adjusted by sex, age, geographical area, glucose level control, body mass index, blood pressure control, diabetes complications records, time spent with the disease (years) and time spent under control (years). Statistical analyses were performed using the R statistical computing software [25], along with the packages epitools, survival, survminer, ggplot2 and DiagramemeR.

**Results**

The characteristics of the sample, which included individuals with and without blood glucose control (Table 1), were as follows: proportion of women was higher among both groups (60.5% in the
controlled group and 59.0% in the uncontrolled group); median age was higher among the controlled group (63 years, with an interquartile range (IR) of 18 years vs 59 years, with 17 IR); in the controlled glucose group, there was a higher presence of individuals from the Northern region (56.8%), whereas in the uncontrolled group, the different regions had approximately the same amount of individuals; hospitalization proportion was higher in the uncontrolled than controlled glucose group (6.7% vs 4.7%, respectively); median BMI was very similar in both groups (29.6 IR 6.6 vs 29.2 IR 6.4), as well as the percentage of patients with controlled blood pressure (99.3% vs 98.9%); T2DM complications proportion was higher among the individuals in the uncontrolled than controlled glucose group (22.8% vs 18.1%, respectively); median time spent with the disease was higher among the individuals in the uncontrolled than the controlled glucose group (5.1 IR 8.7 vs 3.6 IR 6.9, respectively); finally, median medical consultation time received was higher among the individuals in the controlled glucose than the uncontrolled group (5.9 IR 7.1 vs 5.7 IR 7.7, respectively).

The first hospitalization risk for diabetes mellitus decreased by 38% in the cases where the diabetic patient had been under control at the outpatient care unit (HR: 0.62, 95% CI [0.62, 0.63]) (Table 2). The adjusted risk showed a decrease of 23% (HR: 0.77, 95% CI [0.76, 0.77]), estimated by means of a Cox regression model (Figure 2).

Through this model, it was also estimated that the hospitalization risk decreased by 33% among men (HR: 0.67, 95% CI [0.67, 0.68]); risk increased 1% for every year the patient age increased (HR: 1.01, 95% CI [1.01, 1.01]); risk increased by 10% among individuals living in the Center South region compared to those living in the Center Northern region (HR: 1.10, 95% CI [1.09, 1.12]); and risk increased by 29% in the North-East region (HR: 1.29, 95% CI [1.28, 1.31]) and by 32% in the North-West region (HR: 1.32, 95% CI [1.30, 1.33]) compared with the Center Northern region.

Hospitalization risk was 4% lower for each unit decrease in body mass index (HR: 0.96, 95% CI [0.96, 0.96]); risk doubled when the patient had a diabetes complication diagnosis (HR: 2.18, 95% CI [2.16, 2.20]); risk increased by 9% for each additional year spent with the disease (HR: 1.09, 95% CI [1.09, 1.09]) and decreased by 5% for each additional year of medical attention received at the family medicine unit (HR: 0.95, 95% CI [0.94, 0.95]).
Discussion
Our findings are relevant to patients, clinicians and policymakers and can inform on the healthcare needs and how best to prioritize and deliver care for people with T2DM. The results obtained in this work are consistent in that outpatient care of diabetic patients at the IMSS should be further strengthened by means of preventive and educational strategies. Thus, the results provided evidence that the control of diabetic patients with insurance in the family medicine unit (UMF) at the IMSS was associated with a 22% decrease in diabetes first hospitalization risk. This estimation is very similar to that reported by Caughey et al. [25] for 65-year-old or older adults living with diabetes in Australia who were admitted to the hospital for the first time due to diabetes complications (HR: 0.78, 95% CI [0.69, 0.87]), even when the characteristics of the population assessed in each of the studies were different, and the group of causes related to the hospitalization event was different. Every hospitalization event related to diabetes was considered in this study. A complication diagnosis prior to hospital admission was additionally included as a factor in the model, as the presence of a complication doubled hospitalization risk.
Hospitalization risk was higher in the Northern region of the country, compared to the Southern region, where there has historically been a higher prevalence of diabetes [28] and where the IMSS has a larger hospital infrastructure [22]; disease rate was also higher as age, BMI and uncontrolled blood pressure increased [29]; these factors consistently related to a higher hospitalization risk, which also increased in relation to the time patients spent with the disease and decreased if the patients received outpatient care for a longer period of time.
Among the limitations of the present study, there was the assumption that diabetic patients’ control was due only to medical care received at the family medicine unit when they attended for laboratory tests or medical consultation. During these visits, patients usually receive recommendations about diet care, physical activity and correct use of medications when prescribed. Even if this relation can be taken for granted, it would be necessary to develop further research to assess the reach of this connection or to establish a procedure that allows a more rigorous delimitation of the group of subjects whose disease control can be attributed to medical care.
Different studies have indirectly measured outpatient care effects through the analysis of trends in potentially preventable hospitalizations or those sensitive to primary care [15-17]. It has been claimed that such trends decreased when patients received quality and effective outpatient care; however, the fact that these studies usually have an ecological approach suggests that if the period of analysis changed, the results might be the opposite, as occurred in the study developed by Wang et al. [15]. In that study, there was a decreasing trend in potentially preventable hospitalizations, which was attributed to the effectiveness of outpatient care; however, when Rubens et al. studied the same population during a longer period of time, they found a series of significant changes in the rate of preventable hospitalization, and they concluded that additional studies on the influencing factors should be developed.

Other studies have estimated preventable hospitalization rates by defining a group of diseases where there was evidence of outpatient care effectiveness in reducing hospital admissions and claimed that every hospitalization event related to those causes might have been prevented [5, 12-14, 30]. Several studies have demonstrated that the world disease burden assessed by disability-adjusted life years (DALYs) due to T2DM in 2015 amounted to 2.6%; in Mexico, 8% [30]; and at the IMSS, 10.9% [31-32]. By sex, the world percentage has been higher in women (2.7%) than in men (2.5%); however, in Mexico, there has been a similar percentage in women (8.6%) and men (7.5%). However, in the IMSS, this percentage was higher in men (11.0%) than in women (10.9%). Additionally, in 60-year-old and older patients, the world percentage was 29.5%; in Mexico, 82%; and in the IMSS, 45.6%. From 2010 to 2015, the world DALY rate related to such disease increased slightly by 0.4%; in Mexico, increased by 1%; and at the IMSS, decreased by 0.2%. If the disability-adjusted life years DALYs are taken into consideration, the world diabetes burden increased to 4.4%; in Mexico, increased to 9.5%; and at the IMSS, decreased to 7.5%.

The two approaches just described set a framework for examining the potential impact effective outpatient care has on the possibility of preventing hospital admission and its estimated associated costs; conversely, the present study provides a measurement of the effect an intervention has, which can be used as an element to estimate such impact.
Conclusions
Mexico is at an advanced stage in the epidemiologic transition, with the majority of the disease and injury burden from noncommunicable diseases. A unique characteristic of the epidemiological transition in Mexico is that overweight and obesity, high blood glucose, and alcohol use are responsible for larger burden of disease than other noncommunicable disease risks. The Southern region in Mexico suffers from the largest burden of ill health in all disease and injury groups. Most people with T2DM have at least one other condition that can influence the self-management of diabetes and its progression. We found suggests that outpatient care control of the diabetic patient at the IMSS is effective in reducing diabetes hospitalization risk; therefore, it is necessary to strengthen the set of actions performed on a primary level, such as increasing access to healthcare and improving control quality of the diabetic patient, so they can have a greater impact not only in reducing hospital admission, but also in increasing health and life quality of people with access to healthcare. Some strategies supported by health and information technologies can be implemented to boost primary care effectiveness.

Declarations

Authors’ contributions
JEFG, LMA and NGC to the conception originally and designed of the study. RACG and MLAF contributed to data collection and interpretation; JNZC and MLBA performed the statistical analyses. JEFG, LMA, and NGC critically reviewed the manuscript for important intellectual content and wrote the manuscript and all co-authors critically edited the manuscript. NGC is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. All authors read and approved the final manuscript.

Authors’ information
Not applicable

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Availability of data and materials

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

Ethics approval was provided by the National Research and Health Ethics Committee of IMSS, with the registry number R-2014-785-024

Consent for publication

Not applicable

Conflict of interest

The authors declare that they have no competing interests.

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Not applicable.

Abbreviations

BMI, Body Mass Index; BP, Blood Pressure; DALYs, Disability Adjusted Life Years; HbA1c, glycated hemoglobin; IMSS, Instituto Mexicano del Seguro Social; IR, Interquartile Range; ICD-10, International Classification of Diseases; SANENT®, Non-Communicable Diseases Analysis System; T2DM, type 2 diabetes mellitus; UMF Family Medicine Unit WHO, World Health Organization.

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Table 1. Characteristics of patients with T2DM and with access to healthcare according to glucose control

| Variable               | Controlled       | Uncontrolled     |
|------------------------|------------------|------------------|
|                        | n = 2,070,896    | n = 1,645,135    |
| Sex n (%)              |                  |                  |
| Man                    | 818,772 (39.5)   | 671,351 (40.8)   |
| Woman                  | 1,252,124 (60.5) | 973,784 (59.2)   |
| Age median (IR)        | 63 (18.0)        | 59 (17.0)        |
| Region n (%)           |                  |                  |
| Center Northern        | 438,453 (21.2)   | 409,013 (24.9)   |
| Center South           | 456,850 (22.1)   | 434,381 (26.4)   |
| North-East             | 571,074 (27.6)   | 400,917 (24.4)   |
| North-West             | 604,519 (29.2)   | 400,824 (24.4)   |
| Hospitalization n (%)  |                  |                  |
| No                     | 1,973,824 (95.3) | 1,534,258 (93.3) |
| Yes                    | 97,072 (4.7)     | 110,877 (6.7)    |
| BMI median (RI)        | 29.6 (6.6)       | 29.2 (6.4)       |
| Control of BP n (%)    |                  |                  |
| No                     | 15,445 (0.7)     | 17,783 (1.1)     |
| Yes                    | 2,055,451 (99.3) | 1,627,352 (98.9) |
| Complications n (%)    |                  |                  |
| No                     | 1,695,142 (81.9) | 1,270,129 (77.2) |
| Yes                    | 375,754 (18.1)   | 375,006 (22.8)   |
| Time spent with DM median (IR) | 3.6 (6.9) | 5.1 (8.7) |
| Time with attention median (IR) | 5.9 (7.1) | 5.7 (7.7) |

IR= Interquartile Range, BMI= Body Mass Index, BP = Blood Pressure and T2DM = Diabetes Mellitus type 2
| Variable | Unadjusted | Adjusted |
|----------|------------|----------|
|          | HR         | IC 95%   | HR         | IC 95%   |
| Sex (man vs woman) | 0.62       | [0.62, 0.63] | 0.67       | [0.67, 0.68] |
| Age      | 1.02       | [1.02, 1.02] | 1.01       | [1.01, 1.02] |
| Region   |            |          |            |          |
| Center Northern | Reference |           | Reference |           |
| Center South | 1.14       | [1.13, 1.14] | 1.10       | [1.09, 1.12] |
| North-East | 1.12       | [1.12, 1.13] | 1.29       | [1.28, 1.30] |
| North-West | 1.23       | [1.22, 1.23] | 1.32       | [1.30, 1.32] |
| T2DM control (no vs yes) | 0.68       | [0.68, 0.69] | 0.77       | [0.76, 0.78] |
| BMI      | 0.94       | [0.94, 0.94] | 0.96       | [0.96, 0.97] |
| Control of BP (no vs yes) | 0.89       | [0.86, 0.91] | 0.80       | [0.76, 0.81] |
| Complications (no vs yes) | 2.51       | [2.51, 2.51] | 2.18       | [2.16, 2.20] |
| Time spent with T2DM | 1.09       | [1.09, 1.09] | 1.09       | [1.09, 1.10] |
| Time with attention | 1.02       | [1.02, 1.02] | 0.95       | [0.94, 0.95] |

BMI = Body Mass Index, BP = Blood Pressure and T2DM = Diabetes Mellitus type 2

Figures
Figure 1

Description of the population of study in this diagram was described the sample selection
Cox regression model using days as the time measure between first consultation and first hospitalization dates; the estimations were adjusted by sex, age, geographical area, glucose level control, body mass index, blood pressure control, diabetes complications records, time spent with the disease (years) and time spent under control (years).